CROP PRODUCTION and INFLUENCING FACTORS

Abdulgani DEVLET

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PREFACE

In agriculture, the importance of crop production is mainly reflected in the contribution to human life. Because the continuation of life needs the supply of nutrients to maintain. The source of nutrients and food is farmland. Living in prosperity in this situation. The earth is a big, rich, tidy field and treasure. It's amazing that every grain grows and matures on time. It's also a perfect garden where every vegetable and fruit grows and harvests, and then is assigned to the origin address.

Food and nutrition insecurity is directly proportional to the decline of food production, which is also the result of agricultural drought caused by global warming. Food is very important in human life. The importance lies in that in order to continue to maintain life, food can not be the goal of life, but an indispensable part of it. In the field of agriculture, efforts to develop food technology and remove obstacles have become more and more important and priority. Especially in the global pandemic, today, a small (animal) organism, a microorganism, a particle called coronavirus in the world is poisoning and scaring all people, threatening the human world. From the micro point of view, beneficial and harmful particles are used in the universe and human body, that is, there are continuous disputes between beneficial and harmful microorganisms. From a macro point of view, there are still disputes between day and night, winter and summer, fire and light, light and dark, temperature and cold. Nowadays, Covid-19 is not only a threat to human health, but also a limiting factor to the development of agricultural production. Improving food technology on the basis of preventing and avoiding disasters and removing obstacles provides the basis, investment and contribution for the sustainability of production trends. Advantages, disadvantages and improvement steps can be foreseen. Agriculture is the top priority and challenge of many difficulties.

An important event caused by global climate change is drought. It refers to the natural disasters that occur due to the decrease of precipitation and the increase of temperature, can occur repeatedly, distribute in one or more seasons, and affect all natural resources depending on the existence of water. However, due to global climate change, high temperature and reduced rainfall lead to the persistence of drought and its possible negative effects. The interaction between climate change and the agricultural sector is a common theme in urban planning and sustainable disaster management, as well as one of the priority issues in policy and strategy formulation. By taking preventive measures and making correct countermeasures, we can seriously eliminate the environmental problems that may directly affect human life. We should take necessary measures to predict, avoid, control and reduce drought and other natural disasters, maintain and guarantee development in the new situation of agricultural production and scientific and technological development, identify the strategic needs of science and technology, grasp the opportunities, and ensure the realization and implementation of goals and policies. Back to the original words, the importance of a grain in crop production is to start from the first step of not wasting, take measures to eliminate the impact factors of reducing yield and make contributions. Among them, saving is the key to grain production and the embodiment of increasing production. If we continue to save important natural resources and save without wasting them, we can effectively reduce the challenge of meteorological disasters to the food and agricultural revolution. This is also synchronous with nature. It follows the rules of nature to develop crop production. It is also the development rules of being a man. Because both follow the rules.

BESMELE said: it's very accurate. The universe, the earth and people are in balance. But people often make mistakes. In addition to people's dirty hands to make trouble, everything is obedient to orders, in the implementation of the task. We also rely on its miracle to make the best choice and prevention. All walks of life can use the same principle, especially in crop production, to achieve the goal of "timely, moderate and economic input as the principle of high efficiency and high yield" will be an important direction of synergic agricultural development in the future.

When time begins, there is no time. Solve the problem, grasp the time.

Abdulgani DEVLET
NİSAN 2021

CONTENTS

INTRODUCTION

Human health has always been affected by climate and weather, especially extreme weather can have a negative impact on our air, food, water, shelter and overall human security (Balbus et al., 2016).

Water is inseparable from life. Without water, no known creature can move. There is water and life on earth. (Alpert, 2005) water is essential to all life. Although organisms are very different in their tolerance to anhydrous survival (especially when we reach the microbiological level), all life we know ultimately depends on water. Without water, there is no food; the animals and plants on which we live, and the plants we feed animals, need a lot of water to thrive (Alpert, 2005). That is, some food choices need more water than they provide, while others are more sustainable. We can say that water is not only necessary for life, but also water is life. The human body is 60% of water, and we are made up of more water. Although 70% of the earth's surface is covered by seawater, most of it is seawater, leaving only 2.5% of fresh water. It seems unlikely that it will be a small number for maintaining a population of 7.5 billion and all terrestrial flora and fauna. Animals need clean fresh water to drink and bathe, plants need it to sustain their lives, and humans need it to cook, irrigate crops and many other uses. Recognizing these facts, the United Nations, through resolution 64/292, announced that access to safe and clean drinking water and sanitation is a human right considered to be vital to life and the basis for other human rights (United Nations Media Briefing, 2010).

Countries with a quarter of the planet's population face an increasingly urgent risk: the prospect of water depletion. Globally, 17 countries are in extreme water stress because they are using almost all of their water resources. Globally, the number of predicted daily zeros is increasing (Hofste, Reig and Schleifer, 2019).

The relationship between human and land has been developing rapidly. This change has become more dramatic as human beings use land in new ways to exploit various forms of fuel, minerals and other natural resources in order to accumulate wealth and build a modern economy (Berry, 2010). Human beings are facing the problem of how to use the earth's resources (UNE, 2016). Land, of course, is closely related to food. The ecological value of food is the relationship between traditional knowledge and land and food (Isaac et al., 2018). Health and the control of food resources are intertwined (First National Development Institute, [FNDI], 2013).

Climate change and food production interact. In other words, climate warming is putting pressure on our global food system, and our choice of food affects the speed of climate change. Feeding 7.6 billion people leads to the degradation of terrestrial and aquatic ecosystems, which greatly consumes our water resources and leads to climate change (Poor and Nemecek, 2018). The four biggest ways in which food impacts climate change are: (a) deforestation leads to the reduction of trees to absorb carbon; (b) increasing livestock burping and the transfer of methane, a powerful greenhouse gas; (c) expanding manure and paddy fields, a major producer of methane; and (d) increasing the use of fossil fuels from agricultural machinery (Moskin et al., 2019).

Looking forward to a future including mankind, we need to take the responsibility of ecological respect, protection and reconstruction (Tallamy, 2020). When land is abused, no matter where it occurs in the world, its impact will affect the whole world. Whether that means burning down Amazon forests, melting glaciers, increasing storm intensity, or rising temperatures. In turn, each factor will lead to the acceleration of climate change and the expansion of ecological damage and environmental injustice. This can be reversed by establishing a different relationship between man and nature. In this relationship, we should abide by the laws of nature and develop synchronously and cooperatively, rather than separate from or surpass nature (Tallamy, 2020). Many people all over the world have a deep understanding and respect for the connection between human beings and the natural world, linking people and places (Hooks, 2009; Zapf, 2009).

Despite factors such as population growth, urbanization, land scarcity and land value, world food crop production has tripled in the past 50 years, which frustrates Malthus' theory. 1 the green revolution is the core element of this growth, increasing global food supply and reducing food and feed costs (Venkatramanan et al., 2020a); in fact, it is estimated that without the green revolution, world food prices would rise by 35-65% (Everson and Rosegrant, 2003). Unfortunately, progress in food production has now slowed down. Policy objectives have been focused on economic and social development, leading to little attention to agricultural development. In fact, between 2001 and 2013, the agricultural orientation index of developing countries dropped from 0.37 to 0.31, and the aid to agriculture remained at about 8%, lower than 20% in the mid-1980s (UNSD 2019). In order to meet the needs of the world's growing population, global food production needs to increase by nearly 60% (Alexandratos and Bruinsma, 2012). Although the green revolution has brought obvious benefits and many side effects, including biodiversity loss, pollution and erosion, it is unlikely that the green revolution is suitable for sustainable production. Anthropogenic climate change directly and indirectly affects food and nutrition security. Climate change has changed rainfall patterns and temperatures, increased the number of extreme weather events, and thus had a direct biophysical impact on food and feed crop production. More indirectly, climate change affects soil fertility, irrigation, economy and socio politics. Changes in food production have indirectly affected agricultural markets, which in some cases have led to higher food prices, resulting in hunger and malnutrition in the least developed countries. The proportion of global population experiencing direct and indirect impacts of climate change will increase with the degree of climate warming. In general, Asian monsoon rainfall is expected to increase, while North and South

Africa will become drier (Wheeler and von Braun, 2013). The fifth assessment report (AR5) of the Intergovernmental Panel on climate change (IPCC) pointed out that the increase of water resources and high latitude areas will interact with the increase of sediment, nutrients and pollutant loads, so the quality of raw water will decline, and the increase of drought in arid areas will lead to the decrease of groundwater resources (IPCC, 2014). The 2030-2049 forecast shows that 10% of the forecast output will increase by 10%, and about 10% of the forecast output will lose more than 25%; after 2050, the risk of more serious impact will increase (IPCC 2014). Forecasts also show an increase in invasive agronomic weeds and pests, a decrease in the growing season due to increased frequency of frost and heat, an increase in livestock mortality, and a decrease in energy supply and access to food.

The fifth assessment report of climate change (IPCC) (AR5) shows that the increase in water resources and high latitude areas will interact with the increase in sediment, nutrient salt and pollutant load, so the raw water quality will decrease, and the increase in drought in the current arid area will lead to the decrease of groundwater resources (IPCC 2014). The 2030-2049 forecast shows that 10% of the forecast output will increase by 10%, and about 10% of the forecast output will lose more than 25%; after 2050, the risk of more serious impact will increase (IPCC 2014). The forecast also shows that invasive agricultural weeds and pests increase, growth seasons decrease (due to increased frequency of frost and heat), increased livestock mortality, and reduced access to energy and food. Agriculture is the main mechanism for poverty reduction, food and nutrition security improvement and economic stimulation (Wheeler and von Braun, 2013). Evidence from countries that have successfully improved food and nutritional security shows that GDP from agriculture has grown twice as much as non-agricultural GDP. However, the growth of global population, the growth of wealth and consumption, and competition for land, water and energy are bringing three challenges to agriculture: meeting the rapidly changing food needs of the richer; achieving environmental and social sustainability; and targeting zero hunger in the poorest countries in the world (Godray et al., 2010).

The global driving forces and variability of agricultural production include technology, genetics, climate, soil, field management practices and related decisions, such as fertilization, tillage and crop cross selection, irrigation management, row spacing, wheezing date and depth, and population density. A large part of the progress in agricultural production is the result of genetic, agronomic and resource utilization practices and technological progress (Duvick, 1992 and 1977; Duvick et al., 1999; Andresen et al., 2001;Kucharik et al., 2005).

The continuous growth of the world's population has increased the demand for crop production. By 2050, global agricultural production may need to double to meet growing demand (Tilman et al., 2011;

FAO, 2012). For food security, some studies suggest that increasing crop yields, rather than clearing more land for food production, is the most sustainable way (Godfray et al., 2010; Foley et al., 2011). However, some reports point out that the increase of output is not fast enough to meet the expected demand in 2050. Of course, the world will face a food crisis (Ray et al., 2013). Evidence from agricultural scientific research and crop production data analysis shows that the impact of climate change on crop production is as important as the average value of crop seasonal climate variables (Bhatta et al., 2015). Crop productivity in the world is facing climate adversity, especially extreme events endangering social and economic needs; therefore, it is necessary to formulate better policies and plans for future disaster risk reduction (Duncan et al., 2015).

AGRICULTURE HISTORY AND POLICY

The most important change in human history begins with the development of agriculture. Scholars from many disciplines, such as religiology, archaeology, historical linguistics, biology, anthropology and history, have investigated southwest Asia, South Asia, China, Japan, Southeast, Middle East, Asia and Pacific, sub Saharan Africa, America and Europe, and studied the common development of agriculture with social structure and cultural forms (Barker et al., 2015).

The Food and Agriculture Organization of the United Nations estimates that by 2050, we will need 60% more food. Agriculture must provide more and more high-quality food, fiber, feed and fuel for human beings in an environmentally, economically and politically sustainable way. And agriculture will become more challenging in the future, and the development and correct implementation of precision agriculture will help to achieve this very important task (Zhang, 2016). The link between agriculture and human needs requires reducing pollution in the areas of air, soil and water, improving food production and related socio-economic issues, with a focus on human health and livelihoods. For sustainalable agriculture, four pillars are land management, resource management, human interface and ecosystem interface. Because of the strong influence of personal values, culture, norms and habits, the human interface may be the most unpredictable and complex (Peattie, 2010). Domestication of plants for thousands of years has led to extreme changes in human diet and social development, prompting people to eat more grains. At present, carbohydrates still account for 60% of human calories (Foster et al., 2003), most of which are consumed by grains such as rice, wheat and corn. Both animals and plants in the area have experienced extensive expansion. Once domestication is successful, it will be scattered from the origin area to another part of World. Domestication began with wheat cultivation in Fertile Crescent areas such as Turkey and spread rapidly throughout Europe (Zohary et al., 2012). With the improvement of domestication, the human diet structure has been accelerated, but it is still changing. Urbanization involves more consumption of polished grain (bran removal). Rice and wheat have been treating for more sugar, more animal products and, more food (Drewnowski et al., 1997). Grain production accounts for a large part of the world's agricultural production. According to FAO, world grain production is expected to reach the target of 3 billion tons by 2050 (Alexandratos et al., 2012).

The first challenge facing World Agriculture is to produce enough food to meet the growing world population. It is predicted that the world population will reach 8 billion by 2025. It is expected that in the coming decades, the population in rural areas will decrease, and rapid urbanization will lead to the continued growth of urban population. So far, the income of agricultural activities is low and about 70% of the poor are still rural residents. The second challenge for World Agriculture, therefore, is technical, policy and institutional. Meeting this challenge will require farmers to have access to domestic and international markets. The third challenge facing World Agriculture is that small-scale farmers pay attention to the long-term management of the natural resources they manage. In the new century, we will create a set of technologies, incentives and policies to encourage development. Around the world, it is vital that most of the fields, Forests and pastures are used by farmers. Agricultural water consumption accounts for more than 70% of the world's fresh water, and there are a lot of biodiversity in the agricultural system. It is estimated that agricultural production can cause 70% of the water area, deforestation of most forests and loss of biodiversity (Renan et al., 2008). The border between the forest and the desert is affected by agricultural activities. Therefore, the issue of improving our natural resource management is closely related to improving the productivity and profitability of small-holder farmers in developing countries (Robert et al., 1987). However, there is a huge pressure on agricultural production systems to cope with increasing demand, climate and soil change. This is mainly due to human interference. The increasing of food production in the case of reduced land per capita and water shortage must be described for humankind (Postel, 1996). With the increase of food production, especially the source of high protein food, how to meet the future needs of the population is facing some challenges (Singh and Maharaj, 2017); currently entering a new era of agriculture, scientists are developing "intelligent" plants to achieve healthy life to save the future (PMB, 2006). Human beings always equate their happiness with consumption. Therefore, increasing production has become the competition problem of every country. This, in turn, brings a burden to the environment due to the abuse or overuse of natural resources (Jaswinder et al., 2018).

Thousands of years of plant domestication have led to extreme changes in the human diet, as well as social development, driving to a greater consumption of grains. Carbohydrates are still serving about 60% of our calories today (Foster et al., 2003), Most of these carbohydrates are consumed as grains (mainly rice, wheat, and maize).

Most domesticated plants and animals experience widespread expansion. Once domesticated successfully, these crops and animals expand rapidly and are used in areas where they did not originate. Clearly, the human diet has dramatically altered with increased domestication and is still changing today. Urbanization is involved with greater consumption of polished grains (bran layer removed), where rice and wheat are preferred over grains such as millet, more sugar, more animal products, and most importantly more food is consumed away from home (Drewnowski and Popkin, 1997).

Domestication began with the cultivation of wheat in the Fertile Crescent of Turkey and rapidly spread all over Europe (Zohary et al., 2012). In contrast, recent analyses suggests that new technology, economic, and environmental factors are the driving trends of increase in local production, manufacturing, and services, a process named "deglobalization" (Hammes, 2016).

Harris and Hillman (1989) recognized the main developmental steps of this relationship. First, the use of pounding stones to treat woody and hard tissues. Second, prescribed and controlled fires (slush and burn) and third, harvest seeds and storing them. The next developmental steps were cooking, detoxification by leaching, and cultivation. The later ultimately caused some plants to lose their ability to survive and reproduce wildly without human interference. The main conclusions from Harris' fundamental work are the following: first, the distribution patterns of current plant communities illustrate the habitat preferences of their progenitors more than they tell us about their origin. The second conclusion is related to the essential question—what makes one species a successful domesticated crop (Diamond, 1999).

Human beings always equate their well-being with consumption. Therefore, every nation rich or poor is in a race to increase production. This in turn is putting a burden on the environment due to misuse or overuse of natural resources. Actually around 60% of the total waste generated from industrial, agricultural, or domestic sectors is biodegradable and can be used for production of economically important plants and nutritionally balanced animal proteins. Vermicomposting is one such technology that synergizes microbial degradation with earthworm's activity for reducing, reusing, and recycling waste materials in a shorter span of time. Mutual action of earthworms and microbes brings faster decomposition as earthworms aerate, condition, fragment, and enhance surface area of the organic matter for microbial action (Jaswinder, 2018).

The interface between human demand and agriculture requires efforts to reduce pollution in the air, soil, and water spheres and improve socioeconomic-related issues in food production with an emphasis on human health and livelihood. The human interface may be the most unpredictable and complex of the four pillars (land management, resource management, human interface, and ecosystem interface) as it is influenced strongly by personal values, culture, norms and habits (Peattie, 2010).

Processing of foods is an important topic since 30% of the overall production of food is lost postharvest (FAO, 2013) because of lack of appropriate technologies and techniques for preservation. In the food industry, the control of unwanted microorganisms is essential and decisive (Stoica et al., 2011). The soil is deposited on food processing equipment and forms films that negatively interact with the processing integrity lines, for example, on the walls of an empty tank and on the internal surface of a heat exchanger (Norton and Tiwari, 2014).

In the food systems, the way of production and distribution, as well as the kind of foods we consume can have a certain effect on the planet where we are living on and the society which we are living in. Air, water, land, climate conditions, and biodiversity are the major driving forces for human well-being and, at the same time, major parts of our lives are exposed to human activities intentionally. Sustainability of these natural sources plays a primary role in the food systems. However, food system itself also has a primary role for protecting natural sources because of its certain consequences such as greenhouse gas (GHG) emissions, water and soil pollution, and deforestation (Garnett, 2013).

Nowadays, the definition of food security focuses on the access to food rather than food production. In November 1999, The World Food Summit took place with a participation of 185 countries and the European Community for the eradication of hunger. According to definition of World Food Summit (FAO, 1996), food security is met when "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life." Food and nutrition security are considered as the priorities of food system outcomes and strongly emphasized in the definitions of "sustainable diet" that is comprised of a healthy diet and a healthy environment (Allen and Prosperi, 2016).

Earlier, in 2011, Food and Agricultural Organization (FAO) published a report considering global food losses and food wastes noting that nearly one-third of worldwide food production (1.3 billion ton/year) for human consumption is lost or wasted. The amounts of food loss and waste along the food supply chains, respectively, are 54% of total loss and waste as upstream processes (including production and postharvest) and 46% of total loss and waste as downstream processes (including processing, distribution, and consumption) (FAO, 2011). The European Commission technical report (published in 2010) indicated that around 90 million tonnes of food wastes are generated within European Union (EU) each year. The percentage breakdown of food wastes according to this report is 39% manufacturing, 42% households, 14% food service/catering, and 5% retail/wholesale (2006 EUROSTAT data and various national sources provided by EU Member States). Based on this study, it is expected that food wastes would reach 126 million ton in 2020 (from about 89 million ton in 2006), without additional prevention policies or activities. From 2006 up to 2020, food waste tonnages are expected to be 3.7 million in

EU27 when population increases by nearly 21 million (Otles et al., 2015).

Food supply chains begin from the primary agricultural phase, proceed with manufacturing and retail, and end with household consumption. During this life cycle, food is lost or wasted because of technological, economic, and/or societal reasons. The definitions of "food waste" and "food loss" within the supply chain have been a subject of disagreement among the related scientists. According to the EU Commission Council Directive, 2008/98/ EC, "waste" is defined as "any substance or object, which the holder discards or intends or is required to discard." "Food loss" refers to quantitative and qualitative reductions in the amount and value of food. The qualitative loss corresponds to the loss of caloric and nutritive value, loss of quality, and loss of edibility. Quantitative loss refers to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. FAO (2014) global voluntary definitional framework defined food loss as the decrease in quantity or quality of food, caused mainly by food production and supply system functioning or its institutional and legal framework. Thereby, "food loss" occurs throughout the food supply chain. Moreover, FAO distinguishes "food waste" as an important part of "food loss," which refers to the removal of food from the supply chain, which fits for consumption by choice or has been left to spoil or expire as a result of negligence (predominantly but not exclusively) by the final consumer at household level.

Food supply carries a vital importance for human survival. Nevertheless, the protection of natural resources which is tightly coupled with food supply is an inevitable priority in today's world. The fact of increasing soil, water and air pollution, deforestation, the decline in biodiversity and effects of climate change and in response to all these events, ever-growing human population and the needs for food and energy create a very serious problem to provide continuance of human survive. All these factors constitute certain unsustainability in the global agriculture and food systems, and the generation of huge amount of food waste became a major indicator of this instability. Food industry has to produce enough food and ensure the food safety while giving rise to a less environmental impact. The improvement of food production efficiency, the prevention of food waste generation, and waste valorization for meeting the increasing demand for chemicals, materials, and fuel are the only solutions to restore this unsustainability. Appropriate waste management strategies including the prevention of unsustainable use of natural sources, huge amount of waste generation, and the recommendation of a more cost-effective and environment friendly disposal system should be a global focus point which is shared by farmers, industrial producers, consumers, and policy makers (Otles, 2018).

Definition of Agriculture

Agriculture is a science, art or practice of growing soil, producing crops and raising animals for marketing (Merriam, 2016). Agriculture is the most basic instinct of human beings, which has a broad definition such as the ability to produce food to meet hunger and the survival of species. The word 'Agriculture' is originated from the Latin word 'Ager' means field and 'Culture' means cultivation. So agriculture is an art of raising living organism from the earth for the use of human being (Erick et al., 2002; Alexandratos et al,. 2006) We shall understand agriculture as consisting of activities which foster biological processes involving growth and reproduction to provide resources of value. Typically, the resources provided are plants and animals to be used for food and fiber, although agricultural products are also used for many other purposes (Lehmen et al,. 1993).

Sustainable agriculture is one of the best practices for environmental sustainability. It maintains the fertility of soil and ecosystem and human's health. It relies on improved ecological processes and cycles of local adaptation, as well as natural biodiversity, rather than the use of synthetic inputs and genetically modified materials. Therefore, farmers must be encourage to engage advance agriculture for future. It has the great potential to contribute to food security and economy (FAO, 2013; Fraser, 1998).

Agricultural History

World agricultural land is very rich (Mickelson, 1997). Some local elders and historians believe that their origin story proves that they have always had agriculture (Martin, 1965). From past to now agriculture is not yet a major economic activity. Farmers has been doing agriculture activities for survive and support their families (Apps, 2015). It is very clear that if many of the sub themes that others will emphasize when writing similar works are strictly excluded, and if the book's claims are not so moderate, it will be criticized (Schafer, 1922). Understanding our history also helps us to meet today's local, national and global challenges. Hot issues such as environmental protection, land-use policies and ensuring adequate food supply are not new debates. They come in other times and forms. A deep understanding of the history of agriculture provides the basis for today's agricultural policy (Apple et al., 2015). No matter what the motives of Americans and Europeans are, they are most concerned about making a living. Most newcomers immediately began to produce their basic products with the initial goal of making a living, but it is expected that surplus products will soon be sold in local or national markets.

Agricultural policy

Historically, family farms have provided the strength and vitality of the whole social order. The task is to maintain its health and vitality (Hathaway, 1963). Farmers are "guardians of the countryside" (Cox et al., 1983) and providers of agricultural products, and the free market is considered unable to achieve these numerous goals. Political scientists call this agricultural Exceptionalism (Coleman et al., 1997; Skogstad, 1998). Because agricultural policy-making is carried out in a relatively closed policy network based on common values between the Ministry of Agriculture and agricultural groups (Coleman et al., 1997; Grant, 1995; Halpin, 2005). But these closed networks control the policy process and exclude other interests (Josling et al., 1996; Wilcox, 1949).

In the past 20 years, the traditional agricultural policy agenda and new policies have been challenged. "Agricultural income" is no longer the main concern although food security is a policy concern after the food price panic at the end of this century, adopting a more westernized diet may lead to a 50% increase in food demand (Huang et al., 2010). The new emergence includes food safety, the provision of environmental and ecosystem services, the role of biotechnology in agricultural production (especially genetically modified organisms, genetically modified organisms), intellectual property rights and biological patents, the use of farmland to produce bioenergy, and the role of the agricultural sector in reducing climate change. In developing countries, the policy and practice of developing industry at the expense of agriculture has been abandoned, with "development" and "agriculture" as the central policy instead (FAO, 2004). New policy issues are being addressed in a more flexible institutional environment. In such an environment, there are often conflicts and interactions among regions and institutions based on different values, so policy coordination is needed. This coordination process is called inter agency decision-making. We should encourage participation in the formulation of new agricultural policies. Design and implement policies more effectively. Value balance has become a key feature of the new politics of agriculture and food (World Bank, 2007).

In the past, the research on agricultural decision-making has promoted the development in many political theoretical fields, such as interest groups, policy networks and public policy ideas. The study of these concepts is based on agricultural policy, and often from the agricultural sector to illustrate the theoretical point of view. It makes the agricultural policy department benefit to divide the policy-making process, well-organized policy-making process and agricultural groups with sufficient resources, the government's massive intervention in the market, and the possibility of significant redistribution of income and wealth among economic actors (Daugbjerg et al., 2012).

In order to promote greater agricultural production and linkages with other sectors, more targeted agricultural measures are needed. This may include further integration of food production to provide value-added and market access for food producers in the domestic tourism sector. It is more necessary to provide targeted agricultural funds in order to create more value-added agricultural industries and establish links with services and manufacturing industries. In order to create opportunities that directly benefit the rural population, partnerships among rural agricultural producers, governments and industry must be strengthened. We will provide more targeted agricultural financing, and set up the agricultural and food production insurance market for domestic producers. Invest in agricultural and food infrastructure, such as training and skills development, to improve roads and logistics capabilities, refrigeration facilities, food processing and value-added (Gani, 2018).

Agricultural policies that encourage mass production lead to highly concentrated agricultural practices that are likely to lead to environmental degradation. For example, fossil fuels are used to produce and transport chemical fertilizers and pesticides over long distances; then, raw products and finished products are further transported; water sources are also transported to agriculture; used water is often polluted by chemical fertilizers and pesticides, resulting in "dead zones" in the downstream. Consumers' food prices do not include the actual cost of their production. The actual costs include the cost of environmental clean-up, the cost of toxic exposure to human health and the lack of clean water, the cost of fossil fuel overuse, and the cost of food growth for future generations, while agricultural losses will be significantly reduced. Our current agricultural policies run counter to our nutritional, environmental and economic needs. Agricultural policies should not harm the health of the public, especially our children. Nor should it promote or allow our natural environment to continue to deteriorate. A healthy food system should ensure the well-being of consumers and farmers, as well as the producers, processors and distributors on which they depend. Organic and regional food production are promising examples of change. Unhealthy people in unhealthy places cannot produce healthy food. It is the responsibility of the health community to ensure the conditions for people's health. This means participating in agricultural policies to influence better food supply (Richard et al., 2009). Someone may be a good manager, but being a good politician is another matter. Be able to accept the experience of the past society to guide the future. Agricultural policies are very important for human and environmental health. It is always useful to fully grasp the agricultural and sideline industries and eliminate the harm. Access to and maintenance of a healthy life should be the goal of agricultural policy. As a person, a society, a country, this is unchangeable. This policy is crucial to the economy, business and industry. People can't understand the value of two things at any time: time and health. It should be such a state that the management of a family in a society is basically similar to that of a country.

In most commodities and regions, national research investment is highly productive. The return on internal investment for most commodities is between 30% and 70%. There is a consistent negative interaction between national research and national promotion. Higher research spending reduces the impact of extension services. It seems that most organizations that promote services do not directly deliver or disseminate research products to farmers. Although the impact of extension services is more variable, it is also productive on the whole. However, a more serious problem with extension may be the lack of evidence that extension complements research. The strong negative interaction between research and extension shows that the basis of extension productivity is not so much the extension of research results as the improvement of general productivity through the improvement of farm management. This is not wrong, but the findings indicate that a more systematic study of the extension of research is needed. However, well-organized systems need to be expanded, and the data clearly show the potential for high return national system investment in all countries of the developing world. Finally, there is a need for caution with regard to signals of delayed investment, although generally positive (Evenson, 1987).

Agriculture is a strong and viable industry with growth potential. Agriculture related economies have the potential for growth and diversification. The face of agriculture is changing. Innovative practices are leading to improvements in new products and traditional sectors. There is increasing interest in innovative food and natural products, especially in urban areas, which are opening up new markets and opportunities. As part of the 21st century strategy, it will be appropriate and progressive to support and promote the world-wide, nature-based agricultural industry. If a country wants to become stronger, it must draw strength from science. Because this power will be in the hands of science recently. Promote and expand agricultural research and consulting services to help improve farmers' practice: increase production land area; increase land yield per unit area; maintain soil productivity and reverse soil nutrient exploitation; improve agricultural sustainability through better resource management; select high-yield potential, insect resistance and resistance To promote and expand agricultural research and advisory services to help improve farmers' practice;

Drought, floods, hail, earthquakes, mudslides and many other disasters are the natural risks that the agricultural sector is prone to. Because of these risks, financiers are reluctant to invest in this industry. Ironically, agriculture is the foundation of industry and trade. But the risk of agriculture is more and more huge than other industries such as industry, trade and service industry.

CONCLUSION

Although the agricultural structure has changed significantly and dramatically beyond some elements, the agricultural production sector is still composed of agricultural units owned and operated by families. Still most important are inputs such as rainfall, sunlight and temperature. As a result, changes in climate, topography, soil and other agro ecosystems continue to affect production options for crops and livestock. In turn, the changes of these natural factors affect the implementation of management and technology selection. It can be seen that family decentralized farm management has advantages

(Olmstead et al., 2000). Capital and other technologies have replaced or improved the impact of these natural changes. The nature and speed of technological changes aimed at influencing agricultural production, as well as more general production options. The change of agricultural structure coincides with the increase of animal raising efficiency and the decrease of production cost. The increase of productivity is mostly due to the increase of production scale and technological innovation (Key and McBride, 2007).

In the toolbox of public policy analysis, the theory of policy stability is explained through new corporatism, policy network analysis and new system focusing on path dependence. It is proved that it is effective to determine the mechanism of returning stable agricultural policy path over time. It also emphasizes the importance of compartmentalizing policy-making and involves only a limited number of shared ideas and values of interest. The previous wave of policy reform has drawn the attention of policy analysts to the development theory and analysis framework, which can be used to explain these change multi flow models, punctuation equilibrium model, advocacy alliance framework and concept theory. These theories are the same as "stability theory", that is, the concept of conventional decision-making in relatively closed and exclusive subsystems, or networks (Daugbjerg et al., 2012).

Grant (2012) said that by using new modes of action (such as social media), new participants may be able to "debate. As a result, these new actors may successfully launch and promote through policy and institutional reforms. Inter agency coordination links core policy sectors to new policy areas that have not previously been approached by core policy sectors. The lower political cost strategy proposed by such new actors may be to initiate a policy level process in which new policy concerns are addressed by adding new measures to existing core policies. The concept of policy stratification has not been clearly defined, but the definition of institutional stratification by Thelen (2003, P. 228) may also cover policy stratification. Stratification refers to a "retention of the core (of an institution) while adding amendments through which rules and structures inherited from the past can be synchronized with changes in the normative, social and political environment" (Thelen, 2003, P. 228).

The case study also shows that this is not an easy process, which may lead to the ecological corporatization of policy stratification and the value balance involved in inter agency policy-making. As Feindt (2012) and kJ æ R and Jouchin (2012) show, policy makers should not ignore values. Kay and Ackrill (2012) and Daugbjerg and Botterill (2012) have shown that although this may only have the potential to internalize value conflicts in the short and medium term, value can be balanced through policy stratification. Due to the change of political or economic relations, the value balance has changed. The most stable solution for inter agency policy. Just as Cockfield and Botterill (2012) made decisions when an overall value dominates the policy complex. In the agricultural policy sector, decentralization and inter agency decision-making are becoming increasingly important. It is possible to provide the same theoretical insights as the traditional agricultural policy research in the past. As in the past, contributors to this topic have been firmly involved in the broader theoretical development of political science, enabling them to draw more general lessons from case studies (Daugbjerg et al., 2012).

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MODERN AGRICULTURE AND CHALLENGES

According to the final report of the food and Agriculture Organization of the United Nations (FAO) in 2020, although the covid-19 pandemic has different degrees of impact in all food sectors, the agricultural and food sectors have advantages in this respect, so other sectors are not as good as others in resisting the epidemic. The report predicts that the production and market trends of grain, oil crops, meat, dairy products, fish and sugar will become the world's largest trade grain commodity in 2020-2021. The situation of cereal supply and demand is good. FAO’s early forecast shows that global grain production in 2020 will exceed 2.6% of the previous year. It is estimated that world cereal trade volume will reach 433 million tons in 2020/21, an increase of 2.2% (9.4 million tons) compared with that in 2019/20, and will reach a new historical high due to the expected expansion of all major cereal trade (FAO, 2020).

In order to meet the increasing demand up to 2050, it is estimated that global agricultural production will need to increase by 70% (Bruinsma, 2009) Improving rural poverty and community farms in urban suburbs is one of the measures to achieve food security in developing countries. In order to promote global food security, low-income countries need to increase their quantity and quality of food production in order to reduce their vulnerability. In many food dependent low-income countries around the world, especially in Africa, there are huge differences in production (FAO, 2011b).

Sustainable agricultural mechanization is a key strategy to achieve long-term growth of agricultural production in all aspects, including reducing the coolie of small-scale farmers, improving the timeliness of agricultural operations and improving the efficiency of input and use. In the long run, mechanization will contribute to the sustainable strengthening of production systems and to the establishment of an agricultural sector more resilient to increasingly extreme and unpredictable climate events (FAO, 2017). Small farms are at the center of the strategy of food supply chain. Small-scale agriculture will continue to improve productivity and increase local food supply. In this way, we can not only effectively reduce poverty, but also make a significant contribution to economic development. Around 75% of the world's people, most of them living in rural areas are still extremely poor, live with hunger and fear starvation. Small-scale producers and landless households, a large part of people's income directly depends on agriculture or is engaged in agriculture based activities and the rest are small business owners related to agriculture, such as processing, machinery, storage, seeds, feed or fertilizer. A large number of starving people in poor countries only depend on agriculture for a living, but for a long time, their input is seriously insufficient, which hinders the overall productivity of agriculture. Lack of investment also reduces farmers' ability to cope with price fluctuations and external shocks, including those related to weather and economy. Climate change is affecting farmers' livelihoods and food security around the world. There are clear signs that there may be underinvestment, which will have a huge impact on poverty reduction. For example, in the World Development Report 2008, the quantitative analysis of the effect of poverty reduction shows that the growth of agricultural GDP (gross domestic product) is faster than that of external GDP (World Bank, 2008). Sustainable production of healthy livestock with nutrition and food for everyone is crucial. However, there is no specialized organization that can deal with the risk of specific diseases on time, and prevent, control and eliminate livestock diseases. Therefore, it is not only necessary to be on time in view of the seriousness of disease problems and problems in medicine, public health, veterinary medicine, entomology and environment, but also need to carry out firm international coordination and cooperation to develop and eliminate livestock diseases within the framework of the concept of "one health" Implementing the global strategy for collective health protection (FAO, 2011b). It mainly includes locusts, armyworms and fruit flies, which pose a major threat to agricultural and animal husbandry resources and livelihoods, as well as wheat, coffee and soybean rust, banana fusarium wilt, cassava and corn virus diseases, which spread rapidly, threatening neighboring countries, regions and continents. This disease seriously affects nearly 70 countries in the world, which is highly infectious. More than 80% of sheep and goats and more than 330 million people live in the world's poorest areas, causing losses of US $1.5 billion to US $2 billion per year, many of whom rely on small ruminants for their livelihood (FAO and OIE, 2015).

As a labor-intensive sector, agriculture can certainly absorb underutilized labor. For example, some farmers and rural workers have no land or too little income. In addition, agricultural growth has led to a decline in food prices, a doubling of the role of the local economy, and an increase in rural wages (Schmidhuber and Bruinsma, 2011). Therefore, the necessary condition of food security is not only to make full use of the existing natural resources, but also to invest in small farmers' agriculture and promote the development of fair economy. FAO published a paper entitled "how to feed the world by 2050" at an expert meeting in Rome in 2009, including the main conclusions of the meeting (FAO, 2016). A large part of the world's agricultural production is grain production. By 2050, according to the data of FAO, the world's total grain output is expected to reach 3 billion tons (Alexandratos and Bruinsma, 2012). It is estimated that the global meat production will reach 429 million tons in 2001 and 470 million tons in 2050, which is more than twice the increase (Nigel et al., 2010). The commercial and nutritional quality of fruits and vegetables depends on a range of characteristics, attributes and characteristics (Schröder, 2003).

The identification of commercial quality standards includes origin, freshness, cleanliness, appearance, hardness, consistency, no damage, color, no disease, aroma, texture, size and shape (UN-ECE, 2007). Nutritional quality, essential nutrients such as carbohydrates, amino acids and fatty acids are related to bioactive compounds such as phytosterols, dietary fiber, vitamins, carotenoids, phenolic acids, glucosinolates and flavonoids. In the process of delivery, quality will be affected by various activities in the supply chain. For example, the sales quality of fresh vegetables decreased due to mechanical damage caused by handling and transportation vibration during transportation. The next doubling of food production will be achieved through land reduction per capita and water shortage. In order to meet the needs of the future population, the increase of food production is faced with some challenges, such as the increase of high protein food sources (Singh and Maharaj, 2017). In food applications, it is most important to be able to quickly and correctly detect harmful and unhealthy (off label) animal and plant substances in processed food (Yancy et al., 2008). The main goal of all food safety organizations is to ensure the food safety of consumers in an all-round way (Anne et al,. 2014).

All in all, in human history, the long-term expansion of population has been limited by food supply and disease constraints (Diamond, 1997). The domestication of animals and plants has further promoted the development of human society, caused a large number of people, and increased the risk of disasters and major disease outbreaks (pandemic). The recent global pandemic of covid-19 is caused by the emergence of a disease caused by severe acute respiratory syndrome coronavirus 2 (Sars-Cov-2). Moreover, it has caused great interference and losses to economic activities and severely restricted international cooperation, exchanges and exchanges. The pandemic exacerbates new challenges to food security posed by climate change and major conflicts, both of which are major factors contributing to overall food insecurity. Plant scientists need to identify investment in innovation and change measures to deal with the pandemic. Ensuring supply through the use of modernization and automation at all stages of the food production system will exacerbate concerns and challenges about labor shortages and food safety. Responding to transport and trade disruptions to support food production close to the point of consumption may facilitate accelerated efforts to develop protective crops. Both trends will increase the demand for new crop varieties to meet the growing demand of consumers, better promote more research work, including successful prevention and treatment of epidemics, and accelerate the application of emerging plant breeding technologies in these rapidly developing modern agricultural environments (Henry, 2019a).

Global value chain (GVS) refers to the sharing of international production, a phenomenon that divides production into activities and tasks in different countries. Global value chain accounts for half of the total trade volume, which promotes the surge of international trade and creates unprecedented economic integration: some developing countries are becoming net importing countries and growing constantly: Indonesia, Nigeria, Algeria, Pakistan, Iran and the Republic of Korea are such cases, which make up for the lack of net import growth of developed countries. All over the world, governments are actively and openly intervening in the economy to promote innovation, create new technologies and cultivate cutting-edge industries. These interventions can have a positive or negative impact, especially in today's highly interconnected global economy. On the one hand, they can expand knowledge, increase productivity and disseminate basic tools for global growth and development. But on the other hand, they may also distort trade, transfer investment, benefit one economy and harm the interests of other economies. More than ever, international cooperation and rules are needed to ensure that governments' new focus on innovation and technology policies can maximize positive spillover effects, minimize negative spillover effects, and ensure that competition for technological leadership does not evolve into a struggle for technological dominance (World Trade Report, 2020). The global financial crisis in 2008 also brought a serious threat, adding pressure to the trade led growth model. New technology can shorten the distance between production and consumers and reduce the demand for labor. With the development of industrial and agricultural trade and technological change, global value chain can continue to promote growth. The premise is that developing countries implement more in-depth reform and innovation, and promote participation in global value chains. Industrial countries pursue open and predictable policies, and they need to strengthen and resume multilateral cooperation. With the reduction of trade and communication costs, the development of new products and the improvement of productivity, developing countries should accelerate the reform of trade and investment and improve the level of connectivity. It is conducive to promoting the development of global value chain and making it a sustainable and inclusive development force. (World Development Report, 2020).

Agriculture and challenges

With the rapid development of cities, the urbanization of the world has entered an unprecedented progress, 55% of the world's population is urban, and the border population has been growing by about 7.5 billion since the early 1960s (FAO et al,. 2018). In Asia and Africa, urban population growth has reached 90% (UN DESA, 2018). By 2050, 2.5 billion people are expected to live in urban areas. Unprecedented urban development is now taking place all over the world, and the urban population accounts for more than half of the global population. Access to adequate, safe, nutritious and cash regulated properties in urban areas poses specific food security and nutrition challenges. The actual distance between grain producing areas and consumers, the lack of transport options, the fluctuation of grain prices, the concentration of power in global grain trade, the impact of climate, and the failure of the safety net of low-income urban residents, especially in times of crisis, often limit the access to food (FAO, 2019). In order to meet the growing world population, the production of adequate food has become the primary and sustained challenge for agriculture all over the world. The share of agriculture in total production and employment is declining at different rates, and the challenges are different in different regions. The second challenge facing global agriculture is to develop new technologies, policies and institutions that will help to realize the full potential of agriculture as an engine of growth. Although agricultural investment and technological innovation are increasing productivity, it is disconcertingly low that output growth has slowed down. In order to reduce the loss and waste of grain in agricultural output, the goal of increasing production can be achieved. However, the degradation of natural resources, the loss of biodiversity and the spread of plant and animal diseases and pests across the border have hindered the necessary acceleration of productivity growth, and some of them have become resistant to antimicrobial agents. Developing a new set of technologies, incentives and policies to encourage small-scale farmers to attach importance to long-term management of natural resources, and improving the productivity and profitability of small-scale farmers are closely related to improving the management of natural resources in developing countries (FAO, 2017). On the basis of indigenous and traditional knowledge, the establishment of agroecology, agroforestry, climate intelligent agriculture and protective agriculture is a process of "holistic" transformation. To solve the problem of climate change and the aggravation of natural disasters affects all ecosystems and all aspects of human life, so it needs to be realized through the progress of new technologies, coupled with the sharp reduction of economic scope and the use of agricultural fossil fuels. It is also necessary to strengthen international exchanges and cooperation to comprehensively prevent emerging cross-border agricultural and food system threats, such as pests and diseases. Strengthen the innovation system based on the conservation of natural resources to improve productivity. However, there is a need to respond to growing demand, climate and soil changes, mainly the risk and pressure of human interference with agricultural production systems (FAO, 2019).

Floods affect human survival, property and economic activities in many ways. There has been a lot of research on how to prevent, mitigate, manage and deal with the clean-up and recovery phases. Although the flood frequency is not high and the occurrence time is short, the damage to property and houses can cause serious economic burden. By promoting and supporting integrated watershed and plain management while focusing on the establishment of good drainage systems and forest protection, the capacity and occurrence of catastrophic floods can also be fully mitigated and prevented (Murnane, 2004). Climate change and drought affect all regions of the world. It is not only a climatic feature, but also a temporary condition caused by water shortage, which can occur under almost any climatic condition. The definition of drought occurrence occurs when the rainfall is lower than the long-term average rainfall of a certain place in theory, and the location is very important (FAO, 2019).

From 2010 to 2017, different parts of the world were hit by drought, and agriculture, industry and Commerce posed great challenges. Climate change may lead to more frequent and severe droughts. In dry land, semi-arid areas, which usually have more population and more economic and social activities, are more affected by drought. Based on the analysis of historical drought trend, there are significant regional differences in drought and its impact (IPCC, AR5, 2014). The international food and Agriculture Organization (FAO) said that compared with the global food price crisis from 2007 to 2008, the global food production prospect is optimistic and the food situation is better, which has become a new problem of food access. The price is low, the inventory is high, there are many import and export countries, and the trade base is broad. Due to the "covid-19" incident, the economic growth rate dropped sharply, which restricted people's ability to obtain adequate and nutritious food. Policymakers should be prepared for similar global crises and gain more experience and insight ahead of time. At present, the covid-19 pandemic has also led to the loss of researchers, the closure of many research laboratories, the cancellation of many global research conferences and the reduction of direct contact between researchers, which has partially destroyed the existing agricultural and food research system. (Capell et al., 2020; Tokel et al., 2021).

In different regions and countries, there are great differences in planting system and agricultural technology use. Under the premise of international exchanges, new agricultural technologies and reforms have been widely spread all over the world. The socio-economic, agronomic and technical challenges faced by agricultural measures are due to the limited cost and lack of skills, which are known as socio-economic barriers. There are many technical barriers, including machinery, sensors, GPS, software and remote sensing. However, the adoption of precision agriculture and other measures will gradually eliminate the obstacles encountered, which will play an important role in the future agricultural system (Robert, 2002). However, in recent years, the introduction of high-tech technologies, such as automatic fertilizing devices, autonomous agricultural machinery and a series of computer software for managing various production systems, has generally taken effect everywhere (Gebbers and Adamchuk, 2010). Of course, precision agriculture is a promising form of agriculture (Mulla and Khosla, 2015). These advances in agricultural modernization have also brought many benefits to farmers, including increased productivity and the resulting profitability, farm quality, clean environment, food safety and sustainability, and households and consumers who may be affected globally. At present, the main challenges are to take measures to identify new approaches to crop diseases and pests, reduce pesticides and agricultural practices and activities harmful to humans and the environment, and redesign agricultural management models in the information age (Nyaga et al., 2021).

At that time, more than 840 million people are suffering from malnutrition, of which Africa and South Asia account for a high proportion. Around the world, most of the 1.3 billion people who are engaged in agriculture live on less than $1 a day. The worry is that the rate of degradation of natural resources is accelerating (Alex, 2001). Although it is too early to assess the full impact of the blockade and other containment measures, the report estimates that at least 83 million people, and possibly as many as 132 million people, will starve in 2020 due to the recession triggered by the covid-19 (FAO, IFAD, UNICEF, WFP and WHO, 2020). The map of hunger 2020 depicts the prevalence of malnutrition in all countries in 2017-2019 - if current trends continue, by 2030, the number of starving people will reach 840 million (WFP, 2020). "Green Bay crops" are mainly common garden vegetables, as well as potatoes, some oats and spring wheat. People on the grassland grow many small grains, such as wheat, barley, oats, potatoes and onions. Grain was one of the most important commodities in the trade between eastern Mediterranean and western city states in the first half of the 14th century and the 15th century. Food is vital to survival and an important part of trade. International trade was the focus of the early construction of the Ottoman Empire. The trade relationship between European merchants and Muslim merchants is discussed from the development of the Ottoman Empire in 1300 to Constantinople in 1453. The economic development of the early Ottoman countries and the expansion of Ottoman territory provide a rare insight into their economic aspirations and eventual integration into the Mediterranean basin economy, and clarify the close relationship between Muslims, agriculture and trade (Kate, 1999). White settlers in fur trading villages grow gardens in the hope of feeding their own farmers and trading any additional agricultural products (Apps, 2015).

In 1994, the first genetically modified food approved for marketing was yellow tomato, which successfully inserted an antisense gene delaying ripening and had a longer shelf life. By 2000, transgenic crops such as potato, Bt corn, Bt cotton, glyphosate tolerant soybean and golden rice have been completed (James 2011; Tokel et al., 2021). Advances in biotechnology have created contradictions on a wider range of social, ethical, religious and economic issues. Many environmental organizations and consumers are strongly concerned about the direct and long-term effects of genetically modified organisms on human health. At the same time, environmental risks, such as the reduction of biodiversity, the spread of super bacteria, gene leakage and agricultural sustainability of genetically modified crops, were emphasized (RAFI, 2000). The area of genetically modified crops in the world increased from 1.7 million hectares in 1996 to 52.6 million hectares in 2001. In 2001, the United States (35.7 million hectares), Argentina (11.8 million hectares), Canada (3.2 million hectares) and China (1.5 million hectares) planted 99%. Transgenic companies began to invest a lot of money in the research and development of transgenic crops and determined to expand the transgenic market. Biotech crops have been commercialized for 22 years. In 2018, 17 million farmers in 26 countries planted 191.7 million hectares of biotech crops. Compared with 1996, the planting area of 191.7 million hectares in 2018 increased by about 113 times. Therefore, the fastest crop technology in modern agricultural history is considered to be Biotechnology Crops (ISAAA, 2019).

Farm classification is the process of classifying each census farm according to the main production types. This is achieved by investigating the potential revenue from crop and livestock inventories to estimate and identify the products or product groups that account for the majority of the estimated revenue. Total agricultural revenue includes all agricultural sales, programs and refunds, sales Committee payments, tax rebates for goods and services, customs revenue, cooperative dividends, and agricultural product revenue. The renewal and innovation of agriculture promote the development of new markets and the opportunities brought by new technologies (Planscape, 2003). The innovative approach to food supply is an iterative cycle, including the design and construction of target genotypes (using plant biotechnology equipped with advanced genomics and gene editing) and the production environment (the most cost-effective engineering environment). Sustainable and reliable modern agricultural production can be achieved regardless of the recurrence of challenges such as climate change or disasters such as pandemic (Pouvreau et al., 2018).

Although economic difficulties lead to low population growth rates in developed countries, the adverse impact of covid-19 on the global economy may also lead to new risks of accelerated population growth, thus greatly increasing food insecurity (Genc et al., 2020). Poverty is also a major factor leading to rapid population growth in developing countries (Van Bavel, 2013).

The environmental performance index 2020 ranks 24 performance indicators of 10 problem categories in 180 countries. The sustainable development of agricultural industrialization in ecological countries provides new employment opportunities for researchers, scientists, biotechnology experts, veterinarians, farm workers and development technicians. At present, the introduction of genetically modified organisms (GMOs) has attracted some attention, and the planting area of these organisms is expanding every year (Arvas and Kaya, 2018). The latest technological innovations in agronomy, transgenic plants, chemical pesticides and chemical fertilizers have accelerated the synchronous development and improved the quality and yield. Due to the increase of human population and food demand, genetically engineered plants and their products are obtained by using recombinant DNA technology, which is the result of technological development in the last 25 years (Arvas and Kocacalıskan, 2020).

Agrıculture and Industry

In recent decades, agriculture is characterized by a large number of purchasing inputs, which inevitably depends on the industrial sector. Industrial benefits of agricultural related enterprises have increased significantly, especially due to investment opportunities in post harvest processing of crops, such as food processing and exports (Satterthwaite et al., 2010). The impact of agriculture on production in the industrial sector has increased over time. Before the 1980s, the real GDP of the industrial sector was more flexible than that of the agricultural sector, and the relative importance of agriculture and industry was higher. Agriculture is an integral part of the process of industrial development, and the mutual promotion and development of industry and agriculture is a complete process. Agriculture contributes a lot to the whole industry, especially to the economy. For example, the role of industry in providing inputs to modern agriculture, especially after the green revolution, and in expanding the demand for wage products, need hardly be mentioned (Satyasai et al,. 1999).

The meat industry accounts for a high proportion of the world's food industry in many countries, which plays an important role in the global economy. The poultry (13.6 kg / year) were the largest per capita meat consumption in the world (Zocca et al,. 2008; Silva et al,. 2016). At the same time of consumer demand, refrigeration system is the key to obtain product stability and sensory characteristics, and prevent the development and change of meat ingredients, bacteria and microorganisms in the meat industry (Savell & Mueller, 2005). Slaughterhouses (EC, 2003) and meat processing industries (Ramı´rez et al., 2006a; Alcazar et al., 2012) consume 60% - 90% and 40% - 50% of cooling system power, respectively. Two thirds of the total energy cost of the meat processing industry is equivalent to the cost of electricity (HTC, 2009). According to the FAO meat price index, the average international meat price in 2019 is 175.7, which is 9.4 points (5.6%) higher than that in 2018 and 2.3% lower than that in 2018. Production of other meats, especially poultry, is on the rise, while import demand is surging. Increasing meat production and exports are the response measures of many meat producing countries, but the total global exports are still far below the level needed to fill the deficit, leading to the rising trend of international meat prices (FAO, 2020).

Society, manufacturing and food processing industries are facing technological and economic changes. Therefore, the whole food supply chain has been greatly affected. In order to meet the needs of consumers' healthy lifestyle, enterprises attach great importance to food. The necessity of survival in the fierce competition is to introduce market innovation into the food industry to further update, so large-scale research and exchanges were held. Many achievements have been made in this regard. The protection of agriculture is guaranteed by the international trade system under the GATT. In order to achieve the goal that a country's agriculture will continue to be the top priority sector of all countries and people, which can promote the creation of healthy societies, meet food needs and provide nutritional security. Agriculture not only contributes a lot to GDP, but also provides food, raw materials and fiber for industry (Galanakis, 2018).

People's food is based on products such as milk, cheese and yogurt, which are widely consumed all over the world. Milk is the world's largest consumer, but the milk of sheep, camel, buffalo, goat and other mammals is also being consumed. In November 2020, the United Nations Food and Agriculture Organization (FAO) dairy price index continued the upward trend in recent months, with an average of 105.3 points, up 0.9 points (0.9%) on a month on month basis, approaching the highest point in 18 months. The recent rise is mainly due to the steady growth of global import demand, which is due to the rising prices of butter and cheese, as well as the surge of retail sales in Europe. The milk market is disturbed by cowid-19. On the contrary, it is expected that the global milk production will increase by 1.4% year-on-year to 860 million tons in 2020 (FAO, 2020). Dairy products are important sources of protein and calcium, and play an important role in nutritional diet. Dairy industry has become one of the important sub industries of animal husbandry (Zocca et al., 2018). Many studies emphasize that dairy consumption in Europe, the United States and other parts of the world is the rate of energy consumption. Cheese manufacturing industry, for example, can be used to evaluate and measure the energy performance of the food industry (Nunes et al., 2014, 2015, 2016). The consumption of dairy products in China is on the contrary, and the per capita consumption of dairy products is lower in areas with higher population density (Silva et al., 2016). The new trend of the times will become an industry led information age. To provide a series of safe, healthy, nutritious, affordable and sustainable food for consumers and society is the main goal of agricultural products processing industry under the premise of introducing new technology and maintaining competitiveness. On the whole, a processing plant has the characteristics of limited resource utilization and serious corruption, so it is called agricultural products processing industry, so its use should be as efficient as possible. In general, due to the importance of agricultural products in the human food chain, the industry has changed agricultural products, including not only human food, but also animal feed. Due to the positioning between agriculture and consumer market, the agricultural products industry has its own independent characteristics, and the construction and development of sensitive raw material behavior and market organization (Zocca et al,. 2018).

Agricultural Trade

Agricultural trade has been covered by the general agreement on trade and tariffs (GATT), signed in 1946. In the bilateral aid, the share of production sectors including agriculture, mining, industry, tourism and trade policy continued to increase. (WTO, 2000). GATT and World Trade Organization (WTO) have promoted trade and innovation by reducing tariffs many times, combining discipline with basic principles, and reserving policy space to deal with important social issues. WTO disciplines will continue to promote trade and innovation in the digital world. In addition, the multilateral trading system provides certainty, promotes cooperation, and is flexible in dealing with new problems (WTO, 2020).

In the world agricultural development report, the main driving forces for growth in developing countries are divided into three categories, including agricultural economy (agriculture accounts for about 30% of GDP), transitional economy (agriculture accounts for about 19% of GDP) and urbanization economy (agriculture accounts for about 7% of GDP). In the transition and urbanization economy, industry and service industry are considered as the main sources of economic growth. Only in the first agricultural based economies, mainly in Africa, should focus on agriculture as the main driver of growth. In fact, agricultural and non-agricultural sectors are closely related in terms of inter sectoral demand (including intermediate input). Therefore, the focus of investment may need to take into account the indirect role of the agricultural sector in stimulating rural income growth (WTO, 2008).More and more attention has been paid to the distribution of trade income, so the dominant paradigm of international trade has been under considerable pressure (Kerr et al., 2019).

Agricultural trade is of great significance to the development of national economy, especially to employment and food security. It is controversial to bring agriculture into the rules of international trade. The export of agricultural products is very important, and the import is equally important to the food security of consumers in net food importing countries. Each country has the right to produce enough food, to protect vulnerable farmers, and to develop unique agricultural policies. So far, the approach taken by the international trading system has been to enhance the flexibility of multilateral and preferential trade agreements. Market access, domestic support and export subsidies are the three major agricultural agreements. Export subsidies will increase exports, raise domestic prices and reduce foreign prices. A price wedge equal to the subsidy value will be formed between the foreign price and the domestic price of the product. These measures need to follow standards to limit their impact on trade and production (Ralf et al., 2013).

Agricultural capital refers to the value of farmland, including agricultural machinery and equipment, buildings, livestock and poultry for agricultural operation. However, it does not include the value of existing agricultural inputs such as fertilizers, crops or seeds in the field or stored. Farmland includes all land owned as part of its business activities, including hay grazing or pasture, swamps, buildings and barns, summer fallow, woodland and arable land. The person responsible for the day-to-day management and decision-making of a farm or agricultural operation is referred to as "farm operator", and each farm reports up to three farm operators (Eurostat, 2018).

A major challenge for low-income countries is to design and expand alternatives to social protection for workers in the informal economy (Jansen and Lee, 2007). Formal employment is more important in middle-income countries, and there is often more scope for social protection for workers adversely affected by trade and related economic reforms. The time required to import and export goods is an important trade barrier. Trade liberalization provides business opportunities for companies that are able to export, and offers consumers access to cheaper and different goods through imports. However, these imports may compete with local production, and the local producers concerned may be under new competitive pressure.

New export opportunities and increased competition from imports will lead to the expansion of some activities and the reduction of others (WTO, 2008). In developing countries, the supply of exports and employment opportunities has also accelerated the pressure on agricultural trade. As a successful case of developing countries. Agricultural trade liberalization alone cannot create employment miracle. Similarly, agricultural trade liberalization should not be expected to have a significant negative impact on employment, but these successful strategies are based on agricultural trade. Many agricultural workers need to adjust these plans more reasonably to reduce their social security burden. Trade liberalization is to eliminate or reduce the restrictions or barriers to tariffs (such as tariffs and surcharges) and non-tariff barriers (such as license rules and quotas) on the free exchange of goods between countries. Trade liberalization can lead some developing countries to further increase the specialization of agricultural production. The migration from rural to urban is the concentrated embodiment of a country's population. Measures to promote urban integration may have a significant impact because trade reforms trigger or exacerbate such migration. In order to promote food security for new urban residents, more information and facilities on housing or employment opportunities can be provided, or suburban agriculture can be supported, including planting crops and raising livestock around the suburbs. Although the poverty rate of rural workers is very high and it may cause great difficulties to move from one job to another or from one place to another, reducing this difficulty is a lofty goal and may help to improve economic efficiency (David, 2013). The e-commerce and law reform programme of the United Nations Conference on Trade and development (UNCTAD) provides an opportunity for developing countries to conduct expert reviews of e-commerce legislation and to provide expert advice to policy makers on effective e-commerce laws. The areas covered by the scheme include consumer protection, cybercrime, data protection and privacy, intellectual property and electronic signature (WTO, 2020).

Where does the food come from? If past trends continue, expanding trade will not be the answer. Since the reform of agricultural trade, the world grain output has more than doubled, and the world grain trade has also doubled. Therefore, the share of food consumption in world trade remains around 10%. This shows that 90% of the world's food production is consumed on average in the producing countries. If this trend continues, it is clear that most of the growth in food production must come from the production systems of countries where new populations live (Alex, 2001). Sustained agricultural investment will inevitably have positive side effects on the agricultural industry, as Z manufacturing (such as food and beverage) shows. The agricultural sector is likely to play a greater role in the global economic integration. In populous developing economies such as India and China, per capita income and food demand are also growing, indicating that the agricultural sector has considerable expansion potential. The agricultural sector has always been the foundation and component of the world economy and development. It plays a role in providing food and raw materials to the domestic market, absorbing domestic labor and capital, and generating export income. It also supports manufacturing and services. However, when formulating effective and up-to-date policies on agricultural trade and sector linkages, the impact of trade on agricultural value added and the spillover effects of agriculture on the world economy and other sectors deserve further analysis. The conclusion is that policy makers need to seriously consider new agricultural policy initiatives to bring the agricultural sector closer to other sectors such as tourism services (Gani, 2018). In fact, in many of the world's economies, the trade and agricultural sectors have been the main areas of research. If a country wants to be strong, it must rely on itself to develop agricultural economy and ensure ecological and nutritional security.

CONCULUSION

In order to promote "modern agriculture" and overcome "challenges", it is necessary to further strengthen agricultural scientific research. On the road of common development of agriculture, industry and commerce, we should first prevent and avoid food shortages, disasters and conflicts. Secondly, we need to find new methods of international trade competitiveness and obtain the growth of agricultural production level; at the same time, we need to realize sustainable development. We should learn from the past experience that no matter how many problems there are, solutions should be given priority. The problems are not insurmountable but it uses modern agricultural methods to get through them. A comprehensive survey of the challenges facing today's agriculture, such as covid-19, population growth, changes in eating habits, destruction of seed resources, shortage of water resources, air pollution, climate change and changes in food prices, shows that it is the common responsibility of all countries to invest the most in solving these problems. In addition, floods and droughts continue to affect the growing season of crops, limiting water supply, increasing the growth of weeds, pests and fungi, and reducing crop yields. With the simultaneous development of food security and industry and commerce, we need to completely change all social production and consumption patterns. To protect and strengthen the reserve of natural resources, maintain and improve the quality and efficiency of sustainable grain and modern agricultural production through the innovation and competitiveness of agricultural modernization system, is one of the main focuses of modern agricultural development policy. Although many studies emphasize the potential of traditional agriculture, the machinery and technical facilities in the agricultural sector, as well as the relationship between supply and demand, are changing rapidly. Today, for example, genetically modified plants have reached a huge commercial scale. The technology of artificial meat is more and more popular. I hope this product can be launched as soon as possible. The greatest hope for meeting the challenge of sustainable agricultural development lies in the ongoing innovation process, which uses modern genes and information technology to improve agricultural productivity, while balancing the economic, health, environmental and social outcomes related to agriculture and food systems.

Great changes are taking place in the face of agricultural modernization. The innovation practice of traditional industries is speeding up the improvement of new products. Especially in urban areas, people are more and more interested in innovative food and natural products. They are opening up new markets and opportunities. Agriculture is one of the oldest commercial forms of industrialization. At the end of the 20th century, from the beginning of "Green Industrial Revolution", agricultural production based on cultivated land, planting plants and raising animals has become an important part of national economy in developing countries. Since then, agricultural industrialization has continued to grow, including the production, supply, sales and export of agricultural products. The industry has become an important industry in India, Africa and other ecological countries. Ecological country's goods and services, laws, guidelines and policies are environmentally friendly, also known as eco-friendly, nature friendly, or green, which means that the practice is sustainable, reducing or minimizing the damage to the ecosystem and the environment. Being eco-friendly helps to save water, energy and other resources and prevent air, water and land pollution. Environmental performance index (EPI) is a method to measure a country's policy environmental performance.

Human safety is directly proportional to food safety. As a human standard, it needs to be divided into the material and spiritual supplements. The development of an economy is in direct proportion to the support of economic investment. The only barrier to economic integration is the existence of interest. The development of an agricultural economy is also the development of trade and industry. If covid-19 prevents low-income countries from getting rid of poverty and further promotes agricultural modernization, otherwise population growth may be higher than previously predicted, which will bring greater pressure on food security, trade and industry.

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FACTORS EFFECTING INCREASE OF CROP PRODUCTION

Due to the interaction and feedback among the basic components of atmosphere, ocean, ice sheet, biosphere and energy from the sun, the climate system can remain stable for thousands of years. The analysis of ice cores and other ancient thermometers (such as tree rings and coral cores) shows that the harmonic between the tilt and eccentricity of the earth's six orbits around the sun controls the oscillation of the earth's climate between the glacial and warm periods. Until the 20th century. According to all the studies reviewed by the Intergovernmental Panel on climate change (Albritton et al., 2001), to explain the global warming approaching 1 °C in the 20th century, it is necessary to cite the accumulation of greenhouse gases (carbon dioxide, nitrogen oxides, methane and chlorohydrocarbons (CFCs) in the lower atmosphere (or troposphere), about 10 km. In fact, the cooling trend of the past 1000 years has reversed (Mann et al., 1998). In the past 420000 years, carbon dioxide (CO_2) in the troposphere has been kept in the range of 180 to 280 ppm according to the measurements of the Vostok ice core in Antarctica (Petit et al., 1999). Today, oxygen is 366ppm, which exceeds the rate of change observed in ice core records (Albritton et al., 2001). The reduction of carbon dioxide in the ocean and on land may have played a feedback role. Today, the burning of fossil fuels (oil, coal and natural gas) is producing carbon and other greenhouse gases, leading to their accumulation. The decrease of forest coverage accounted for 15-20%

of the increase (Houghton et al., 1996). Global warming is not static. In winter and at night, the warming rate is twice as fast as the overall warming rate (Easterling et al., 1997), which is a key driving factor of biological response; in high latitudes, the warming rate is faster than that in the areas near the theme (Houghton et al., 1996). In addition, the heat in the world's oceans is increasing, reaching 3 kilometers (Levitus et al., 2000). The result is measurable changes in the hydrological cycle. The oceans are warming, sea ice and ice shelves are melting, and water vapor in the atmosphere is increasing (Trenberth, 1999). In addition, there is now clear evidence that the climate system is unstable, as extreme weather events such as long-term drought and rainstorm events (> 5 cm / day) increase in intensity and frequency (Easterling et al., 2000). Agricultural areas are moving northward, but not as rapidly as major pests, pathogens and weeds, which consume 52% of the world's growing and storage crops in today's climate (Rosenzweig et al., 1998; Rosenzweig et al., 2000).

Although climate change and global warming were regarded as a serious environmental problem by scientists in the early 1970s, these predictions began 120 years ago (Weart, 2008). Global warming is the most obvious and harmful consequence of human activities, which has the most serious impact on agricultural production. The estimated results show that by the 1980s, climate induced agricultural productivity had decreased by 16% globally (20% in Turkey) (Cline W.R., 2007). However, the food and Agriculture Organization of the United Nations estimates that the food demand of the world population will increase by 70% in the next 40 years, and the growth in developing countries will be more obvious (FAO, 2006).

Under the special circumstances of the pandemic of covid-19, the preliminary assumption in The Outlook| discusses the possible macroeconomic impact of the epidemic on the agricultural market in the short term. As agriculture and the overall economy are expected to recover in the next decade, the forecast for the next few years is consistent with the basic economic drivers and trends affecting the global agricultural market. Therefore, the short-term impact of the pandemic on agriculture and fish markets will not change the medium-term benchmark scenario (OECD and FAO 2020). The agricultural sector, including crops, livestock, forestry, fisheries and food processing, will, as always, play an important role in the transition to a green economy today and in the future. Agriculture uses 70% of the world's fresh water, farmland, pastures and forests account for 60% of the land, and the whole sector provides livelihoods for 40% of the world's population. The production process of agricultural sector is highly dependent on natural resources, which not only causes environmental harm, but also brings environmental benefits. While current practices account for more than a third of global greenhouse gas emissions, good management practices can lead to a nearly carbon free sector, the creation of environmental services and renewable energy, while achieving food security. The agricultural sector can also be an engine for economic development and the creation of millions of green jobs, especially in the poorest countries. Therefore, there is no green economy without the agricultural sector. At the same time, food and nutrition safety must be realized as an integral part of green economy. This is because food and agricultural systems are threatened by climate change, resource degradation and poverty. This is exactly the problem to be solved by the green economy. Only an economy that can improve human well-being and social equity, while significantly reducing environmental risks and ecological trauma, can provide food security for more than 9 billion people in the resource poor world by 2050 (FAO, 2012).

About 1 billion people starve and about 1.7 billion are overweight and obese due to micronutrient malnutrition (WHO, 2011). Organic products should provide high quality nutrition, which is conducive to the physical and mental health of consumers. Therefore, improving variety nutritional quality is one of the main goals of organic crop breeding (Zdravkovic et al., 2014). However, increasing crop yield and improving nutritional quality are often contradictory goals. In fact, although crop yield has increased significantly in the past 100 years due to the intensification of agricultural measures and intensive fertilization. This process is often accompanied by low concentrations of primary and secondary nutrients, proteins and secondary metabolites in agricultural products, which is called "dilution effect" (Simmonds, 1995).

Domestication and improvement of crops can be said to be a process of successive rounds of selection, which eventually leads to the isolation of valuable genetic diversity from the wild species of ancestors. These successive rounds of selection produce crops on which the world depends for survival, but at the cost of reducing their genetic variation so that their allelic diversity is lower than that of their wild ancestors and crop wild relatives (CWR) of other plants (Ross Ibarra et al., 2007; Van Heerwaarden et al., 2011). This is often referred to as "domestication bottleneck". Useful genetic traits span breeding barriers, expand genetic diversity of domesticated plants, and open up new opportunities for environmental resilience and future quality and yield growth (Hammer, 1984; Tanksley and Mccouch, 1997). The reduction in genetic diversity during domestication is exacerbated by the need for high crop productivity and consistency between field and market crops. The unexpected result of recurrent selection is the screening of potentially valuable genetic variations and phenotypes from the crop gene pool. Many of these traits, from disease resistance to drought tolerance, and even yield related traits, remain in the CWC. Gene flow or adaptive introduction of CWR during domestication is the source of additional genetic diversity in some crops (Hufford et al., 2013; Sawler et al., 2013). Breeders also try to restore some of the beneficial genetic diversity lost in domestication and crop improvement by crossing cultivated varieties with wild ones. This "pre breeding" attempts to reset the genetic diversity of crops by reintroducing genetic variation. In fact, previously unavailable genetic diversity is also used for pre breeding due to genetic incompatibility or geographic overlap (Cooper et al., 2001; Dwivedi et al., 2008; Ogbonnaya et al., 2013).

Cases dating back to the early 18th century documented the use of wild species to transfer resistance to crops. A century later, commercial varieties were developed using wild species (Prescott et al., 1986). Until the 1970s and 1980s, despite the increasing use of wild species in crop improvement programs around the world, there was little concerted effort in the crop research community to share progress, best practices, limitations and opportunities in the use of chemical weapons. Similarly, efforts to systematically assess the usefulness of wide diversity of specific CWR species are rare (Warschefsky et al., 2014). The review identified some potential constraints for achieving a more coordinated and systematic use of wildlife for crop improvement. Significant progress has been made in overcoming the challenges posed by the use of CWS in crop improvement. The ongoing basic and applied research will undoubtedly further promote their use in the next few years. At the same time, in order to make progress, a number of challenges in the defined prebreeding process need to be addressed. In particular, strategies aimed at enhancing coordination among actors in terms of pre breeding continuity will facilitate the sharing of characteristics and evaluation data, as well as raw genetic materials stored in gene banks and more advanced materials being developed. Important elements of strategies to improve the pre breeding process may include the selection of common parents for introgression lines, systematic and coordinated evaluation of pre breeding materials at multiple locations, the establishment of feedback mechanisms for screening data, and data management and sharing plans (Dempewolf et al., 2017).

This synthesis is the result of various efforts to collect experts and literature on the past uses and future potential of chemical weapons. It extracted common themes from a series of consultations coordinated by the Global Crop Diversity Trust from 2011 to 2013. These organizations bring together taxonomists, conservation experts, genomics experts, breeders from the national agricultural research system (NARS), breeders from the CGIAR crop improvement program. The private sector to discuss the latest progress and bottlenecks in breeding and breeding, as well as possible future strategies. In addition, targeted interviews were conducted with another group of experts in 2014. An in-depth review of the use of coal water slurry was conducted to document and classify past and potential uses of coal water slurry. CWR in various crop improvement programs did receive attention (Hoyt and brown, 1988).

Mining biodiversity to ensure food security will be achieved through three steps. The first step is to obtain sequence information samples from the genomes of all non repetitive plant samples in the world gene bank. This "fingerprint" of each plant will serve as the basis for assessing genetic relationships and make it possible to systematically select a subset of materials for in-depth study. Secondly, phenotypes of gene pool materials need to be analyzed to evaluate their traits and overall performance. The third key step is to establish an internationally accessible information infrastructure to catalogue the diversity of the world's seed collections. This will link seed and gene banks directly to passport, genome and phenotype information, thus stimulating the creativity of geneticists and breeders, and providing impetus for plant improvement in the next few years(McCouch, 2013).

New technology of genetic engineering in recent years, a new set of genetic engineering technology, the so-called "new breeding technology" (NBT), has emerged in plant breeding. In particular, Clustered Regularly Interspaced Palindromic Repeats (CRISPR)/CRISPR associated protein (CAS) (Jinek et al., 2012) has great potential, it is not only more accurate and reliable than previous genetic engineering technology, but also cheaper to use. Since some NBT can be used to induce genetic modification, which cannot be found in the final product, it is important to consider whether to consider NBT as a genetic engineering technology has been a political debate. However, the organic sector has a clear position on this issue, from the perspective of the organic sector, technology or process should always be evaluated in a process rather than a product oriented framework (Nuijten et al. 2017). For example, organic products are certified according to the specific characteristics of the farming process rather than the final product. Therefore, the organic sector believes that crops derived from NBT should be defined as genetically modified crops and that mandatory risk assessment should be carried out. Whether NBT is allowed in organic crop breeding is still a problem. Nuijten et al. (2017) summarized the organic sector evaluation guidelines for new breeding technologies in a comprehensive analysis, and concluded (Wickson et al., 2016) that NBT application does not conform to the principles and values of organic agriculture, because they have been included in International Conference on Organic Animal and Plant Breeding (IFOAM) position papers (2014, 2016) and EU organic plant breeding (ECO Pb, 2015).

New technologies need to be evaluated in accordance with a series of interrelated principles of agricultural ecology, socio-economic and ethical (Verhoog, 2007; Nuijten et al., 2017). Genetic engineering and NBT do not conform to these principles at all three levels. NBT is not in line with the ethical principles of organic agriculture, which protects the basic integrity of organisms (Lammerts van bueren et al., 2003).

In organic agriculture, the autonomy, self-organization level, integrity and dignity of all life entities are endowed with their intrinsic value. Therefore, the breeding technique of interference at the subcellular level is not considered suitable for organic crop breeding, because the cell can be regarded as the lowest level of self-organizing life. Another organic agricultural ethics principle that NBT does not comply with is the nursing principle or the prevention principle (Nuijten et al., 2017). Because of its overall world view, organic sector has different risk perception compared with other sectors of society. Adverse side effects, including environmental and health risks, are considered inherent in reductionist approaches, such as gene editing techniques that interfere at the single nucleotide pair level. In addition, the application of NBT is incompatible with the principles of Agroecology and socioeconomics of organic agriculture (Verhoog, 2007; Nuijten et al., 2017). One of the main concerns of farmers in the field of genetic engineering and seed preservation is the inherent intellectual property rights of farmers. Other problems include the pollution of genetically modified organisms and the limited choice of breeders, farmers, processors and consumers. There is an urgent need for alternative perspectives and development approaches in organic crop breeding (Nuijten et al., 2017; Ceccarelli, 2014).

Since the beginning of the industrial revolution, the impact of human activities on natural resources has been increasing (Steffen et al., 2007). In recent decades, these activities have intensified dramatically, which may change the ecological function of the earth in a way harmful to many parts of the world. The concept of "planet boundaries" is a framework to determine the threshold of indicators for monitoring different earth system processes. In other words, it establishes a safe operation space for human beings. Therefore, in order to ensure the scope of future safe operations, human beings must limit the impact of their activities and recognize that crossing these planetary boundaries may lead to sudden changes in the earth system. This will have a negative impact on the ecosystem and damage the further development of human beings. The process of climate change, the rate of biodiversity loss and the nutrient cycle of nitrogen in the earth system have crossed their boundaries, while the global freshwater use, the nutrient cycle of phosphorus, land use change and ocean acidification will soon reach their boundaries, trying to meet the needs of the global population of about 9 billion in 2050 (Rockström et al., 2009a). However, the boundaries of these planets are not fixed. In terms of development, they reflect the actual efficiency of the utilization of the earth's resources. Therefore, they are closely related to the sustainability of land, water and agricultural management and production technology. Population and income growth are the main driving forces of food production and demand. These levels of demand can be met through the use of knowledge and technology to manage supply. Crucially, this provides an intervention point that focuses on the ecosystem's ability to meet global needs if the appropriate management structure can be undertaken (FAO, 2012).

Under the current management system, the planet boundary of the above-mentioned earth system processes has been reached, or is about to be reached, because the human demand for natural resources is far from decreasing. The current and future scenarios of resource utilization show that resources such as land, biodiversity, energy and nutrition will face greater pressure in the future, which will further widen the actual gap. In the future, the environmental constraints set by the earth's boundary will aggravate the shortage of natural resources (Freibauer, 2011). In general, the current situation of resources and their scarcity, the actual constraints on the supply and availability of these resources, and the impacts of pollution, biodiversity loss and climate change all result in environmental constraints. At the geographical level, the scarcity of nutrients, water and agricultural land varies greatly. In particular, the nutrient cycle (P, N) is obviously unbalanced on a large regional scale. One resource may also be scarce in some parts of the world, while in others, overuse of the same resource can cause pollution. The carbon cycle is characterized by large differences between the northern and southern hemispheres and between winter and summer. The main challenge now is to rebalance the cycle from a situation characterized by large-scale degradation of agricultural systems at risk (FAO, 2011b).

The relationship between agriculture and drought affects the global food system and faces major challenges. Crop yields need to be substantially increased in order to ensure adequate food supplies for the growing world population. In the past 15 years, the world population has increased from 6 billion to 7.5 billion. According to the United Nations (2015), the world population may increase to about 10 billion by 2050. The total output of the three major food crops must double in the next 35 years to meet the food needs of these populations. Only by adopting effective farming methods, providing more land for crops and developing high-yield varieties, can such yield increase be achieved (Schaffnit Chatterjee et al., 2010). First, it is a "biotechnology method" that relies on cell culture technology and intelligent breeding methods using markers and advanced reproductive technology for selection (Lammerts van bueren et al., 2010). Next, there is a broader approach to genetic engineering, using different technologies that directly affect DNA. In recent years, due to the so-called "new breeding technology" and new genetic technologies such as CRISPR / CAS technology, the potential and risk of this method have greatly expanded (Jinek et al., 2012). Finally, the "integrated organic" approach is expected to maximize average crop yields in an environmentally sound way. Interventions at the subcellular or genomic level are not allowed for organic crop breeding (IFOAM, 2014).

Simple technical solutions to complex problems are proposed, often without taking into account the broader socio-economic, political and legal context (FAO, 2015). Apart from new breeding methods, other factors, such as proper food waste management and the reduction of world meat consumption, have not been fully considered, as nearly one third of food production in developed countries has been lost (Gustavsson et al., 2011), and about one third of agricultural land is used for animal feed production (Alexandratos and Bruinsma, 2012). In addition, privatization of water, soil, and seeds limits access to these factors for many and exacerbates global inequality (Rulli et al., 2013).

In order to meet the challenges of food security, food security and food sovereignty in the future, systematic reform of the agricultural sector is needed (Kiers et al., 2008). Despite these findings, multinational seed and pesticide companies have proposed genetic engineering as a panacea for solving world hunger and agricultural problems. Therefore, a prominent focus of these companies is to develop herbicide resistant crops, so that farmers can kill weeds in the field without harming the crops. But the benefits of encouraging widespread use of herbicides are related to environmental costs and health. In general, genetic engineering has brought inestimable systemic risks to natural and agricultural ecosystems. Therefore, this technology does not conform to the principles of organic agriculture (Jacobsen et al., 2013).

In addition to the nutrition gap, another major challenge for agriculture will be climate change. Its influence ranges from changing precipitation patterns and more extreme weather events to different and multiple pest pressures (Lamichane et al., 2015). Agriculture is very important for human survival and social development. With the growth of world population and economic development, the demand for agricultural products is increasing, which brings great pressure to agriculture and natural resources, and then causes environmental pollution and ecological degradation. Agricultural sustainability has become a key issue in the sustainable development of complex socio-economic natural system. Climate change, natural disasters and food production are complex issues. In the past few decades, global warming has been the main cause of global climate change, which is related to the annual seasonal change in a certain geographical area over a period of time. This seasonal change is related to carbon dioxide and other greenhouse gases produced by various anthropogenic sources such as industrial development, urbanization and land use. Climate change related issues have always been one of the main concerns of local and international environmentalists and the scientific community, because climate change will change rainfall patterns, humidity, sea level, irregular seasons, floods, droughts and storms, resulting in obvious and worrying consequences. Land flooding is another serious threat caused by global climate change. In recent years, great achievements have been made in increasing grain production all over the world, but great losses have been caused to natural resources and environment. This poses new challenges to sustainable agriculture. At present, the concept and principle of agricultural sustainable development have been incorporated into sustainable development strategy and economic and social development plan, and expressed. The basic goals of agricultural sustainable development are food security, employment, natural resource protection and environmental protection, which are generally accepted at present. Its main components can be summarized as the sustainability of agricultural production, rural economy, agricultural ecosystem and rural society. Because the main function of agriculture is to provide food for mankind, it is reasonable that the primary goal of sustainable agricultural development is to provide enough food for present and future generations. In recent decades, with the improvement of people's living standards and the sustained economic growth, the demand and quality of grain are increasing rapidly. The potential of agricultural production increase is mainly restricted by the extreme shortage of water and cultivated land resources, low productivity, low efficiency of agricultural policies and management systems, and soil degradation. Therefore, the most concerned problem in the sustainable development of modern agriculture is whether agricultural production can ensure food security in the future.

Because hundreds of farm animals are crowded together, factory farms will cause a series of pollution problems. This affects the natural environment and the animals and plants that inhabit it (CDC, 2011). In 2006, the food and Agriculture Organization of the United Nations (FAO) described animal husbandry as "one of the most important factors causing the most serious environmental problems today" (FAO, 2006).

More traditional farming methods can be relatively effective in turning grass and other waste into useful food. But the efficiency of "rapid growth, high-yield" factory farming mode is much lower, it uses a lot of grains and protein rich soybeans. These crops usually need a lot of insecticides and fertilizer rich in nitrogen and phosphorus to promote the growth of plants (Greenpeace, 2017). This has obvious uses to help us achieve higher plant yields, but a lot of fertilizer can be wasted and lost to the environment (PC, 2008).

Farm animals produce a lot of nitrogen and phosphorus rich waste every day. That could be a good thing - animal waste can be a useful fertilizer to replenish the soil. But on factory farms, the concentration of animals indoors usually means that waste is concentrated in relatively small areas. These wastes should be properly managed and disposed of, but this is not always the case, they can enter the natural environment (USEPA, 2011).

Nitrogen and phosphorus can cause serious problems: they can leak into waterways, for example. This can kill plants and animals and even leave large "dead zones" where few species can survive. Some of the nitrogen will also become gaseous and ammonia, such as (EIP, 2011), which can acidify water and deplete the ozone layer. We will also be directly affected as the quality of the water supply may be threatened (USEPA, 2011).

Factory farms produce more than dangerous levels of nitrogen and phosphorus - they produce a mixture of pollutants, including pathogens such as Escherichia coli (NRDC, 2001), heavy metals and insecticides 18, which can harm our health and the health of other animals and plants. Some large farms produce more waste than the population of big cities in the United States (GOA, 2008). Animal husbandry accounts for more than 60% of global ammonia emissions (FAO, 2006). Animal husbandry is one of the most destructive sectors to the earth's increasingly scarce water resources. It causes water pollution from, among other things, animal manure, antibiotics and hormones, tannery chemicals, fertilizers and pesticides used to spray feed crops (UN, 2010).

Because a large amount of feed is used in factory farming, a large number of other resources are needed for planting. One is land, which is much more needed to produce meat or dairy products than vegetables, grains or fruits (AJCN, 2003). There is also water, which is often used to irrigate crops, especially those grown in countries with low rainfall. According to WWF data (WWF, 2008), livestock production accounts for about 23% of total agricultural water consumption - equivalent to more than 1150 liters per person per day. In addition, a large amount of energy is needed, especially for the production of synthetic fertilizers and pesticides for growing feed crops. In addition, these pesticides and fertilizers require a lot of valuable resources, such as nitrogen and phosphorus. Many of these resources can be better utilized, such as helping us grow enough crops to meet the needs of the current world population.

The term "peak" is used to refer to a range of non renewable resources, such as oil and phosphorus (Nature, 2009), both of which are largely used in industrialized agriculture. In essence, this means the time when the availability of resources reaches the peak and the supply begins to decrease. Although people have different opinions on when these materials will be used up, the simple reality is that one day, we will not be able to obtain some of the materials that the industrialized aquaculture food depends on. Since these materials are now found in a limited number of countries, there are significant geopolitical risks for net importers (SEI, 2004).

It is essential to prevent and avoid the destructive effects of current food production practices on human health, food security, rural livelihoods in the poorest countries, endangered species, animal health and the environment, promote the formulation of unified food and agricultural policies, and solve global problems.

This study provides a theoretical basis for solving the technical measures and progress of agricultural development. The key difficulties are provided from the aspects of soil, nitrogen, crop root system, drip irrigation, the relationship between crop development and temperature and photoperiod. The structure and function of farmland biodiversity, the adaptation mechanism of crops to climate change, crop improvement continuum, the collaborative improvement of grain yield and quality, the comprehensive regulation of dryland Crop Root System and the diagnosis index of crop water shortage were discussed.

Climate change and variability

"Weather" and "climate" are different concepts. "Weather" refers to the atmospheric conditions experienced or expected in a certain place for several hours or days, while "climate" usually refers to the average performance of these atmospheric conditions in several years or decades. Weather refers to the instantaneous or short-term atmospheric conditions in a certain area, such as cloudy, sunny, rainy, snowy, cold, warm, dry, humid, fog, frost, lightning, etc. Although climate also refers to atmospheric phenomena, it is the average condition for many years, which is usually reflected by the characteristic values of temperature, precipitation, wind, sunshine, humidity and other climatic elements recorded by meteorological observation equipment. The weather changes rapidly and the law of climate change is orderly.

The change of the earth's atmosphere in decades to thousands of years is called "climate change". Although climate change may be caused by natural processes such as volcanic activity, solar change, plate tectonics or changes in the earth's orbit, we usually refer to changes that can be attributed to human activities, such as increased greenhouse gas emissions, when talking about climate change. The assessment report of the Intergovernmental Panel on climate change (IPCC, 2013) found that the global average temperature rose by about 0.85 ℃ from 1880 to 2012, and concluded that more than half of the global average temperature rise was caused by greenhouse gases caused by increased emissions of carbon dioxide and other pollutants.

Now through research, it can be determined that man-made climate change is real, and it poses a great threat to the earth and its residents. Current data show that we need to reduce greenhouse gas emissions in developed countries by at least 80% by 2050 in order to have the opportunity to keep the average temperature rise below 2 ° C. Modern agriculture is a major factor in coping with the challenge of climate change due to industrialization, which releases a large number of greenhouse gases (TRS, 2011).

Climate variability is an inherent characteristic of climate, which is closely related to climate change (Gibbs WJ et al., 1975). Climate change refers to a long-term trend of the change of the average value of climate elements; climate variability refers to the degree of oscillation of the average value of climate elements, that is, stability, which is usually expressed by mean square deviation. After climate change, the "new" mean values of temperature, precipitation and other climatic factors such as temperature increases by 3 °C, precipitation increases by 10% will have to determine the oscillation mode. This is one of the difficult problems that scientists have been exploring, but it is still difficult to answer.

There are many factors affecting climate variability, which can be roughly divided into three categories according to the size of time scale: one is the external force of the climate system; the other is the disordered fluctuation within the climate system; the third is the increasing human activities (Smith JB et al., 1989). On the maximum time scale such as 100000 years, astronomical factors galactic dust, solar storms, orbital parameters, etc., from the outside of the climate system have a great impact on the climate variability; on the large time scale such as hundreds to thousands of years), the changes within the climate system (atmospheric evolution, underlying surface, air sea exchange, etc., can significantly change the climate variability; In the decades or even shorter time scale, the change of climate variability caused by human activities has attracted the attention of governments and scientists all over the world. Climate variability can be divided into interannual variability and daily variability. The interannual variability is mainly affected by the external forces of the climate system (volcanic eruption, sunspot activity, etc.) and the changes of ocean surface temperature El Nino, southern oscillation, etc., while the daily variability is usually affected by the weather processes high and low pressure air masses, upper jet, etc. The intensified human activities have certain effects on the interannual and daily climate variability (Rosenzweig C et al., 1994). Climate variability is important because it is related to the frequency, intensity and duration of extreme weather events, such as drought, flood, typhoon, rainstorm, heavy snow, heat wave, cold wave, hail and other disastrous weather events, which do great harm to agricultural production. China is a typical country with continental monsoon climate. The occurrence of various weather disasters has the characteristics of inevitability, universality, regionality, non-equilibrium, accumulation and alternation (Zhang, 1998). In addition, for a long time, the agricultural ecological environment has been damaged to a certain extent due to the intensification of human activities, In recent years, the scope of disasters has been expanding year by year, and the frequency and intensity of disasters have been increasing. It can not be ignored that the number of disaster species is also increasing. For example, the high temperature and heat damage in Rice Heading and flowering period is a new disaster species with strong lethality, which is gradually emerging and becoming more and more severe in the

Yangtze River Basin in recent years. It can lead to large-scale "flower but not fruit" (abortion) of rice, which not only has more empty grains, but also greatly reduces yield, even leads to no harvest. The IPCC Assessment report points out that with the global warming, extreme weather and climate events will become more frequent and intense. Therefore, climate variability is one of the core issues in the study of climate change and its impact assessment. At present, the prevailing method to study the impact of climate change on crop production is to combine the Global Circulation Model (GCM) with crop growth model. GCM is one of the most advanced means for atmospheric scientists to study global climate change, which can simulate the impact of natural factors and human activities on complex climate system (Wang, 1994); crop growth model is based on the theory of crop physiological ecology, which can dynamically simulate climate, soil, genotype, cultivation management and atmospheric CO_2 The effects of concentration increase on crop growth and yield formation (Ritchie JT, 1986; Hansen J, et al.1988).

However, there are still two deficiencies in the existing studies. One is that when generating climate change scenarios, only the average changes of climate factors such as temperature, precipitation and solar radiation are considered, but the possible changes of climate change rate are not considered. The other is that in the crop growth model, only the normal climate is considered However, the response of crop growth to extreme weather events and disasters was not considered.

Therefore, the existing climate change and its impact assessment research is still not perfect, and there are still many uncertain factors.

A lot of work has been done to estimate the future climate variability, which can be summarized as follows.

(1) Statistical methods. Based on the climate data of a warm period (or cold period) in history, the quantitative relationship between the average climate change and the change of climate variability is analyzed. For example, Lough et al. (1983) analyzed the relationship between mean temperature, precipitation and climate variability by using the meteorological data of warm period (1934-1953) and cold period (1901-1920) in Europe in the 20th century. Although this kind of research found that there had been significant changes in climate variability in history, there was no significant correlation between them and the change of climate average. The cause of the short warm period (or cold period) is not clear, but it is certain that it is different from the current global warming caused by excessive emissions of greenhouse gases. Therefore, this kind of research cannot answer the question of how the climate variability will change in the future.

(2) Model method. In the 1980s, American scientists used the Goddard Institute of Space Studies model (GISS), and the National Center for Atmospheric Research model (NCAR) GCMS to analyze the possible changes of climate variability in four regions of the United States when CO_2 doubled. The main conclusions are as follows. The daily and interannual variability of temperature will decrease, and

the interannual variability of precipitation will increase. However, there are some inconsistencies between the results of the two GCMs, and the results are not statistically significant when compared with the climate change scenarios based on GCM. The daily variation rate of summer temperature will decrease. However, the simulation results of the two GCMS for other seasons are contradictory. Because there are still many uncertainties, scientists generally believe that there is no sufficient reason to change the assumption that the climate change rate in the future climate change scenario will maintain the current level. Therefore, when generating GCM based regional climate change scenarios, most studies assume that there will be no change in climate variability in the future, and then add the future warming amplitude of each region to the climate background data and multiply it by the change percentage of precipitation and solar radiation (Lough et al, 1983).

(3) Hypothesis method. A few studies have made some assumptions, such as the variability of temperature and precipitation will increase by 5% and 10% in the future, and then used the weather generator (WGEN) to generate scenarios (Jin ZQ, 2008) considering the future climate variability under various assumptions. But this method is still artificial and random. In order to improve the response ability of crop growth model to disasters, many scholars have established rice high temperature abortion model, wheat waterlogging model, wheat drought model, corn low temperature model and so on on on the basis

of artificial control experiments. And then it is nested with the crop growth model without considering disaster, and the preliminary effect is achieved. But this kind of research is not systematic enough, most of them stay in the paper stage, and have not been tested by production practice. The quantitative relationship between climate change and disaster frequency and intensity needs to be further studied. The main difficulties are as follows:

(1)It is difficult to predict the future climate variability based on historical climate data. There is an urgent need to understand the evolution mechanism of climate change in theory, and then develop and improve the climate change model, which requires a high-level talent team.

(2)At present, the global climate change faced by human beings is unprecedented in the cause and speed of change, but at present, all kinds of extreme weather and climate events are small probability events, because of the lack of data, it is difficult to deeply analyze.

(3)There is an unknown nonlinear relationship between the mean value of climate elements and the probability of extreme weather events. Even if the average value of temperature and precipitation changes little, the frequency and intensity of different disasters may increase significantly, and there may be different nonlinear relationships in different regions.

(4)In order to understand the response characteristics of different crops and varieties to various meteorological disasters in different growth periods under different planting systems, it is necessary to carry out a large number of prevention and control experiments and simulation experiments, establish key laboratories, and purchase instruments and equipment (Jin ZQ, 2011).

Different aspects of climate change, such as temperature, precipitation and their interactions, may affect crop growth and productivity in a disproportionate way. We classified the relationship between yield variability and normal or extreme fluctuations of temperature or precipitation variability or their interactions. Here, the linear term and the square term represent normal and extreme variations, respectively (Lobell, D. B. Et al., 2011; Rowhani, P. et al, 2011; Urban, D. et al., 2012) The "best fit" models of each political unit are divided into one of seven categories and then mapped on a global scale: in the model, production changes are explained by (I) normal temperature or (II) normal precipitation changes, but not both; in the model, production changes are explained by (III) normal and extreme temperature or (IV) normal and extreme precipitation changes, but not both (V) the change of yield is explained by extreme temperature or (VI) extreme precipitation, but not both; and (VII) the interaction between temperature and precipitation and their combination. We further developed simplified models of temperature and precipitation and mapped them in each political unit. The resulting global map identifies where and to what extent normal and extreme climate change explains yield change, and quantifies it, which can be used to study the causal relationship between yield and climate change, and ultimately take policy interventions to stabilize farmers' income and food supply (Ray, D. et al., 2015).

Uncertainty in future climate change prediction may come from three different factors:

1) model uncertainty uncertainty caused by differences between climate models,

2) scenario uncertainty caused by forced scenario differences, and

3) uncertainty caused by internal changes caused by unpredictable internal changes in the climate system. With the improvement of the model and our understanding of the future forced scenario, the uncertainty of the model and scenario can be reduced. The uncertainty caused by internal climate change comes from the chaotic nature of the climate system, and its unpredictable degree may be irreducible (Hawkins and Sutton, 2009).

The analysis model is based on three assumptions:

1) the internal variability is Gaussian distribution;

2) the characteristics of anthropogenic forcing in surface climate can be simulated as linear trend;

3) the standard deviation and / or autocorrelation of internal climate variability do not change with anthropogenic forcing. The robustness of the model to all three hypotheses is strongly supported by the following close similarities:

1) the uncertainty of the climate trend estimated from the statistical data of the non forced control simulation;

2) the uncertainty found in a large number of climate change simulations. To the extent that the hypothesis of the model is valid, the results show that the large set provides little information about the role of future climate internal variability, which can not be inferred from the statistical data of non forced control simulation. The analysis model also makes clear the direct relationship between the bias in model control simulation and the uncertainty in future climate change prediction. In the first mock exam of a given climate model, the amplitude of internal climate variability is biased relative to the observed value. The uncertainty of future climate change simulated by the same model is also biased (David W. J., 2015).

There are shortcomings in the observation of internal climate change and the estimation of climate model. Observations provide reliable estimates of internal climate change on intraseasonal and interannual time scales. However, this record is relatively short, thus providing limited insight into internal climate change on decades and longer time scales. In contrast, numerical models provide long-term records for estimating the magnitude of internal climate change. However, not only on the interdecadal time scale (Laepple and huybers 2014), but also on the interannual time scale. To some extent, imperfect observation records provide a more realistic representation of the real world than climate models. Therefore, it is better to estimate the role of internal changes in future climate trends, rather than through long-term control simulation or large-scale climate change simulation, but based on the observation and estimation of internal climate change (David W. J., 2015).

It is predicted that the speed and scale of climate change in the 21st century may have a profound impact on the operation of the earth's ecosystem (Garcia, R. A. et al., 2014). 7Much of the current understanding of how biodiversity responds to climate change is based on responses to changes in the average climate state (Thomas, C. D. et al. 2004). However, climate variability and the increase of extreme events in the warming world have a great impact on the structure and function of ecosystems (Holmgren, M., et al., 2013; Pederson, N. et al. 2014; Doughty, C. E. et al. 2015;). Given the importance of identifying ecologically sensitive areas for the provision of ecosystem services and poverty reduction, there is a key knowledge gap in how to identify and prioritize the areas most sensitive to climate change.

The speed and scale of climate change in the 21st century can be expected to have a huge impact on the operation of the earth's ecosystem (Garcia, R. A., 2014). Based on the response to the change of average climate state, the current understanding of how biodiversity responds to climate change (Thomas, C. D. et al. 2004). However, climate variability and its associated extreme events in a warming world have increased (Kharin, V. V. et al., 2007). This has different effects on the structure and function of ecosystems. Given the importance of identifying ecologically sensitive areas for providing ecosystem services on the one hand and poverty reduction on the other, there is a key knowledge gap on how to identify and prioritize the most sensitive areas to climate change. Finally, the mean and absolute values of variable conversion Piloting Climate Resilience (PCR) coefficients have been found, which provides an empirical method for mapping the relative importance of global climate to productivity. The climate weight of each variable is rescaled between 0 and 1 (using the minimum and maximum values of any climate coefficient value) for the calculation of ecological sensitivity. To estimate ecosystem sensitivity globally, we created a seasonal detrended time series (minus the monthly mean) of each variable for each pixel and period found to be associated with climate and the T-1 variable in our monthly principal component regression. We estimate the variance of climate variables and evi over these time series. Because we found the relationship between variance and mean in different months, we used the residual of quadratic linear model to fit the mean variance relationship between enhanced vegetation index (EVI) and climate variables in each pixel (Seddon, A., et al., 2016).

In addition to the conventional prediction of temperature, precipitation, sea-level pressure field, atmospheric circulation field, sea-level height, ice and snow, the prediction of global climate change also gives the prediction of cloud and diurnal changes, and also gives some important phenomena, including Arctic Oscillation, Antarctic oscillation, North Atlantic Oscillation, meridional reversal circulation, monsoon, ENSO, and some extreme weather And climate events, including extreme maximum and minimum temperature, length of cool summer, length of frost period, intensity of flood and drought, tropical and temperate cyclones, frequency and intensity of hurricanes and typhoons (Zhao, 2006).

The results of multi-mode and multi emission scenarios show that by the end of the 21st century, the global average surface temperature will increase by 1.1-6.4 ℃, and the global average sea level will rise by 0.18-059m. In the next 20 years, the temperature will be about 0.2 ℃ / 10A. Even if the concentrations of all greenhouse gases and aerosols are stable at the level of 2000, they will increase by 0.1 ℃ every 10 years. If the emission rate of greenhouse gases in the 21st century is not lower than the current level, it will lead to further warming, and some changes will be more significant than those in the 20th century (IPCC, 2007).

The fourth assessment report (AR4) of IPCC "climate change: basis of natural science" clearly points out that the linear change trend of global surface temperature in the past century (1906-2005) is 0.74 ℃. The linear warming trend in recent 50 years is 0.13 ℃ every 10 years.

Eleven of the past 12 years (1995-2006) were the hottest since 1850. There is no doubt that the climate system is warming. The report also points out that the warming of the climate system observed in the past 50 years is likely due to human activities. The IPCC Assessment report summarizes the comprehensive research results of peer review in the international scientific community, represents the current level of scientific understanding of global climate change research, and provides an important basis for the international climate system and relevant national policies.

The results of the fourth assessment report on the distribution of warming and other regional scale characteristics are more reliable than those of the third assessment report, including changes in wind field, precipitation, extreme events and ice. It is predicted that the warming in the land and high latitudes of the northern hemisphere is the most significant, while the warming in the Southern Ocean and the North Atlantic is the weakest (Fig. 1). The snow will shrink, the melting depth of most permafrost regions will generally increase, and the sea ice in the Arctic and Antarctic will shrink. The frequency of extreme heat events, heat waves and heavy precipitation events is likely to continue to rise: annual tropical cyclones, including typhoons and hurricanes, may be stronger, accompanied by greater customs and stronger precipitation. The path of the storm outside the tropics will move to the polar direction, causing the changes of wind, precipitation and temperature field outside the tropics. Precipitation in high latitudes is likely to increase, while water in most subtropical continental regions may decrease. Because various climate processes and their feedback are related to time scales, even if greenhouse gas concentrations tend to stabilize, anthropogenic warming and sea-level rise will continue for several centuries (Qin Dahe, 2007).

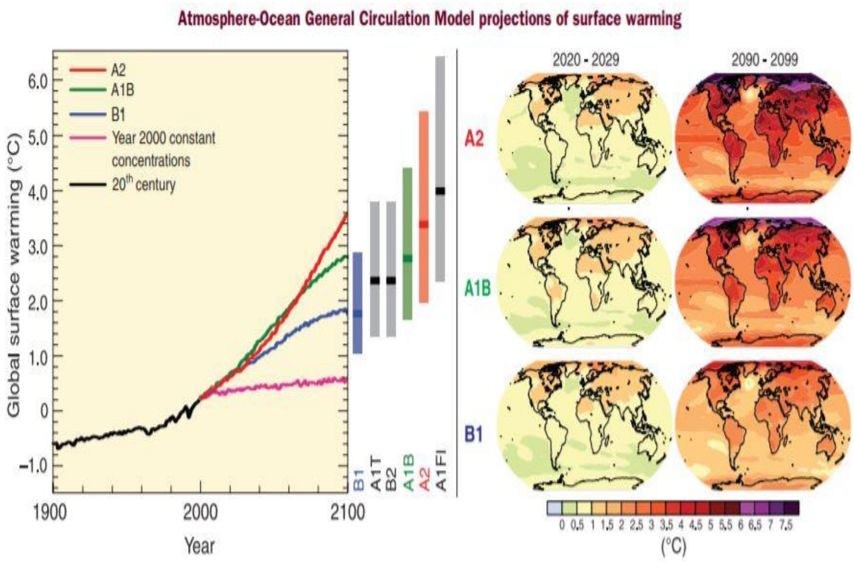


Figure 1. AOGCM projections of land surface temperature change in the early and late 21st century relative to 1980-1999 based on climate change prediction (from: IPCC)

Climate variation and change bring many challenges to plant breeders. In the past, considering the well-known abiotic and biological constraints and the quality of the final product, it was sufficient to develop a variety suitable for a specific agro ecological region. Now, however, breeders have to consider, in addition, how the variety will perform in environments with high concentrations of carbon dioxide and greater variations in temperature and water availability (Brettel, 2008). Climate trends suggest that in the future, crop varieties must be able to withstand not only dry or hot, but also more variable conditions. Understanding each of the major constraints will help breeding design appropriate adaptation strategies to adapt to changing climate.

For several generations, especially in the arid environment where rainfall changes have the greatest impact on livelihoods, farmers have developed coping strategies to cushion the uncertainty caused by seasonal changes in water supply and socio-economic drivers that affect their lives (Matlon 1988; Reardon et al. 1999; Carloni, 2001). According to the assessment of risk and vulnerability, farmers make some choices and adjustments in technology, production and consumption decisions. Farmers adopt a series of specific coping and adaptation strategies to cope with climate change, some of which are common across regions, while others are driven by specific local factors (Thomas et al., 2007). These include risk management options, such as selecting specific crop varieties, investing in water resources management, diversifying agriculture and other related livelihood businesses before the start of the season; intraseasonal adjustment of crop and resource management options based on the nature of the rainy season, and options to minimize the impact of adverse climate shocks on livelihoods (e.g., selling assets, borrowing, cutting non essential projects) The cost of the project). However, such coping strategies enable agricultural families to survive; they are essentially risk averse. They aim to mitigate the negative effects of poor seasons, but fail to take advantage of the positive opportunities of "average" and "better than average" seasons.

As a result, most families remain poor and vulnerable to further impacts of climate change and shocks. A survey conducted by Deressa (2007) showed that among the main adaptation methods identified in the Nile basin of Ethiopia, the use of different crop varieties was the most commonly used method, while the use of irrigation was the most inadaptable method. The use of different crop varieties may be related to the lower cost and easy access of farmers, and the limited use of irrigation may be attributed to the need for more capital and the low potential of irrigation. With the development of climate change in the future and farmers learning how to implement adaptation strategies, it depends on the type of land tenure, income, etc. farmers can make long-term adjustments, such as changing the crop varieties and planting locations. Potential options include shifting to robust varieties that are more suitable for the new environment (Kurukulasuriya and Mendelsohn, 2008). For example, Matarira and Mwamuka (1996) highlighted Zimbabwean farmers who have successfully converted to more drought resistant crops in areas where frequent droughts make agricultural production difficult. Another example is that in areas with increased rainfall, major diseases that attack small crops, such as corn streak virus and cassava mosaic virus, may spread. In areas with reduced rainfall, sorghum head smut is a fungal disease and peanut rosette disease is a viral disease. In areas where Yumi has become marginalized, farmers can adaptively switch to sorghum and peanut Growing cowpeas could exacerbate the situation. With the frequent occurrence of drought, the possibility of peanut and its products contaminated by aflatoxin is increasing, which is the main reason for the collapse of peanut international trade in the international market. In the Sahel region, although most small-scale farmers have very limited ability to adapt to climate change, they survive and respond in various ways over time. Supporting local farmers' coping strategies through appropriate public policies, investment and collective action will help to take more adaptation measures and reduce the negative consequences of predicting future climate change, which will benefit the most vulnerable rural communities.

1. Adaptation mechanism of crops to climate change and crop production

Agriculture is a basic human activity, providing food, clothing, medicine and other useful products for human society, as well as some important ecosystem services, including biodiversity, soil formation, water regulation, carbon sequestration and so on. As our world population is expected to reach 9.1 billion by 2050, agricultural production needs to grow accordingly to meet this growing demand; climate change poses a challenge because it has and will continue to seriously affect agriculture. The International Institute for Food Policy Research (IFPRI) estimates that climate change is likely to reduce irrigated wheat and rice yields by 30% and 15%, respectively (Nelson et al., 2009). The agriculture, forestry and Fisheries sectors are critical to the livelihoods of about 75 per cent of people living in rural areas. Therefore, the threat of climate change is very important to the livelihood of most of the world's population. Agriculture and other terrestrial sectors are not only affected by climate change, but also major emitters of greenhouse gases. About one third of global emissions can be attributed to agriculture, forestry and other land use sectors. Agriculture accounted for 13.5%, and land use change and forestry accounted for 17.4% of all greenhouse gas emissions (IPCC, 2007). However, the land-based sector is also part of the solution to climate change because of their great potential in reducing emissions and enhancing carbon sinks. This potential provided through the Agriculture, Forestry and Other Land Use (AFOLU) sector can make an important contribution to the necessary goal of reducing the threat of climate change. In early 2010, the food and Agriculture Organization of the United Nations (FAO) set up a new project "mitigation of agricultural climate change" (MICCA) to support the efforts of developing countries to mitigate climate change through agriculture and move towards carbon free agriculture. As one of the first activities under the project, small farmers will be supported to participate in agricultural greenhouse gas mitigation activities. This includes the development of three to five pilot projects to test the participation of small-scale farmers in climate change mitigation. It presupposes that if changes are implemented in the production system, emissions can be reduced, sinks can be generated in biomass and soil, and the resilience and productivity of the agricultural system will also be improved. It is very meaningful to adopt climate smart agriculture with important synergy among productivity, adaptation and mitigation. The environmental services provided by farmers should be paid. The specific demand of agricultural production, the investment demand of improving agricultural production mode, the slow process of carbon accumulation and the time lag of improving productivity all pose challenges to the financial mechanism that can promote the transformation of existing agricultural system to climate intelligent agriculture (FAO, 2010).

A lot of work has been done on the relationship between climate change and grain production and the impact of agricultural natural disasters on grain production (Kaiser H M. et al., 1993). Different researchers choose different regions and discuss different contents, such as the countermeasures to adapt to climate change from the farm level (Grosson et al., 1993); the impacts of climate change and agricultural production and economy from the regional level; and the impacts of natural gas from the national level (Adams Rm. et al., 1990; Rosenzweig C, et al., 1993).

The impact of ENSO related climate variability on the agricultural sector has been well documented (IPCC, 2001). In recent years, the increase in extreme weather events has led to a 2.4-fold increase in floods, droughts and landslides compared with the periods 1970-1999 and 2000-2005 (Magrin et al., 2007, IPCC, 2007), many of which are related to ENSO. In the last 25 years of this century, two very serious ENSO events (1982-1983 and 1997-1998) caused huge losses and increased the vulnerability of agriculture to natural disasters (Magrin et al., 2007). In the case of El Nino in 1997-1998, the total loss of the agricultural sector in the region was about 20 per cent: 17 per cent in Peru, 19 per cent in Colombia, 23 per cent in Bolivia and nearly 50 per cent in Ecuador (ECLAC, 2009). Irregular rainfall and high temperatures in Peru are affecting potato and corn crops (MINAM, 2009). In the past 12 agricultural movements, 80000 hectares of potatoes and 60000 hectares of white jade rice have been lost due to climate change. Divide the yield by two. In the Pampas region of Argentina, potential wheat production has been declining at an increasing rate since 1930, mainly due to an increase in minimum temperature (Magrin et al., 2009). However, the impact is not always negative. It has been established that maize and soybean yields tend to be higher than normal during El Nino and lower during La Nina (Berlato and Fontana, 1997; Grondona et al., 1997; Magrin et al., 1998; Baethgen and Romero, 2000). In Brazil and Argentina, the abundant soil moisture brought by the typical El Nino phenomenon made soybean yield record. Wheat production has shown growth (24% and 3% respectively) in the steppes of Argentina and Uruguay (Magrin et al., 2007, ECLAC, 2009). In the past decade, the impact of El Nino in eastern Paraguay has also led to a significant increase in soybean production. At present, China is the fourth largest soybean exporter in the world (USDA-FAS, 2007; Fraisse et al. 2008), accounting for about 3% of the world output. Increased precipitation during 1960-2000 resulted in higher productivity of maize crops in the humid grasslands of Argentina (26%) and the dry grasslands of Argentina (41%), Uruguay (49%) and southern Brazil (12%), as well as higher yields in the pastures of Uruguay (7%) (Magrin et al., 2007; ECLAC, 2009). In the last century, the corn yield in pampas, Argentina, increased from 1500 kg /ha to 4000 kg / ha; this trend is partly explained by technological progress. It also had a positive effect on soybean and sunflower, increasing crop yields by 38% and 12%, respectively (Magrin et al., 2005). On the northern coast of Peru, higher temperatures during El Nino resulted in shorter growth cycles for cotton and Mango (Torres et al., 2001).

The world will have more and more demand for agricultural production. As part of the IPCC process, Smith et al. (2007) summarized the current situation of agriculture and the potential impact of climate on agricultural production. There may be many things in North America. The trend of precipitation reduction in the southwest will continue to put pressure on the decreasing water resources. Agricultural systems are the main users of irrigation water in the region, so more effective water use methods must be developed or species that may be diverted to less water demand. The precipitation type has changed, and more precipitation is deposited as rainfall than in the Nevada mountains of California (Lettenmaier et al., 2008). California's current irrigation water treatment system is designed to handle snow melting in spring and early summer, which will require changes in the water collection and storage process. In these areas, agricultural water is derived from water collection and irrigation, and the challenge will be to make more effective use of existing water resources. In the plain areas of Triticum aestivum L. and Sorghum bicolor (L.) Moench, the trend of large changes in summer precipitation, winter warming and the increase of possible extreme temperature events will bring additional pressure to these crops. Alternative crops are unlikely, but the focus must be on soil management practices to increase soil storage to provide more available water to crops. Although there is a trend of growing season prolongation, the possibility of frost in late season will still exist and will pose additional risks to crops such as winter wheat (Jerry L. 2011).

Africa is the second largest continent in the world, with an area of 30 million square kilometers, accounting for about 20% of the world's total land area. It is the only continent that spans the equatorial center and is surrounded by the Atlantic, Pacific and Indian oceans. The African continent is composed of 53 countries with a total population of 880 million (FAO, 2005) and a high population growth rate (1.9% in 1992-2002). Africa represents a wide range of climate systems (Hulme et al., 2005), including arid climates in equatorial humid regions, Sahelian semi-arid tropics, Sahara and Kalahari deserts, as well as temperate Mediterranean climate in the north and temperate climate in mountainous areas, although most continents are considered arid or semi-arid. Even in these different climatic zones, many changes were observed because of the varying degrees of temporal variation, especially rainfall. Compared with many parts of the world, the lack of appropriate climate data hinders the scientific understanding of these systems (DFID, 2004).

The agricultural production of a country or continent largely depends on the geographical distribution of heat and humidity. Based on the fact that the average annual length of crop growth period (LGP) depends on precipitation and temperature, Africa has four major agro ecological regions, including humid, sub humid, semi-arid and arid (Sahelian) regions (Dixon et al., 2001). The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007a, 2007b) predicted that the changes in rainfall patterns observed in some areas of Africa. Especially, in the Sahel, will affect the seasonal and annual water balance and agricultural crop production in addition to the changes in thermal conditions. To achieve viable adaptation, stronger agricultural growth in Africa requires action in a number of areas, including infrastructure, especially transport and irrigation; agricultural extension. development of improved crop varieties. The right to poverty, which encourages investment in land and farms, including women; access to microcredit; physical security, in order to achieve long-term returns on investment; and better forecasting And coping with the weather; and the occurrence of diseases and pests. The assessment of the relationship between crop productivity and climate change depends on the combination of modeling and measurement. In contrast, challenges related to climate change impacts and farmers' adaptation remain unresolved (Ranjana, 2011).

Over the past 250 years, deforestation, fossil fuel combustion and the production of agricultural products such as rice and livestock have led to a significant increase in the concentration of carbon dioxide (CO_2) and other greenhouse gases in the atmosphere. Greenhouse gases absorb energy from earth to space and warm the atmosphere. As a result, climate change has been properly described as one of the greatest challenges of our time and identified as a major threat to sustainable growth and development in Africa and the achievement of the millennium development goals. Therefore, climate change and its associated global warming may reduce agricultural production in tropical areas in which many developing countries are located (Darwin, 2001). Africa remains one of the most vulnerable continents due to multiple pressures and low adaptation (Anuforom, 2009). The rise of global average temperature will have many effects on agricultural production, mainly due to the change of growth season, that is, the length of time when soil temperature and soil moisture condition are suitable for crop growth. The expansion of the earth's oceans will increase sea level and reduce the number of land available for agriculture. Extreme weather events, such as storms and floods, may increase frequency. Higher atmospheric CO_2 concentration will improve water use efficiency of all crops (by reducing evapotranspiration) and increase photosynthesis rate of most crops.

However, in areas where fertilizer use is low or other factors inhibit crop growth, such as sub Saharan Africa (SSA), the direct impact of carbon dioxide will be small. The direct and harmful effects of other fossil fuel emissions, such as sulfur dioxide and ozone, will offset some of the benefits of high concentrations of carbon dioxide (Darwin, 2001).

Climate change will also affect the overall pattern of planting cycle. It is likely to become more and more important to cultivate medium maturing crops, which will largely mitigate the negative impact of climate change on yields. With the increasing possibility of drought, the key is to understand the dynamics of water absorption and how the water absorption of key development stages affects the yield under drought stress. Under the condition of climate change, the temperature will almost certainly increase, even if the air humidity increases slightly, the vapor pressure deficit (VPD) may also increase. As the increase of VPD will lead to the decrease of water productivity with climate change, it will be a challenge to identify germplasm resources that can maintain high water productivity under the condition of high evaporation demand. The increase of VPD only increased the difference between wet leaves and dry leaves, and tended to drain water from leaves, resulting in faster soil water profile consumption, unless stomata were closed to reduce water loss. With regard to the role of roots, it will become more and more important to deal with the rooting characteristics in a more dynamic way, especially to study how a specific water absorption mode will match the control of water loss by leaves in a comprehensive way. Therefore, the first way to deal with climate change is to control the water loss of plants under sufficient water conditions. Therefore, it is necessary to better understand the hydraulic problems related to water movement in soil plant atmosphere continuum (Vincent et al, 2011).

The relationship between climate change and agricultural production; the impact of climate change on food supply from the global level. According to the definition of Intergovernmental Panel on Climate Change (IPCC), climate change refers to "the change of climate state, which can be distinguished by the change of average value or rate of change of its characteristics. This change will last for a period of time, usually decades or longer. Climate change may be caused by natural internal processes or external forcing, or by persistent anthropogenic changes in atmospheric composition and land use". Global climate change has become one of the major environmental problems that human beings must face. The fourth assessment report (AR4) of IPCC pointed out that the global average surface temperature increased by (0.7 ± 0.18) °C from 1906 to 2005 (IPCC, 2007). In the past 100 years, the annual average surface temperature in China has also increased significantly, and the warming range is slightly stronger than the global average in the same period. Moreover, the drought in North China and Northeast China is becoming more and more serious, and the flood in the middle and lower reaches of the Yangtze River and Southeast China is aggravating (NCCARCC, 2007).

Changes in the environment will inevitably lead to changes in the physiological state of plants, and promote plants to release different ways of biological signals to adapt to the changing environment. According to the average change of plant phenology in the northern hemisphere, from 1950 to 2000, leaf extension and flowering were advanced by 1-4 weeks and 1 week respectively, leaf abscission was delayed by 1-2 weeks, and growth period was extended by 3 weeks on average. The change of plant growth period also caused the change of animal phenology and global water and nitrogen cycle (Penuelas J., 2001). Different plants have different responses to temperature changes. Under the dual effects of temperature and vernalization, the growth period of winter wheat can be adjusted by adjusting the number of expanded leaves. Studies have shown that there is a good correlation between the sowing to seedling stage and temperature, but the length of the period from seedling to heading is largely independent of temperature (Miglietta F, 1995). The time length of each growth stage of maize decreased with the increase of temperature. If the temperature is too high and the grain filling is too fast, the yield will be greatly reduced. Therefore, it is of great significance to study the response mechanism of plants to climate change.

Agricultural production is one of the most sensitive and vulnerable industries affected by climate change (Alexandrov VA. et al., 2000). Climate factors (such as temperature, light and precipitation) are not only the material and energy basis of crop growth, but also the limiting factors of its normal growth and development. Many experts and scholars at home and abroad have studied the impact of climate change on crop production. They believe that temperature rise and high-temperature heat wave are the main climatic factors causing crop growth period shortening and yield decreasing (Rosenzweig CF. et al., 1994; Lobell dB. et al., 2003). After high temperature stress, the photosynthetic carbon assimilation process was first affected, mainly the decrease of Rubisco enzyme activity; then the functions of photosystem I (PS I), cytochrome complex and thylakoid membrane were affected, while the functions of photosystem II (PS II) were generally not affected. Only when the temperature continues to rise can PS II cause irreversible damage, damage the thylakoid membrane structure, disorder the electron transfer, and may lead to the death of cells, leaves and even plants. The increase of temperature can also cause stomatal closure, limit the diffusion of CO_2, and further affect the photosynthetic rate. In addition, the increase of temperature promotes the growth and development of crops, and ripens early, which affects the grain filling and plumpness of crops, changes the physical and chemical components of crops, and reduces the nutrient content of crops. The carbon content in plants increases, the nitrogen content decreases, and the protein content also decreases, Finally, it leads to the decline of crop quality. Assuming that the global average temperature continues to rise by 1-3 °C, the negative impact on food supply will be more serious (Easterling et al., 1998). Climate change has significantly affected the world's agricultural production. Whether crop production can adapt to the impact of climate change and ensure food production security has become one of the urgent problems to be solved. It is very important to ensure food security in the future (Yang XG. et al., 2011).

Since the 1980s, climate warming has prolonged the crop growing season and increased the heat in the growing season, which is beneficial to crop production to a certain extent. Previous studies have shown that with the increase of temperature and accumulated temperature, the northern boundary of double cropping system and three cropping system in China from 1981 to 2007 moved northward in varying degrees compared with that from 1950 to 1980 (Yang XG. et al., 2010). However, the precipitation in the north of China has little change, the available water resources are relatively reduced. The drought affected area is expanded, and the flood in the south is aggravated, resulting in the increase of crop yield fluctuation and instability of food production. Qin Dahe (2002) and Lin Erda et al. (1997) Have shown that in the next 30 years, China's crop production may be reduced by 5% - 10% due to global warming, in which wheat, rice and corn are mainly reduced. The increase of carbon dioxide concentration is also an important factor of climate change. There are three responses of plants to the increase of external CO_2 concentration:

1. For plants with stomatal protective regulation function, with the increase of external CO_2 concentration, some stomata close to maintain a stable CO_2 concentration in the air cavity, so as to

maintain the normal photosynthetic assimilation rate of crop leaves. Due to the closure of some stomata, the diffusion resistance of internal and external exchange increased, resulting in the decrease of transpiration and the increase of water use efficiency.

2. With the increase of CO_2 concentration, the gradient of CO_2 concentration inside and outside leaves was increased, the photosynthetic rate was increased, but the transpiration was also significantly increased, and the water use efficiency was greatly decreased. Therefore, water supply has become a decisive factor to limit the rate of photosynthesis.

3. Between the above two, it is a plant with mediating regulatory function. Li yu'e predicted that the increase of CO_2 concentration would increase the yield of spring maize and summer maize in northern China. However, in North China, Northwest China and southwest China, limited by the lack of effective water resources, its impact on crop production is not very significant (Li yu'e and Zhang houyu, 1992).

Global climate change not only aggravates the biotic and abiotic stresses of crop production, but also increases the precious light and heat resources. Therefore, it is one of the effective ways to deal with global climate change and ensure food production to speed up the research on the response mechanism of crops to climate change, cultivate and plant more "tough" crops, and reasonably change crop planting methods. At present, the main difficulties in the field of adaptation mechanism of crops to climate change at home and abroad are as follows:

① in the past, the adaptation mechanism of crop production to climate change was mostly studied from the perspective of single factor change of temperature and CO_2 concentration rise, while the comprehensive effects of heat, CO_2 concentration, water and nutrients on crops were lack of basic research.

② Under the condition of climate change, there is a lack of systematic research on the adaptation of physiological and ecological processes such as dominant crop varieties, resistance of gene resources, crop growth and development, yield formation and quality shape to climate change.

③ There is a lack of mechanism research on the effect of agricultural cultivation management and cultivation measures on crop adaptation to climate change. The effects of climate change on soil physical and chemical properties, especially soil organic matter and soil fertility, need to be explained clearly. The law of change is also a key issue. The impact on the future development of crop production needs to be studied systematically (Yang XG. et al., 2011).

Although climate change has brought many different changes, no matter how much, we must not ignore the impact on food security.

Therefore, crop yield assessment can only provide a partial assessment of the impact of climate change on food security. Moreover, climate change is not the only factor that may lead to food security problems. Regional conflicts, changes in international trade agreements and policies, infectious diseases and other social factors may exacerbate the impact (Easterling et al., 2007). The ability to cope with environmental stress is as important as the degree of exposure to climate related stress. As a result, the prediction of malnutrition depends on climate impacts as well as economic development, technological conditions and population growth (Gregory et al., 2005). Food security has four main components: access to food through production and trade; stability of food supply; access to food; and actual food use. They are all affected by climate change (Gregory et al., 2005; Easterling et al., 2007). In the future, many factors including climate change and socio-economic development will affect the number of risk population. There are still many uncertainties in the impact of regional climate on food supply and demand. However, sub Saharan Africa is likely to surpass South Asia as the most food insecure region in the world (Tubiello and Fischer, 2007). Few studies attempt to quantify the impact of climate change and socio-economic factors on food security (Fischer et al., 2002, 2005; Parry et al., 2004; Tubiello and Fischer, 2007). They pointed out that the number of people at risk of starvation will mainly depend on socio-economic development. Slowing economic growth and population growth can significantly reduce the number of people at risk of hunger. Under the pessimistic scenario of global warming, high population growth and severe effects of no CO_2 fertilization, by 2080, the new population at risk of starvation may be as high as 500-600 million (Parry et al., 2004). Similarly, if the critical point of the climate system is broken, the situation may get worse (Battisti and Naylor, 2009).

The effect of climate on agriculture depends on regional and local environment to a great extent. Adaptive capacity and adaptive choice depend on the level of economic development and institutional setting to a great extent, which have great differences in the world and can almost make up for each other. However, uneven spatial distribution may affect food security in many areas in a harmful way. If the critical point of the climate system is violated, food security may be seriously threatened. A prominent example of climate turning point is the dynamics of Indian monsoon, which may be destroyed under certain conditions (Zickfeld et al. 2005). This will have a negative impact on agricultural production conditions in most parts of South Asia. Generally speaking, tropical developing countries will face the strongest direct climate impacts and the lowest level of adaptation. The areas most affected are expected to be sub Saharan Africa and the Indian subcontinent. If the global average temperature rises by more than 2-3 °C compared with the pre industrial level, the middle and high latitude countries will also be strongly affected. There is still uncertainty about future precipitation patterns and water supply at the regional level, the impact of extreme events on agriculture, and changes in soil fertility and agricultural pests and pathogens. The interaction between climate related stress factors also needs further study. The role of carbon dioxide fertilization in nutrient and water limitation needs to be further clarified. The negative impact of climate on agriculture can be reduced through a series of adaptation measures. Adjusting production technologies and soil management, crop insurance schemes, diversified international trade flows and designing better agricultural policies can improve regional food supply and agricultural income security. However, limited fertile soil, limited fresh water, limited financial means and institutional support, and limited resources often impede the necessary adjustment (Hermann, 2011).

Reducing global climate change forecasts to the regional level requires regional climate and crop growth data. Crop simulation models provide reliable and objective methods to infer the possible crop responses to climate change in different landscapes and time periods (Hansen and Jones, 2000; Hoogenboom, 2000). Taking Victoria, Australia as an example, the method was applied to illustrate the response of crop growth to local climate variables, and to provide information for possible adaptation strategies. Appropriate methods can be applied to other regions with sufficient climate and crop data. Landscape scale analysis is helpful to explore local adaptation strategies to climate change. Similar models must include functions that explain the effects of carbon dioxide and temperature rise expected to occur in the coming decades. If crops in the study area suffer or may suffer from severe water stress, these models must also consider water shortage. Previous regional analyses of climate change in Australia were conducted as a series of point source analyses, using representative regions to describe the possible responses of wheat to future climate scenarios (Hammer et al. 1987; Wang and Connor 1996; Asseng et al. 2004; Howden and Jones 2004; Howden and crimp 2005; Anwar et al. 2007; Crimp et al., 2008). Especially in southern Victoria, where future wheat production and acreage are likely to increase as the climate gets warmer and drier. It has been shown how landscape scale crop models can be compared with experimental data across the region, including atmospheric CO_2 elevation data from the free air CO_2 enrichment (face) experiment conducted in holsham, Victoria, Australia, in 2007 (Mollah et al. 2009). Landscape scale crop models were selected from the catchment analysis tool suite (Beverly et al. 2005).

Climate is the key driving force of crop activities, and its key impacts include soil moisture, drought (especially during grain filling period), frost, heat damage and storm damage during crop cycle. Climate also affects nutrient leaching, salt transport and erosion risk. Climate change may change many of these effects, for example, by increasing the damage of high temperature to grain quantity and quality, enhancing drought stress and reducing initial soil moisture conditions. However, climate change may also lead to the reduction of other specific hazards, such as salinization and alkalization of drylands (e.g.

Australia is an important producer and net exporter of rice. Until 2007, its output dropped to an 80 year low of 163kt In 2008, production fell to 18 KT, accounting for less than 2% of the long-term average (ABARE 2010). The climate prediction of the main sugarcane planting areas showed that the precipitation in the central and southern planting areas showed a downward trend, especially in spring, autumn and winter, the average temperature increased, especially the frequency of hot day and night increased (CSIRO and BOM, 2007). Australia's horticultural industry is extremely diverse, from tropical fruits, vegetables and nuts to varieties that require a lot of low temperatures. Since 2004, the average annual output value of fruits and nuts is a $280 million, and that of vegetables is a $310 million (Abare, 2010). A recent analysis of the adaptation programs of Australian cereal system (Howden et al. 2010) shows that several different response levels can occur individually or in combination. These measures include changes in inputs such as crop variety and nutrient management to adapt to the prevailing climate, changes in irrigation water volume and improvement in irrigation water efficiency, and more effective residue and canopy management. By changing the planting time, method and interval to modify the planting system, change crop rotation rules, adopt accurate agricultural practices, change crop livestock combination, diversify farm income sources, integrate pest, disease and weed management, and use a variety of climate. Other changes at the farm level can also be predicted at different time scales.

Australia's climate is changing; recent observed temperature increases, rainfall changes, and ocean and atmospheric circulation patterns are consistent with expectations of future climate change due to anthropogenic greenhouse gas emissions. A powerful example is that if changes in climate variables continue along the observed trajectory, they will affect almost all aspects of Australian agriculture. The cropping system discussed in this chapter accounts for a large proportion of national economic activities and export income. It is also an important regional activity and main land use to provide high-quality and important food for Australian consumers. There is likely to be an increasing demand for adaptation technologies, practices and policies that will provide agricultural decision makers with choices of all sizes for more effective management in a changing climate. Here we outline a range of such options, from the paddock level to the policy level. However, only a few of them are evaluated in terms of practicability and cost-effectiveness. Farmers, researchers, industry and government policy makers will work together to effectively develop and assess adaptation options, but this will provide a key path for the future of Australia's climate changing and changing cropping system (Howden et al., 2011).

In order to reduce the scale of global climate change, we need to put it into the detailed modeling. It is important to pay attention to the genetic maturity and climate change in the selection of varieties. In order to meaningfully review climate change scenarios at the local level for decision-making and assisting farmers in choosing adjustment strategies, further understanding of local conditions and validation of crop models are needed. Specifically, for our study sample area, rainfall reduction in arid areas is a huge challenge, while rainfall reduction in high rainfall areas of 500 – 800 mmpa is less problematic. In the semi-arid areas of the region, if crops are sown outside the June sowing date, production in Northwest Victoria is expected to decline by about 10% to 20%. For high rainfall areas in the southwest, production is expected to increase by about 10% to 20%. In the southwest of Victoria, the adaptability of high rainfall area was maximized due to the slow growth type and late sowing time. And the yield still increased by 2070. However, production is expected to decline in most areas by 2070. In Victoria, farmers have begun to adapt to climate change. These strategies include early and late sowing, less tillage, stubble, opportunistic planting, computer models of climate and weather, and computer models of crops and strategies. Low risk options include Cereals, long fallow, hay and spring crops, and sheep. To sum up, because adaptation is very important, and there are still great benefits to be obtained. The following directions point to the research and development of high benefit / cost ratio:

Selecting the type with slow development for adaptive varieties; choosing low-cost precision agriculture and less tillage for adaptive agronomic measures; using remote sensing and close range remote sensing for more effective use of water and fertilizer; paying attention to productivity and profitability It is necessary to strengthen the cooperation and partnership among growers, industry and government (Garry et al., 2011).

According to the observation of Latin America in the fourth assessment report of IPCC (IPCC, 2007), the growth rate of soybean, wheat and corn in the southeast of South America is relatively small. In tropical and subtropical regions where crops are currently close to the heat tolerance limit, increased thermal stress and dry soil are expected to reduce productivity to one third of its current level (ECLAC, 2009). According to FAO estimates, the more sensitive crops in the Andean region are palm, soybean, sugarcane, cassava, potato, corn, barley, rice and wheat. In Brazil, there are soybeans, sugarcane, cassava, maize, rice and wheat (ECLAC, 2009). The forecast shows that there will be little change by 2020, but it will increase after 2050. Even if the current temperature only rises by 1.5 – 2 °C, the change may be very large. Temperature and precipitation in the Amazon region are expected to increase significantly during both the rainy and dry seasons (ECLAC, 2009). Since cereal, oilseed and protein crops depend on temperature and, in many cases, on the length of sunshine to reach maturity, an increase in temperature may shorten their growth period and, in the absence of a compensatory management response, reduce yields (Porter and Gawith, 1999; Tubiello et al., 2000) and change the areas suitable for their cultivation. According to the International Food Policy Institute

(IFPRI, 2009; Nelson et al., 2009), climate change will have a negative impact on crop yields in Latin America and the Caribbean in 2050. The average yield of rice, corn, soybean and wheat in this region will decrease by 6.4%, 3% and 6% respectively. These results indicate that, compared with other studies using crop simulation models and future climate scenarios, the trend of major negative impacts on crops in Latin America is the same: by 2055, corn production by small producers in Latin America and the Caribbean may decline by an average of 10%, although production in Colombia remains largely unchanged, while in Piedmont, Venezuela, it is expected to decline Profitability will drop to almost zero (Jones and Thornton, 2003). In Latin America, rice production generally declines by 3% to 16% in Guyana, 31% in Costa Rica, 16% to 27% in Guatemala, and 2% to 15% in Bolivia. According to the 95% forecast, sugarcane production in Brazil and the Andean region will fluctuate by + 5% (ECLAC, 2009). Corn productivity is forecast to decline in Brazil and fluctuate by + 5% in the Andean region (ECLAC, 2009). For soybean and Maize in southeastern Latin America, the model considered the increase of CO_2 concentration, adaptive measures including optimal sowing date and nitrogen application rate, and predicted that the average yield of Maize in 2020 and 2050 would increase by 14% and 23% respectively under The Special Report on Emissions Scenarios (SRES) A2 (11% and 15% respectively under SRES B2). According to SRES A2, the corresponding figures for average soybean production in 2020 and 2050 are 35% and 52%, respectively (24% and 38%, respectively, according to SREs B2) (Gimenez 2006). In Sao Paulo, Brazil, by the beginning of this century, the land area suitable for growing coffee in Sao Paulo will be reduced by 10% (if the temperature rises by 1 °C, the precipitation will increase by 15%) and 97% (by 5.8 °C and 15% respectively) (Pinto et al., 2002).

Latin America's agriculture accounts for a large proportion of its GDP, with an average of 5%. The region is a global net food exporter, accounting for 11% of global value. It is predicted that climate change will increase the temperature of the whole African continent, especially the poor areas in Central America and the Caribbean and the countries along the Caribbean coast of South America. Rainfall is expected to increase in many parts of the continent, but Central America and the Caribbean countries are once again expected to suffer the most. For Costa Rica's coastal areas, this does not mean a serious impact, but for areas currently suffering from drought, including Colombia, Venezuela and the Caribbean coast, and in other areas such as the Caribbean Sea, these changes do require urgent definition of adaptation actions to cope with the negative effects of severe and long-term drought. In addition, the impact of these changes on crop production is largely unknown, and research is needed to further understand the complex responses of crops to climate change, including variability and long-term average climate. However, the current data show that the expected growth of some major commodities in the African continent, mainly soybeans and cassava, has little or no decline, as well as the decline of most other crops, including soybeans, bananas, potatoes, etc. Research must aim to better estimate the impact on crop production, and crop experts must study different adaptation options to solve specific problems. Given the high heterogeneity of the production environment in Latin America, multiple adaptation measures must be developed and implemented in a site-specific manner (Andy J. et al., 2011).

Climate is a factor in the complex combination of processes that make agriculture and animal husbandry in Africa highly unproductive. Changes in climate patterns are expected to affect population growth, migration, food supply, poor and degraded soils, drought and disease rates, etc. Over 60% of the African population is directly dependent on agriculture and natural resources for their livelihood (FAO, 2003), while agriculture is highly dependent on climate change (Salinger et al., 2005), making the threat of climate change particularly urgent in Africa (Boko et al., 2007). Sub-Saharan Africa (SSA)'s current population growth rate is 2.3% (World Bank, 2009). The United Nations predicts that the population of the region will be close to 1.5 billion by 2050. However, the impact of climate change on population growth is still controversial, and past studies have shown that population expansion will exacerbate the impact of climate change. Recent studies have shown that the real problem is not the growth of the population itself, but the growth of the number of consumers and their consumption level (Satterthwaite, 2009). However, climate change will lead to more people moving from the most affected areas to a more favourable environment. The food supply assessed as calorie supply will also be significantly affected. Information on the threat of climate to food security in developing countries remains limited (Darwin, 2001). Without climate change, the calorie supply of SSA is expected to increase between 2000 and 2050. However, with climate change, the per capita food supply in the region will decrease by an average of 500 calories or 21% in 2050 (Nelson et al., 2009). Similarly, in the absence of climate change, only SSA (among the six regional groups of developing countries studied in the report) believes that the number of malnourished children increased from 33 million to 42 million between 2000 and 2050. Climate change will further increase this number by more than 10 million, resulting in 52 million malnourished children by 2050.

Defining uncertainty is important in all areas of climate change research, not only in the assumptions of stochastic or deterministic models, but also in biological processes that lack knowledge or understanding. However, considering the impact of climate change on food security, it can be said that the uncertainty is greater. Food security can be defined as "all people can obtain sufficient, safe and nutritious food from material and economic sources at any time to meet their dietary needs and food preferences, so as to lead an active and healthy life" (FAO, 2003) or "fair price, choice, access through open and competitive markets, continuous improvement of food security, and transition to healthier drinking" Food and a more environmentally sustainable food chain "(Anonymous, 2008a), although a simpler definition may be" the risk of not having enough food. ". It is a combination of multiple food supply, food access and food utilization issues. Each of these is affected by many factors, such as economic recession, currency fluctuations, water pollution, political instability, HIV (Human Immmunodeficiency Virus)/ AIDS (acquired immunodeficiency syndrome), war, trade agreements and climate change, which complicates the uncertainty in each. Problems such as education, poverty, poor market access, rising food prices, unemployment and property rights are also considered to be the causes of food insecurity (Scholes and Biggs, 2004). These have led to many food security "hot spots" around the world, especially where multiple factors coexist (Figure 2). Sub Saharan African countries are at the top of the list.

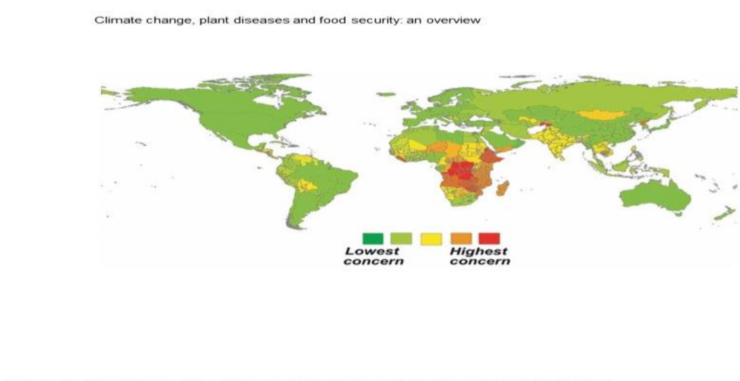


Fig. 2 identifies food insecurity hotspots based on FAOSTAT and wri's 2001-2003 data on hunger, food aid and dependence on agricultural GDP. [global environmental change and food system (GECAFS), personal communication].

Europe is one of the largest and most productive suppliers of crops and commodities. In 2004, the African continent provided 20% of global grain production, with an average yield per hectare 60% higher than the global average (Alcamo et al., 2007). Agricultural land area, including arable land and woodland, accounts for more than three-quarters of the territory of the European Union (EU) (European Commission, 2007). The impact of climate on agriculture may have little impact on the European economy as a whole, as agriculture accounts for only 2% of GDP and about 5% of total employment (Barthelemy, 2007). In some areas, however, the local impact of climate change can be significant. Agricultural water consumption accounts for 32% of the total water consumption. In the north, water intake is stable or decreasing, but it is increasing in the South. The common agricultural policy (CAP) of European Union dominates the development trend of European agriculture. Over the past decade, it has undertaken reforms to reduce overproduction and environmental damage and to improve rural development (Alcamo et al., 2007). In the future, European agricultural policies need to support agricultural practices to adapt to changing climate conditions. However, so far, there are many uncertainties about the future climate conditions in different parts of Europe. In addition, socio-economic factors may have a greater impact on future productivity and land use decisions than climate factors (Audsley et al. 2006).

Depending on the climate, there are many kinds of crops in Europe. The most important crops are cereals, which are mainly used for animal feed and human consumption (Olesen and Bindi, 2002). The continent has the highest wheat yield, for example, France has about 8 T / ha, while southern Europe, especially Spain and Greece, has the highest corn yield (Olesen et al., 2007; Reidsma et al., 2007). Future climate conditions will expand grain acreage, but at the same time reduce production in some parts of southern Europe. Wheat is the most important crop in Europe. There have been some studies on the effects of climate on wheat yield and distribution. The change of yield depends on the increase of temperature, the change of precipitation pattern, the increase of carbon dioxide concentration and the development of technology. The overall impact of climate change may be positive. However, the extent of production growth will depend on CO_2 concentration and technological development. According to Ewert et al. (2005), the average wheat yield in Europe in the future may increase from 6 – 8 t/ha in the special report on emissions scenarios (SRES) B2 scenario in 2080 to 15 t/ha in the SRES A1fi scenario. In the very high emission scenario A1fi, the strong increase in production is the result of the expected positive impact of increased CO_2 concentration. However, under the average production conditions in this field, the effect of carbon dioxide fertilization is still a controversial issue. Wheat production will increase in northern Europe and parts of central and Eastern Europe, while it will decrease in southern Europe, especially in southern Spain and Portugal

(Giannakopoulos et al., 2005; Maracchi et al., 2005; Olesen et al., 2007). A more detailed study by Maracchi et al. (2005) showed that wheat production in southern Portugal, southern Spain and Ukraine would be reduced by up to 3 t / ha. In other parts of southern Europe, such as northern Spain, southern France, Italy and Greece, and Scandinavia, wheat production is likely to increase by 3-4 t / ha. In the rest of Europe, production growth is estimated to be about 1-3 t / ha. Corn cultivation is currently limited to parts of southern and central Europe. According to Olesen et al. (2007), the northern boundary of maize suitability may move northward. However, the extent of this depends on the climate and varies widely. Areas suitable for corn could reach southern England and the Baltic States. For Ireland, the rest of England, Denmark, Finland and southern Sweden, future applicability is uncertain (Olesen et al., 2007). Production will decrease mainly in the South and increase in the north. However, because maize is a C4 plant, the response of Maize to the increase of CO_2 concentration is not very strong compared with C3 plants such as wheat, so the increase is small (Maracchi et al. 2005).

The current policy aims to support agricultural income and protect farmers from world market conditions and external price fluctuations. In particular, export subsidies for certain products often put agriculture in a disadvantageous position in the rest of the world. In the future, the pressure to change (CAP) may come from four different areas:

The requirements for further trade liberalization in WTO negotiations, the implementation of climate adaptation strategy in agricultural production, the reduction of greenhouse gas emissions from agriculture, the contribution to the more general goal of climate protection, and the increasing demand for biomass energy carriers (Hermann, 2011).

The 15 countries of the Former Soviet Union (FSU), covering an area of nearly 22.5 million square kilometers, have diverse climate conditions, distinctive agricultural characteristics and different strategies to adapt to climate change. In the former Soviet Union, the most important food crop is wheat. In 2007, the area harvested by wheat accounted for 60% of the area of cereal crops and 44% of the total area of main crops (FAOSTAT, 2010). Despite its popularity, wheat is more susceptible to cold weather and soil acidity than other grains in temperate climates. These two factors limit the geographical distribution of wheat planting in forest steppe and grassland. Although spring wheat varieties mainly use surface soil water, winter wheat can use deep soil water, even in dry summer can also obtain sufficient harvest. Generally, the yield of spring wheat is only half that of Winter Wheat (Kruckov and Rakovskaya, 1990). In Ukraine, the north Caucasus and the chernozem regions of southeast Europe, where the climate is more conducive to the winter of crops, winter varieties have been developed. In West Kazakhstan and North Kazakhstan (SI), less snow in winter is beneficial to spring varieties. Depending on climate and soil, wheat acreage ranges from 18% of grain acreage in Belarus to 90% in Uzbekistan (FAOSTAT 2010). Further north, wheat is replaced by barley and rye. In Estonia, 33% of the main crop acreage is under barley 46% of grain acreage (FAOSTAT 2010). In Belarus, 16% of the main crop area is rye 24% of grain area (FAOSTAT 2010). Barley also has lower requirements for soil and summer precipitation than wheat. Oats, another important food and feed crop, are more demanding of high temperature and moisture conditions and are more susceptible to drought. However, oats can grow on poor acid ash soils, thus promoting forest areas in Latvian, Estonian, Belarusian, Russian and Lithuanian countries ranked by crop percentage (Kruckov and Rakovskaya, 1990). Western Ukraine and Moldova in ES, Georgia in CC. Overall, only 4% of the grain harvested in FSU is corn, compared with 33% in the United States (FAOSTAT 2010). FSU's agriculture is vulnerable to global economic changes. Three countries in the region Ukraine, Russia and Kazakhstan are major food producers and exporters, and their agricultural performance determines the global food market. Examples of world wheat and flour exports: Russia exports 7.2%, Kazakhstan exports 3.9%, Ukraine exports 2.4% (5th, 8th and 9th in the world, calculated according to the average value (tons) of FAOSTAT trade data from 2003 to 2007 in 2010). In the total world barley grain exports, Ukraine exports 13.6%, Russia exports 7.5%, Kazakhstan exports 1.6% (third, fifth and eleventh). Three CA countries are the main cotton exporters in the world, and Uzbekistan is the second largest cotton exporter after the United States. The following countries have the highest malnutrition rates: Tajikistan

(29%), Armenia (23%), Uzbekistan and Kyrgyzstan (13%) (FAO, 2010).

Annual production changes in FSU are likely to be greater than in any other major food producing region in the world. Compared with the United States, the coefficient of variation of wheat yield in 50-70 years is almost twice that of Russia and 2.4 times that of Ukraine (white 1987). In the current period (1992-2007), the coefficient of variation ranges from 11% in Kyrgyzstan to 38% in Uzbekistan, much higher than 7% in the United States (FAOSTAT, 2010). In Moldova, wheat production was 0.5 t / ha in 1992 and 4.0 t / ha in 2007 (FAOSTAT 2010). Grain production in the low Volga steppe, the southernmost Sicily and Northern Kazakhstan varied the most (35 – 50%) (Kruckov and Rakovetskaya, 1990). Although the crop composition of FSU is mainly determined by thermal conditions, the high fluctuation of yield is usually the result of precipitation variation. Historical records (Dronin and Bellinger, 2005) show that drought has become the most important extreme event affecting steppe and forest steppe agricultural areas Moldova, Ukraine, central chernozem, North Caucasus, Volga, southern Siberia and Northern Kazakhstan. The drought is determined by the summer atmospheric circulation in the main agricultural areas of FSU. The impact of drought increases as it continues into the next year. During the 20th century, at least 27 major droughts occurred in the Soviet Union and Soviet countries (Meshcherskaya and Blazhevich, 1990).

On a global scale, climate warming and "carbon fertilization" (enhancing photosynthesis in the case of high atmospheric carbon dioxide concentrations) may lead to dramatic changes in agricultural production, including a decline in growth from 6% to 8% in industrialized countries and from 9% to 21% in developing countries (Cline, 2007). According to research, the increasing temperature from 1981 to 2002 has reduced the increasing trend of yield of six main crops: wheat, rice, soybean, barley, corn and sorghum. For wheat, corn and barley, the main cereal crops in FSU countries, global yields have a significant negative response to temperature rise: for example, it is believed that wheat yield increased by 0.85 tons per hectare from 1981 to 2002, but decreased by 10% due to temperature rise; barley yield increased by 0.45 t / ha, decreased by 30%, and maize yield increased by 7% (Lobell and Field, 2007). Although the impact of climate change on agricultural production is expected to be minimal, reducing the expected yield growth rate, the tight balance between food supply and demand leads to even small changes in food supply may have a great impact. However, this impact is affected by adaptive adjustment including technological changes. In our review of climate change impacts and adaptation, we focused on two main factors, namely, limiting agriculture, temperature and precipitation, and related changes in growth season length, accumulated temperature growing degree days (GDD), precipitation seasonality, frequency of drought and flood, and potential evapotranspiration. Although the impact of carbon fertilizer on yield may be important, especially in areas with limited water resources, they avoided discussing carbon It's about availability. In any case, the FSU countries lack corresponding experimental data, which makes it impossible to estimate the possible consequences of incorporating adaptation measures to water shortage in the new water resources management plan. These measures include selection of new varieties, introduction of new crops, early planting, changes in crop mixing and rotation, changes in management practices, and new pest control techniques. However, if climate change accelerates, as predicted by the global climate monitoring system in this century, reactive adaptation may bring high costs; planned adjustment may be needed. In addition, the adaptability of FSU countries is also very different. An obvious limitation of adaptation is that the necessary capital investment may be too high, while many countries in the region have not exceeded or hardly exceeded the per capita GDP of 1991. However, there are many other physical, technical, financial, social, information or cultural barriers to adaptation. Better regional integration helps to overcome these constraints. California's water management system, for example, requires the joint efforts of many governments to operate effectively. The existing and future strategies of the above impacts on FSU agriculture need to be further studied. When adaptation to water shortage is incorporated into the new water management plan. These measures include selection of new varieties, introduction of new crops, early planting, changes in crop mixing and rotation, changes in management practices, and new pest control techniques. However, if climate change accelerates, as predicted by the global climate monitoring system in this century, reactive adaptation may bring high costs; planned adjustment may be needed. In addition, the adaptability of FSU countries is also very different. An obvious limitation of adaptation is that the necessary capital investment may be too high, while many countries in the region have not exceeded or hardly exceeded the per capita GDP of 1991. However, there are many other physical, technical, financial, social, information or cultural barriers to adaptation. Better regional integration helps to overcome these constraints. California's water management system, for example, requires the joint efforts of many governments to operate effectively. More research is needed on current and prospective strategies of autonomous adaptation and planned adaptation countries in the region (Andrei et al., 2011).

IPCC tar specifically pointed out that Asia is most vulnerable to climate change related impacts due to poor adaptability of human systems (Lal et al., 2001; Prabhakar and Shaw, 2008). In tropical Asia, several countries in tropical Asia reported an upward trend in surface temperature and a downward trend in rainfall over the past three decades (Sivakumar et al., 2005). For surface air temperature (SAT), most climate change scenarios predict deterioration of climate conditions, characterized by more frequent droughts and shorter growing seasons (Ribot et al., 2009). To be specific, the South Asian tropical cyclone is not a long-term change in total number, but an increase in intensity. In most areas, the daytime temperature range (DTR) will decrease due to the increase of nighttime temperature (Sivakumar et al., 2005; Kao, 2009).

CHINA

China has established the National Climate Change Coordination Committee (NCCCC), which is currently composed of 17 ministries and agencies. The National Climate Change Coordination Committee has done a lot of work in formulating and coordinating important policies and measures related to climate change in China, providing guidance for the central and local governments to deal with climate change. In 2006, China issued the national climate change plan for adaptation to climate change. In 2010, part of the goals are to improve grassland, protect it from the effects of degradation, desertification and salinization, improve the utilization efficiency of water resources, reduce the vulnerability of water resources, and improve agricultural adaptation technology. Some technical requirements for China to adapt to climate change determined by the national climate change plan are high-efficiency water-saving agricultural technologies, such as sprinkler and drip irrigation, high-efficiency flood control, agricultural biology, agricultural breeding, new fertilizers, pest control, etc., and observation and early warning technologies for flood, drought, sea-level rise, agricultural disasters, etc. (NDRC, 2007).

INDIA

In its first national communication to the UNFCCC, India pointed out that the reduction of freshwater system may lead to the shortage of water resources, thus posing a threat to agriculture and food security. It also identified specific strategies to reduce drought vulnerability, such as changing land use patterns, water conservation, flood warning systems and crop insurance (Prabhakar and Shaw, 2008). Ongoing projects, such as watershed development projects, command area development projects, crop diversification, in some flood prone areas, in addition to various flood control measures, irrigation facilities will be extended to larger areas, which requires the development of common national adaptation strategies, such as integrated watershed management at local and watershed levels (Prabhakar et al., 2009).

TURKEY

Turkey's climate is generally characterized by warm or hot summer and cold or extremely cold winter. However, Turkey's coastal areas are much more temperate than its inland areas (MSO, 2016). Therefore, the western and southern coastal areas of Anatolia have a Mediterranean climate, while the central plateau has a grassland climate (large temperature difference between day and night). On the other hand, the coastal area of the Black Sea belongs to continental climate. Due to these different climatic zones, the impact of climate change in Turkey is expected to vary from region to region. Most climate change scenarios agree that the overall temperature rise in Turkey will reach 5 °C. The annual precipitation in the western and southern regions decreased by 30%, while that in the northern regions increased by 20% (Fig. 3).

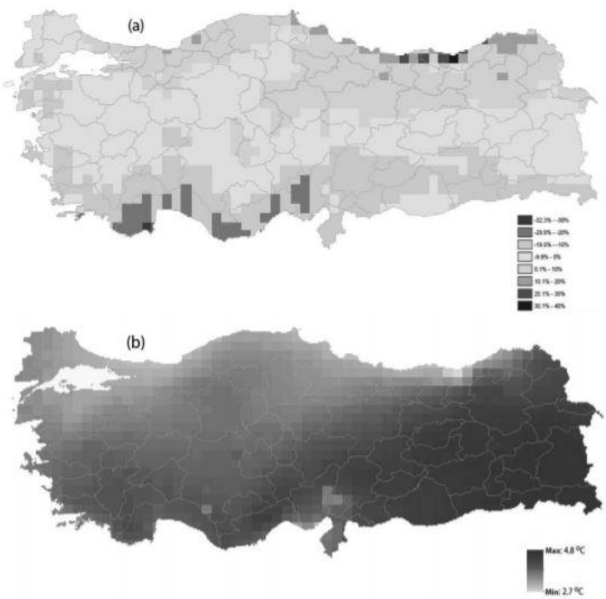


Fig. 3 Simulation of precipitation (a) and temperature (b) changes in ecam5 global climate change model A2. Data were calculated based on changes between 1961-1990 records and 2070-2099 scenarios (Şen, 2003; Önol and Semazzi, 2009)

Shintaro Fujihara et al. (2008) investigated the potential impacts of climate change in the Saihan River Basin in southern Turkey, which is one of the most productive agricultural lands. They predict that annual precipitation will decrease by about 160 mm, which will lead to increased water demand in the basin, leading to water shortage. Konya, located in the high plain of Central Anatolia, has seen its groundwater level drop more than 20 meters in the past 20 years. According to the prediction of Köken et al. (2015), the temperature in the basin will increase by about 1.5-3 °C, and the precipitation will decrease by 25-50%. The gap Great Urfa basin has experienced 17 abnormal to abnormal dry years since 1951 (Aydoğdu et al., 2016). Over the past few decades, the traditional arid agricultural system in the southeastern basin of Turkey has been rapidly transforming into an irrigation system (Özdoğan et al., 2006). On the other hand, it is predicted that by the end of this century, the precipitation in the basin will decrease by more than 10% and the temperature will increase by 4-5 °C (Fig. 3). The climate scenario estimates that the temperature in the northern coastal area of Turkey will rise by 2-4 °C. However, they also predict that precipitation in the Northeast will increase by 200-300 mm, while precipitation in the northwest is not expected to change significantly (Terzioğlu et al., 2015). Forecasts for the end of the 21st century indicate that annual precipitation in the gediz and greater Menderes basins along the Aegean coastline will decrease by 50% (TMU, 2012). To assess the response of major crops to future environmental conditions, significant changes in the impact of climate change across Turkey should be considered.

Turkey's average wheat production in the past five years was 17.4 million tons (TUIK, 2016). Most of the wheat is produced in the Konya basin in central Turkey (Fig. 4). Although the largest producer is Konya (1.5 million ton). Wheat is usually grown all over Turkey.

Konya and central Turkey have the lowest precipitation (Dursun et al., 2012), which is one of the most sensitive regions to the impact of climate change on crop production. In particular, wheat production has a great dependence on the total amount and distribution of precipitation in the whole growth period. More than 70% of the precipitation is received during autumn and winter, while limited precipitation between April and June often leads to wheat drought stress (Soylu et al., 2012). Although water deficit may be experienced at all growth stages of wheat due to unfavorable rainfall distribution, the effect of drought increases significantly after wheat growth and during grain filling stage (Özturk, 1999). These key stages of wheat growth are considered to be the most important stages of yield formation (Acevedo et al., 1999). Drought inhibited the reduction of photosynthesis and the reactivation of dry matter to grain after anthesis, resulting in a significant decrease in grain yield (Palta et al., 1994; Ercoli et al., 2008). A 10 mm reduction in total rainfall usually results in a 13.4 kg / ha reduction in production in the region (Soylu et al., 2012). Turkey produces about 6.8 million tons of barley per year (Fig. 4).

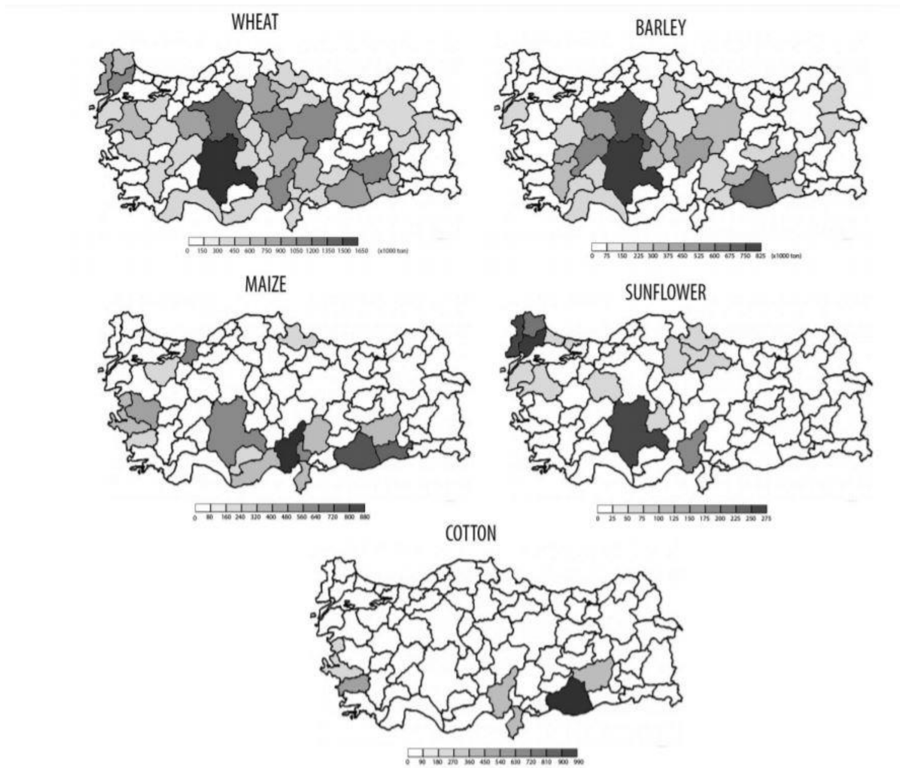


Fig. 4 yield distribution of wheat, barley, corn, sunflower and cotton in Turkey. Cities are based on the average annual production from 2011 to 2015 (Tatar, 2016).

The distribution of barley planting area is similar to that of wheat planting area, as shown in Figure 1. Barley is relatively more tolerant to land shortage than wheat (Li C. et al., 1970). Soylu and Sade (2012) observed that barley yield decreased less than wheat yield in dry years in central Turkey. As the cultivated land of wheat and barley, the distribution of corn yield is not extensive (Fig. 4). Turkey produces 5.4 million tons of corn a year. Most producers are located in the southern, southeastern and western coastal areas of Turkey (Fig. 3).

These lands usually have Mediterranean climate conditions. Climate change prediction shows that the average temperature in these areas increases by about 3 °C, and the annual precipitation decreases by 10-30% (Fig. 3). For the past decade, the northwest of Anatolia has been a major sunflower growing area. But production in Central Anatolia has increased rapidly because turkeys need to grow fat. In contrast to Thrace in the northwest, sunflowers are mainly grown in irrigated areas in the central Konya basin. Therefore, the shortage of water resources caused by climate change will be a major risk for sunflower production in the region. In some parts of the basin , the groundwater level has begun to drop by 0.7m per year (Doğdu et al., 2007). The water requirement of Konya sunflower in growing season is about 450-500 mm (Soylu and Sade, 2012). From the perspective of future forecast, the impact in Central Anatolia will be more severe than that in the Northwest (Fig. 3). Existing varieties may not become convenient in the future. Turkey produces about 2.3 million tons of cotton (Fig. 4). About half of the cotton plantations are around the Aran UL faharan basin in southeastern Anatolia. Over the past few decades, cotton production in the basin has increased dramatically due to the improvement of the ultrastructure of water sources by the National Program (GAP). The average temperature higher than 35 °C during the day limits photosynthesis, while the average temperature higher than 25 °C at night increases respiration and increases the loss of cotton assimilates (Bange M. et al, 2007). The Halan basin often faces temperatures above 35 °C from June to September (MSO, 2016).

High temperature has a negative effect on cotton yield, especially at the early stage of flowering and Boll Development (Oosterhuis D.M., 2013). Early sowing may be one of the possible choices to avoid heat stress in these critical periods. It is expected that the impact of climate change on cotton cultivated land in southwest Turkey will be more obvious. Therefore, the improvement of heat-resistant varieties and effective water management application should be mainly suitable for the region (Tatar, 2016).

Global food security is threatened by climate change. While maintaining the already tense environment, providing enough food for the growing population is one of the most important challenges in the 21st century. Climate change has had a significant impact on water resources and soil in some parts of the world. Agricultural systems should be changed due to the effects of rising temperatures and changes in rainfall patterns. Plant growth conditions in some parts of the world will improve, while those in others will deteriorate. Temperature rise may aggravate the problem of diseases and insect pests, and then lead to crop yield reduction. Kucuk Menderes main is one of the areas where climate change may have an impact. Therefore, we must be prepared to avoid any decline in agricultural production. In order to achieve this goal, the following steps can be taken: improving the basin's agronomic management system to improve resource utilization efficiency; effective rotation planning should be carried out together with annual vegetables and field crops. To improve new varieties (field crops, vegetables and fruits) with salt tolerance, drought tolerance and high temperature tolerance; to improve new varieties of fruits with low cold requirement; to improve new rootstocks of fruits; to carry out adaptability test on new varieties (tropical) unknown in Turkey. Irrigation training should be given to basin producers (Hepaksoy et al., 2018).

PAKISTAN

In Pakistan, the following national policies are considered in the implementation process: (1) National Environmental Policy (2005), (2) National Health Policy (2006) and (3) national energy conservation policy (2006). Pakistan has established a global change impact research center, the prime minister's climate change Commission, the national environmental administration, the National Environmental Policy Executive Committee and, most importantly, the Pakistan Environmental Protection Council as a variety of national initiatives. Pakistan believes that disaster risk reduction and climate change are areas of common concern. Pakistan has promulgated national disaster management regulations. In addition, UNDP has established a disaster reduction unit. The organizations responsible for disaster management include NDMA, the Federal Flood Commission, the emergency rescue team and the Pakistan meteorological service (Kundi, 2008).

BANGLADESH

Bangladesh submitted its national adaptation programme of action to the UNFCCC Secretariat in November 2005. The panel on climate change has determined to continue the Napa process and promote the implementation of Napa. The goal of the integrated disaster management programme is to mainstream disaster management and risk reduction into national policies, institutions and development processes, and to promote the management of long-term climate risks and uncertainties (government of the People's Republic of Bangladesh, 2005, human development report, 2007 / 2008). Bangladesh will officially release three flood resistant rice varieties, which will help farmers prevent up to 1 million tons of crop losses caused by mountain torrents every year. The development of salt tolerant and early maturing rice varieties by research institutions is a technical development in recent years to deal with salt and flash flood respectively in crop agriculture. The government of Bangladesh, in consultation with civil society, including non-governmental organizations, research organizations and the private sector, developed a new climate change strategy and action plan in 2009. It was built on the Napa river. According to this, the needs of the poor and vulnerable groups, including women and children, will be given priority in all activities under the plan of action.

SRI LANKA

Sri Lanka was the first country in Asia to develop a national environmental action plan in 1992, and further updates were released in 1998 and 2003. Priority environmental issues were identified from the perspective of poverty. According to the world bank's environment department, Sri Lanka's poverty reduction strategy paper of March 2003 was quite successful in mainstreaming these key environmental issues. In addition, community driven development plays an important role in its success (IDS, 2006). As a small island country, Sri Lanka belongs to the category of "vulnerable" small island countries under the UNFCCC and the IPCC, and is seriously threatened by various impacts of climate change, such as sea-level rise and severe floods and droughts (UNFCCC, 1992; IPCC 2001a; Yamane 2003). The national communication reports submitted to the UNFCCC proposed a number of agricultural adaptation measures, such as developing forest crop agriculture, developing drought resistant rice varieties, changing land use patterns in landslide prone areas, making farmers aware of climate change and changing irrigation methods (Srilanka, 2000; Yamane, 2003).

THAILAND

In Thailand, the Ministry of natural resources and environment (MONRE) is responsible for government policies, of which the office of natural resources and environment policy and planning (ONEP) is the national focal point of the UNFCCC. The national climate change sub committee was established under the National Environment Committee after the country ratified the UNFCCC. In July 2007, the government upgraded the national climate change sub commission to the national climate change Commission, which is headed by the prime minister. Technical subcommittees have also been set up under national committees to support different aspects of climate change, including mitigation, vulnerability and adaptation. Thailand has developed a national climate change strategic plan and is currently developing a 10-year climate change plan. A key policy objective is to strengthen the link between sustainable development measures and measures to address climate change (ADB Report, 2009).

VIETNAM

MONRE is the main government agency activity to implement UNFCCC and Kyoto Protocol and to deal with all climate change. Vietnam submitted its initial national communication to the UNFCCC in 2003. NTP (national goal plan) is formally described as the main framework for the management and coordination of CC activities. The national strategy aims to reduce disaster risk, and the key institution is the central committee for flood control and storm control. Climate change adaptation projects are particularly prominent in the central coastal areas. Most project activities focus on the local level and are linked or integrated with ongoing support from donors and international non-governmental organizations for drought, flood and typhoon preparedness and response to national entities and communities. In the Mekong Delta, adaptation measures have been attempted at the farm, community and national levels (Suppakorn et al., 2006). Vietnam has not yet developed a national or local climate change adaptation strategy, and there is an urgent need for national and local capacity-building to ensure that policy responses are fully effective (Chaudhry and Ruysschaert, 2007).

Long term climate change research is the focus of early climate change research. In recent years, climate variability has been paid great attention by climate researchers. This study focuses on both long-term and short-term climate change. The above discussion shows that countries, especially in the national meteorological satellite system, are vulnerable to current climate conditions and future climate shocks. Therefore, understanding the nature and extent of vulnerability is the primary issue for any climate change research to establish an adaptation strategy. At the same time, it is also necessary to understand the adoption of adaptation strategies at the ground level to cope with the current climate situation. On the basis of these discussions, this chapter aims to draw attention to three issues that are being addressed through ongoing research work at the International Centre for space research and elsewhere. Therefore, the study is a comprehensive effort to understand and analyze the vulnerability and impacts of climate change and the adaptation strategies of farmers in selected areas. It is expected that by solving the above three problems. This study will help to solve the challenges of climate change in the semi-arid region of Asia, provide suggestions for strategies and policies to reduce vulnerability and strengthen adaptability, and provide farmers with better adaptation opportunities and choices to cope with future climate change (Naveen et al., 2011).

Climate change is a global phenomenon, and its impacts are unevenly distributed in different geographical locations. Climate change in Southeast Asia takes many forms. Generally speaking, existing global and regional studies show that Southeast Asia and Japan are no exception (Parry et al., 2007; Asian Development Bank, 2009; Japan Meteorological Agency, 2009), and the countries in the region have begun to show signs of climate change (Asian Development Bank, 2009; Japan Meteorological Agency, 2009) and differences between countries and regions. This section reviews the different observed and predicted trends of climate change in Japan and Southeast Asia.

JAPAN

The average temperature in Japan has been rising at a steady rate. The analysis of temperature records in Hokkaido, Japan from 1900 to 1996 shows that the annual average temperature rises from 0.51 °C to 2.77 °C (Yue and Hashino, 2003). However, climate change is not the sole cause of the temperature rise. A variety of other factors include urbanization, increased vehicle traffic and related pollution (Aikawa et al. 2009) and heat island effect (Aikawa et al. 2007). Historical precipitation events show that there is an obvious trend in Japan. Japan received heavy rainfall in the mid-1920s and 1950s, and has experienced increasing fluctuations since the 1970s (Japan Meteorological Agency, 2009). In recent years, the change of rainfall has increased significantly. Changes in daily precipitation patterns have also been reported (Fujibe et al., 2006).

INDONESIA

Since 1990, the annual average temperature in Indonesia has increased by 0.3 °C (PEACE, 2007). Observations also show that the 1990s was the hottest decade in the whole century, and 1998 was the hottest year. In addition to temperature changes, long-term changes in rainfall patterns were observed. The observation of BMG (badan meteorology dan geofisika) shows that the rainy season in some parts of Indonesia West Sumatra, Jambi, Jayaputra and Merauke) is advanced by 60 days. That in other parts of Indonesia (Baten and Jakarta) is advanced by 30 days, and that in other parts of the country (Ujung, Kulon, Ujung) Padang, Madiun, Malang, Kediri, Pacitan, Gresik and Blitar (Ratang, 2007). Observations also show that rainfall intensities at tamanbogo and Genteng stations increased significantly between 100-150 mm per day from 1991 to 2000.

MALAYSIA

With the exception of Kuching, the number of rainy days decreased significantly at all stations (Manton et al., 2001). There is no other significant trend in the extreme rainfall index. In 1998, the night became warmer and a big peak appeared. The frequency of cold days and cold nights also decreased significantly.

Climate change is expected to threaten rice crops, the most important staple food crop in Southeast Asia, due to heat induced spikelet sterility or increased crop respiratory loss during grain filling (IRRI 2006). At present, most of the rice crops are in the critical temperature level suitable for the growth of rice crops. In Southeast Asia, the hottest month is from March to June, just before the start of the monsoon season, which is the last stage of the dry season rice harvest. These areas have experienced high temperature of 36 ℃ and above, so they are at the critical level of tolerance. Any warming in these areas means a significant decline in rice production (Wassmann et al., 2009). HadCM3 global climate model using IPCC SRES scenario showed that global and regional yields of wheat, rice, maize and soybean decreased (Parry et al., 2004). Projected climate change scenarios indicate significant declines in the yields of major crops in Southeast Asia, including rice production by 1.4% (lobell et al., 2008), wheat production by 10-95% (Fischer et al., 2005), and soybean production by 10% (Lobell et al., 2008). The agro ecological region model predicts that the wheat yield available in the 1980s will decrease by 10-95% compared with that in Southeast Asia in 1990 (Fischer et al., 2005).

Climate change observation and prediction in Southeast Asia face several challenges. Many of these limitations are related to the quality of available data, the density of meteorological stations, the limited ability to adopt advanced climate prediction models and comprehensive climate risk assessment. Due to the inherent limitations of GCMS in spatial resolution and the limited representation of local climate conditions such as El Niño/Southern Oscillation (ENSO) phenomenon, the prediction results are uncertain. More detailed and accurate information is needed to design effective adaptation and mitigation plans at the local level. There is still a long way to go to obtain reliable downsizing impact forecasts. Meteorological Research Institute (MRI) earth system model (MRI-ESM) and other tools help to reduce the uncertainty of global and regional prediction. However, the combination of GCMS with dynamic crop models and Agroecological models needs further development. In general, on a regional basis, there is agreement in the literature on the predicted warming trend, the related changes of precipitation and the impact on crops. However, the climate observed and predicted at the national level has spatial and temporal variability. This requires high-resolution climate models that can provide reliable estimates of climate variables compatible with regional climate models and dynamic crop models. Crop cultivation is based on specific geographical conditions, including local climate, weather, soil and farmers' management practices. These factors influence each other and interact with the complex local cultural factors. All these factors must be taken into account in any method of assessing the impact of climate change. No single model method is very useful. Climate change requires innovative ways to produce new crop varieties and innovative crop management practices. Increased incidence of floods and sea-level rise could change the types of crops grown along the coast and in other vulnerable areas. There is a need for genetic and agronomic adaptation of crops, from yield oriented approaches in agricultural research and extension systems to adaptation oriented approaches, while benefiting from the positive aspects of climate change (Sivapuram, 2011).

Since the industrial revolution, due to the intensification of human activities, large-scale use of fossil fuels such as oil and coal, and excessive development and utilization of land resources, the earth's natural ecosystem has been seriously damaged, resulting in a sharp rise in the concentration of greenhouse gases such as carbon dioxide (CO_2) in the atmosphere, resulting in global climate change characterized by warming. From 1906 to 2005, the global average surface temperature increased by (0.74 ± 0.18) °C, and it will increase by 1.1 ~ 6.4 °C by the end of the 21st century (IPCC, 2007).

Climate is the environmental condition of crop growth and development, climate change will inevitably affect the growth of crops. The increase of CO_2 concentration in the atmosphere can improve the net productivity of crops. This is because the "fertilizer effect" of CO_2 can increase the photosynthetic rate and water use efficiency. The effect varies with different crops. CO_2 had a positive effect on C3 crops such as wheat and rice, but had no significant effect on C4 crops such as corn, sorghum, sugarcane and millet. However, the effect of increasing CO_2 concentration on crop growth is restricted by the changes of crop respiration, crop growth stage and other factors, which are likely to offset the effect of increasing CO_2 concentration. Climate warming is closely related to crop production. Climate warming makes the annual average temperature rise, which leads to the increase of accumulated temperature and the extension of growth period. Research shows that climate change in the future will change the existing crop layout and planting structure, expand the planting range of crops, and improve the global land carrying capacity. When the temperature rises, in the equatorial region, the main crop production areas will move several latitudes to the polar direction. According to the analysis, by 2050, the agricultural planting system in almost all places will have great changes (Wang, 2002).

In addition, climate change in the future will accelerate the growth rate and shorten the growth period of main crops, and affect the time of dry matter accumulation (Adams RM, et al., 1990). Especially, after the temperature rises, the high temperature and drought in summer will inhibit the growth and development of crops, and then affect the yield of crops, especially the cool loving crops (Rao AS, 2009). Under the premise that the existing planting system, varieties and productivity level remain unchanged, if no measures are taken, the yield of wheat, rice and maize will be reduced in the future (Wei X, et al., 2007). In addition, in the context of climate change, the probability of abnormal climate will be greatly increased, especially the increase of extreme weather phenomena, the aggravation of regional climate disasters, desertification and sandstorm, which will inevitably lead to the instability of world food production. At the same time, under the warming climate conditions, warm winter will increase the number of plant diseases and insect pests, reduce the mortality of overwintering, significantly increase the number of effective disease and insect sources after winter; it will also lead to the advance of disease and insect occurrence and migration period, the extension of damage period and the northward shift of overwintering limit of crop diseases and insect pests; warming in winter will also lead to the spread of weeds, which means that climate change is possible Increase the application of pesticides and herbicides. In addition, the microbial decomposition of soil organic matter will accelerate with the increase of temperature, and the accumulation and decomposition of root biomass will be limited once the soil is affected by drought, which requires more fertilizer to meet the needs of crops (Wu JG, 2007). The increase of fertilizer not only increases the cost of agriculture, but also harms the soil and environment. Climate change has threatened agriculture. The future climate change will aggravate the instability and vulnerability of agricultural production, and the risk of agricultural production will be greater. Therefore, in recent decades, scientists have been working on the impact of climate change on crop production. At present, the impact of global climate change on crop production is mainly focused on observation experiment and model simulation. The research on the observation and experiment of the impact of climate change on crop production has been carried out more abroad. Among them, face (free air CO_2 enrichment) experiment is the most representative. Face refers to increasing CO_2 concentration in free air. It is a technical means to control CO_2 concentration in the open field and create a micro ecological environment with increasing CO_2 in the future to simulate the impact of climate change in the future (Allen JR, 1992). Face experiment aims to explore the effects of increasing CO_2 concentration on plant growth and yield as well as the key processes of ecosystem; in the aspect of model simulation, the more mature one is to use climate model and crop model to connect dynamic simulation, so as to evaluate the impact of climate change on crop production. However, there are still many difficulties in the research on the impact of climate change on crop production, mainly including the following aspects.

(1) In the observation experiment, the effect of elevated CO_2 concentration on crop growth is not isolated, temperature, water, nutrients, oxygen, light intensity, growth space and other factors have an important impact on crop growth (Bai LP et al., 2004). How the elevated CO_2 concentration and these environmental factors work together to affect crops (biochemical, cell, organ and whole plant scale, etc.), how crops respond to the interaction of a variety of environmental factors, and the response mechanism remain to be studied. In addition, under the condition of face, the experimental study of crops is to apply CO_2 directly during the growth period of annual crops, but in nature, it is a gradual process, during which there will be a slow process of adaptation among individual, population, variety and generation, and the effect of adaptation can not be

reflected in the face experiment (Xie LY et al., 2008). It is an effective way to solve the above problems to carry out large-scale face comprehensive experiments of long time series.

(2) In the aspect of climate model simulation, although the global climate model has been greatly improved and the climate numerical simulation has made considerable achievements, there are still many shortcomings and problems, especially the failure to provide accurate and reliable information about the change of climate variability, and the change of frequency, intensity and duration of extreme weather events caused by climate variability, To a certain extent, it can affect the growth and development of crops more than the change of average climate (Sun BN, 2007). In recent years, although the application of regional climate model can solve some of these problems, the parameterization of terrain and natural processes in regional climate model will increase the uncertainty of the model, and then affect the coupling results of climate model and crop model. Therefore, it is necessary to reduce the uncertainty of climate models in the future.

(3) In the aspect of crop model simulation, some processes of crop growth and development (such as leaf development, leaf senescence and dry matter distribution) in the model are still based on experience, and this uncertainty will inevitably affect the accuracy of the results. In addition, in the context of climate change, diseases and insect pests may occur frequently in the future, and crop models do not take into account the factors closely related to actual production, such as human,

natural and geographical factors. In order to effectively solve the problem of crop model, it is necessary to develop comprehensive models suitable for different regions.

(4) It is very difficult to separate the climate change factors from the social development, science and technology development for the climate change that has occurred. Therefore, it is very difficult to distinguish the climate change itself from the human impact when judging the impact of the climate change on crop production. We should strengthen the detection and attribution analysis of the impact of climate change (Xu YL et al., 2011).

The increase of CO_2 concentration has an effect on crop seed yield. Bunce (2008) found an important 38 crop varieties in Phaseolus vulgaris that adapt to climate change through the interaction of CO_2 concentration. The highest yield variety under elevated CO_2 concentration is not the highest yield variety under environmental conditions. He observed that the main response to elevated CO_2 concentrations was an increase in the number of pods, which led to an increase in yield. He concluded that the response of pod and seed number may be more important than the photosynthetic response of stem biomass (Bunce, 2008). Uddling et al. (2008) concluded that the effects of elevated CO_2 concentration and irrigation on wheat grain production and biomass allocation were changed by plant source sink balance. They observed that sink limitation was the main limiting factor for CO_2 induced grain yield in spring wheat. They believe that under high carbon dioxide conditions, increasing photosynthetic rate before and after flowering as a method to improve wheat yield may not produce the expected results unless source intensity is also considered (Uddling et al. 2008). In a recent Australian study on wheat, Luo et al. (2009) used the APSIM (the Agricultural Production Systems Simulator) wheat model to evaluate different adaptation strategies, including rainfall and nitrogen management. They found that the negative effects of high (− 15%) and low (− 10%) crop available water capacity on grain yield were predictable, and these effects were not offset by changes in nitrogen application or variety selection. The most effective adaptation strategy is early sowing to utilize the increased soil moisture in the early growing season. Wang et al. (1992) used a simulation model to assess the impact of climate change on wheat productivity earlier and found that increasing CO_2 concentration to 700 ppm would increase wheat yield by 28 – 43%. However, increasing temperature at 3 ° C at the same time would reduce wheat yield by 25 – 60% (using existing varieties). They did not consider changes in rainfall patterns in their studies. However, compared with late maturing varieties, changes in rainfall may favor early maturing varieties (Luo et al., 2009). Xiong et al. (2010) studied the different scenarios of agricultural water availability in China, and found that the future grain irrigation demand is very sensitive to the characteristics of daily precipitation. The overall results show that China's agricultural water use will be insufficient. In the next few decades, water stress may become the main climatic factor determining crop response to climate. These findings are similar to those reported by Hlavinka et al. (2009), who found that drought is one of the main causes of inter annual crop yield changes in the Czech Republic. Xiao et al. (2009) observed from 1981 to 2005 that with the increase of temperature and precipitation, the wheat yield in high altitude and low altitude areas increased. It was further predicted that with the increase of temperature and precipitation, the wheat yield in low altitude areas would increase by 3.1%, and that in high altitude areas would increase by 4.0%. In specific regions of the world, the interaction of temperature and precipitation will regulate the response of crop yield.

The water demand of crops showed a changing trend. Supit et al. (2010) observed that the water demand of wheat decreased from 1976 to 2005. This is due to the shorter growing season due to the higher temperature in spring. This downward trend may also be related to the decrease of evaporation demand in winter and spring due to the decrease of global radiation (st). They found that only some areas showed an upward trend. For Beta vulgaris, they found a downward trend in water demand due to reduced evaporation demand due to reduced solar radiation in summer and autumn in the Mediterranean region of France and Spain. The rising trend of water use is related to higher temperature in summer and autumn (Supit et al., 2010). Haim et al. (2008) found that wheat and cotton yields in Israel are very sensitive to rainfall in dryland areas. They observed that under the climate change scenario, the yields of both crops decreased. Yang et al. (2008) observed that climate change has taken place in Northwest

China, and in the past 40 years, Northwest China has changed from warm type to warm wet type; however, other areas in Northwest China have experienced intensified drought patterns. With climate change, changes in rainfall patterns will have significant impacts on crop growth and yield in all agricultural areas, which may offset the positive effects of increased CO_2 concentrations. In India, Pathak and Wassmann (2009) observed no trend in rainfall patterns over the past 30 years; however, in ludiana, the lowest and highest temperatures showed an upward trend of 0.06 °C and 0.03 °C, respectively. In their analysis, they used the year with moderate rainfall as the benchmark yield. In the year with less rainfall, the wheat yield was only 34% of the benchmark yield, while in the year with less rainfall, the wheat yield was only 61% of the benchmark yield. In the years with high rainfall, ludiana's production is 200% of the benchmark production, while Delhi's production is only 105%. They found that early sowing helped yield under all rainfall conditions. Grassini et al. (2009) observed that yield follows a longitudinal gradient caused by seasonal rainfall and evaporation demand. These gradients are caused by the pattern of water stress in the growing season. In the growing season, dry crops growing in the western corn belt are often subjected to transient and inevitable water stress before and after silking stage. It was also observed that sufficient water at the time of planting helped to counteract, but could not eliminate, the water stress period. As the temperature increases further, these effects may be exaggerated, which will increase the evaporation demand of crops and increase the vertical gradient of yield. A similar study of Indian wheat by Ortiz et al. (2008) showed that higher temperatures reduce productivity in areas that are already in the optimal range. They suggest that one of the positive agricultural practices is the adoption of conservation agriculture, which will lead to an increase in soil water supply to crops and a decrease in soil water evaporation rate to increase the availability of crop transpiration.

The interaction of temperature, carbon dioxide and rainfall patterns during the growing season will affect plant growth in many different ways. The increase of temperature will accelerate the development of plants, when combined with the increase of carbon dioxide, it will lead to a moderate increase in plant volume. The interaction between these parameters is complex and becomes more complicated due to the rainfall pattern in the growth process. Water is a dominant factor that, when combined with temperature stress, will cover the positive effects of increased CO_2 and further reduce plant growth and yield. Because of these interactions, the impact on agroecology is multifaceted. These can be summarized as follows: increasing carbon dioxide will have a positive impact on plant growth, and the positive impact on C3 plants is greater than that on C4 plants. The enhanced response of C3 plants was attributed to the competitive inhibition of photorespiration and lower internal CO_2 concentration than Michaelis constant of ketose diphosphate carboxylate / oxygenase (Amphor and Loomis, 1996). These effects on plant growth are more obvious than on grain yield. 2. The increase of temperature will lead to faster plant development, which is consistent among species. Compared with CO_2 effect, C3 and C4 plants showed no significant difference in temperature response. The increase of temperature will increase the water use efficiency of crops, which is due to the effect of temperature on vapor pressure deficit (VPD). Increasing CO_2 will increase stomatal conductance, which leads to the increase of crop water use efficiency, because the growth of crops is increased relative to transpiration rate. These effects are not consistent among species, and the final response depends on soil water status. At the canopy level, there was an interaction between CO_2 and N management, and elevated CO_2 concentration had a positive effect on N response. As we move into the future, concerted efforts must be made to combine genetic and management responses to ensure the maximum food supply for the world's growing population. The current literature does not provide a clear consensus on how these interactions affect food production. Our challenge will be to determine how to quantify the response of a range of genetic material and agronomic practices to climate factors (Jerry L. et al., 2011).

Weather Hazards in Crop Production

The climate of the earth always changes with the changes of ice, hydrosphere, biosphere and other atmospheric and interactive factors. It is generally believed that human activities are increasingly affecting global climate change (Pachauri & Reisinger, 2007). Since 1750, the global emissions of radioactive gases, including carbon dioxide, have increased rapidly. If we can not effectively curb the increase of global emissions, this trend may accelerate. The man-made increase in carbon dioxide emissions comes from industry, especially due to the use of carbon based fuels. In the past 100 years, the global average temperature has increased by 0.74 °C, and the atmospheric CO_2 concentration has increased from 280 p.m. in 1750 to 368 p.p.m. in 2000 (Watson, 2001). Under the A2 scenario, it is predicted that the temperature will rise by 3.4 ° C and the carbon dioxide concentration will rise to 1250 p.m. by 2095, accompanied by greater climate change and more extreme weather related events (Pachauri & Reisinger, 2007). Behind these trends are many spatiotemporal heterogeneity, and the prediction of climate change impacts in different regions of the world is also different. Some of these are clear in the outputs of the models, which take into account geographical criteria such as land mass distribution, topography, ocean currents and water masses, as well as known meteorological features such as air currents. However, historical data show that seasonal and regional changes are not taken into account in the model processes (e.g., Barnett et al., 2006), and these processes have a significant impact on the actual processes, including crop sowing, harvesting or pest and pathogen infection, and all the activities resulting from them.

Climate is a key determinant of health. Climate limits the scope of infectious diseases, and weather affects the outbreak time and intensity (Dobson et al., 1993) the long-term warming trend is encouraging the geographical expansion of some important infectious diseases (Epstein et al., 1998), and extreme weather events are spawning a series of disease outbreaks and triggering a series of unexpected events (Epstein, 1999 and 2000). Ecological change and economic inequality seriously affect disease patterns. However, climate warming and instability play an increasingly important role in promoting the emergence, resurgence and redistribution of global infectious diseases (Leaf, 1989; McMichael et al., 1996).

Climate change characterized by temperature rise has become a hot issue in global research, and this upward trend will continue in the foreseeable period. Some studies have pointed out that the earth's average temperature will rise by 1 °C by 2025, and maintain a growth rate of 0.3 °C every 10 years, so that the earth's temperature will rise by 3 °C by the end of the 21st century (Houghton JT, 1990). The reason is that the rise of carbon dioxide and other greenhouse gases in the atmosphere is the "culprit" of global climate change. The existing observational data show that since the industrial revolution, the content of carbon dioxide in the atmosphere has increased by about 30%, and is growing at an annual rate of 5%. It is estimated that the concentration of carbon dioxide in the atmosphere will rise to 415-480ppm by 2050, and it may reach 714-1009ppm by the end of the 21st century (Yu Jiaju, 2007). This is consistent with the trend of global temperature rising in the future, which confirms the correlation between the two. The most direct consequence of global warming is to accelerate the melting of glaciers in the Arctic and high-altitude areas, raise sea level, threaten coastal cities and countries, and have a serious impact on the development of the world economy. In addition, scientists are concerned about the relationship between biological change and climate warming in terrestrial ecosystems. In the long process of evolution, the organisms on the earth have evolved a good adaptation mechanism to the earth's environment. In the short term, the abnormal changes of the earth's environment are bound to bring great challenges to the survival and reproduction of the existing organisms. Climate change should be maintained at a certain constant degree, so as to adapt to the growth of all things. Otherwise, too much or too little climate can affect the growth of organisms, or lead to the occurrence of diseases. At present, about 59% of the world's species have responded to climate warming, and 70% of the species distributed at the earth's poles or high altitudes have been extinct (Guo Yunhai, 2008). The loss of species diversity is a serious biological disaster caused by climate change. Some studies have found that the extinction rate of species in the world is 100-1000 times of that in the prehistoric period of human civilization (Stone R, 1995). Lethal high temperature and habitat destruction may be the main reasons why these organisms can not survive. Even if they can survive, the increase of temperature and the slight change of atmospheric composition will lead to the disorder of the growth law of some organisms, which will lead to the advance or delay of the phenological period of plants. What's more, it will lead to the outbreak of pests, viruses and bacteria. This is mainly because climate is one of the important factors affecting the spread of infectious diseases. Global warming will directly or indirectly affect the spread of many infectious diseases (Yang Kun, 2006). Stone pointed out in 1995 that the health of 40% - 50% of the global population will be affected by malaria, schistosomiasis, dengue fever and other insect borne diseases due to climate warming (Sun Guangzhong, 1990). According to the prediction results of the model, by 2100, the global average temperature will increase by 3-5 ℃, the number of malaria patients in tropical areas will increase by 2 times, and that in temperate areas will exceed 10 times (Chen pan, 1996). These scientific research results may be far away from our real life, and the world's fear of (Severe acute respiratory syndrome) SARS and (Influenza A viruses are hemagglutinin and neuraminidase) H1N1 respectively in 2003 and 2009 is still lingering. Although there are different opinions about the causes of these two diseases, it is difficult to exclude climate factors, at least to a certain extent, climate change has a direct or indirect effect on their occurrence.

Due to the long-term incubation period of sars-cov-2 virus (Linton et al., 2020), the prevalence of asymptomatic individuals (Nishiura et al., 2020) and their exponential growth (Levy and Tasoff, 2017), it is difficult for human beings to grasp its expansion dynamics, which makes pandemic crisis management extremely difficult. Similarly, climate change has a complex but slower temporal dimension. They are difficult for public thinking and long-term climate change forecasters to master. In this case, the crisis becomes apparent only when it is too late to prevent. Scientists have long been cautious about anthropogenic climate change and stressed the need for strong early action to prevent its most serious consequences (Houghton, 1996; Oreskes, 2004; Ripple et al., 2019).

The covid-19 crisis is the fact that once the virus reaches a certain number in the population, its control becomes extremely difficult. The continuous spread within the community leads to a chain reaction of exponential growth. Climate change is likely to work in a similar way. Scientists increasingly agree that once the temperature rises above certain critical thresholds, sudden and unchangeable changes will occur (Trisos et al., 2020). In addition, changes in large-scale climate patterns may initiate new and irreversible processes with unforeseen consequences. For example, changes in polar jet (Meehl et al., n.d.), salinity of ocean (Durack et al., 2016) and PH value (Caldeira and Wickett, 2003), or methane released by permafrost melting (Whiteman et al., 2013) may have large-scale and irreversible effects on global climate, which can last for decades or hundreds of years. As with early action to control pandemic, identifying and preventing climate change threshold crossing will help to avoid the worst case and reduce the economic and social costs of climate change (Jakob et al., 2012).

In addition to the rise of average temperature, another way of climate change is reflected in the occurrence of extreme climate events such as extreme high temperature, low temperature, flood, etc. Although the frequency of extreme climate events has shown a downward trend in the past few decades, the economic losses caused by them have gradually increased. According to the estimation of Munich company, the loss of natural disasters has increased three times from 1960s to 1980s, among which the economic loss caused by atmospheric disasters is the largest, reaching 42-51 billion yuan per year, and that caused by biological disasters is 1-1.5 billion yuan per year (Leemans R et al., 2002; Pimm SL et al., 1995). The daily observation data of 61 stations also show that the trend of regional extreme climate in China in recent 50 years is 5-10 times of the average climate trend. The Yangtze River flood in 1998 and the severe ice and snow disaster in 2008 are the best evidence that we have experienced recently. Some experts believe that the losses caused by the latter are more than the former (Yan et al, 2000). The drought in Southwest China, which plagued us in the spring of 2010, should also be a typical extreme climate event. Although it is not possible to assess the specific losses caused by it, it has affected the hearts of the people of the whole country. Now the earth's environment is a stable state after hundreds of millions of years. The change of climate factors is bound to have an impact on the biosphere from many aspects, and its interaction with organisms is the most complex. This is mainly because, such as the Gaia hypothesis, organisms are not only affected by the earth's environment, but also regulate the environment in which they live. At present, climate change has changed the evolution and development mechanism of organisms and the relationship between species, thus causing a series of major disaster events, and even endangering the survival and development of human beings. Therefore, the most effective way to reduce the occurrence of biological disasters is to slow down the extent of climate change, give organisms a period of adjustment and adaptation, and rebuild a stable earth environment (Zhou zhiyong, 2011).

The time management of biological disasters is to strengthen the cultivation and protection of disaster bearing bodies, including crops, trees, livestock, human beings, etc., improve the health level and resistance of disaster bearing bodies, strengthen the regulation of harmful organisms from disaster sources, and control their harm to disaster bearing bodies within the allowable threshold. The key to time management of biological disasters is to carry out precise monitoring of biological disasters, accurately find out the critical period of prevention and control. And take effective measures to control the rapid proliferation of pests and prevent the occurrence of biological disasters in the critical period of prevention and control (Zhang guoqing, 2010).

If food production must grow by 50 per cent from the shrinking land resources in the next 40 years, it will require sustained and significant funding, time and hard investment. Like the past world's agricultural triumph, the green revolution has saved us from hunger, and a major component of the solution will come from improved technology. The technology will require the production, processing, distribution and sale of food that is adequate, safe and nutritious to meet the needs and preferences of the world's human diet without affecting the sustainability of the natural environment. Long neglected global investment in agricultural and food research and development must at least be doubled to accelerate the development and application of promising technologies. From 1991 to 2000, the total agricultural research and development expenditure in Africa decreased by 0.4 % per year, and Asia grew by 3.3 %. As a result, land productivity in East Asia increased from 1485 US$ ha-1 in 1992 to 2129 US$ ha-1 in 2006, but in sub Saharan Africa, land productivity fell from 79 % in 1992 to 59 % in 2006 (IFPRI, 2008).

Any discussion of food security is incomplete and does not recognize complex networks of socio political, trade and other issues that are often more important than production and processing issues, since climate change will primarily mediate the effects of plant diseases, thereby affecting food production, quality and security. The review reminds all plant protection experts in a timely manner of the excellent science they deploy to minimize crop losses and can and need to contribute to informed policy debates. To achieve the goal of maintaining the increasing production and quality that can be achieved, research exchanges must be extended beyond the farm gate to promote awareness raising among policymakers and society as a whole. First, the research results can make policy more friendly through "clear take home information".

While researchers are used to dealing with uncertainty, it is often untrue for other members of the community and is not easy to convey information about new findings at a certain level of certainty. However, it is clear that detailed predictions of climate change are unlikely to be accurate for specific locations and actions that depend on them. It is important to determine the trends for simulating biological processes and their interactions and for their experimental verification. Crop yield loss models, mainly the consequences of complex biological interactions that lead to disease, must be combined with crop growth models and need to parameterize the two using the same trend values (Evans et al., 2008; Gregory et al., 2009; Butterworth et al., 2010; Fitt et al., 2011). However, the impact of infection or infection tolerance (which is not usually covered in the yield loss assessment) must also be calibrated by testing and included in climate change conditions (Newton et al., 2010b). The economic and social impact of these biological processes should be of great concern to pathologists and used as a tool for prioritizing research objectives. Especially, when these objectives require long-term capacity-building and Technological Development (for example, the application of advanced genomic technology to identify host characteristics, pest and pathogen collection). Policymakers often deal with many issues, including more acute issues related to climate change, such as rising sea level, malaria, floods and extreme weather events, and the rise in the prevalence of human diseases. Clear economic and social impacts, supported by clear and excellent science, can help raise awareness. Limiting water environment, harmful organisms and diseases, declining fertility, availability and degradation of soil resources are one of the key constraints to improve food production and quality. Climate change adds additional complexity to already complex agricultural ecosystems. Phytopathologists and other crop protection professionals usually develop and deploy strategies and tools in accordance with established principles to manage plant diseases, and many may also be applicable to climate change when considering predicted changes, processes and interactions. Therefore, research to improve crop adaptability by improving crop resistance to disease may not involve a new approach, although managing plant diseases may have additional advantages in reducing the rise of CO_2 concentrations (Mahmuti et al., 2009).

Therefore, most of the new investment to improve disease control in food crops only needs to accelerate the progress of new and existing promising strategies and methods, rather than "reinventing the wheel" under the guise of climate change research. This investment model will ensure that disease management solutions cover all the uncertainties associated with climate change, including the "business as usual" scenario. Under the field conditions simulating climate change, the empirical research on plant diseases is limited, which seriously limits the development of crop adaptation or disease management options under climate change. In addition, a lot of knowledge about the potential impact of global climate change has been collected by using the model. At present, some countries, regions, crops and specific pathogens have been preliminarily evaluated. From the perspective of food security, the focus must now shift from impact assessment to the development of adaptation and mitigation strategies and programmes. Two areas of empirical investigation are crucial: first, to assess the effectiveness of current physical, chemical and biological control strategies (including resistant varieties) in the context of climate change; and second, to incorporate future climate scenarios in all studies aimed at developing new tools and strategies. GM (genetically modified) solutions (Huang et al., 2002) must be seriously considered in an integrated disease management strategy to improve food security.

In the past century, the earth's climate has experienced unprecedented changes. Its potential impact on vector borne diseases also poses a huge threat to human health. The impacts of global climate change and meteorological factors on the number and geographical distribution of vectors, the growth and development of pathogens and the transmission of major vector borne infectious diseases need to be further studied. The variation and change of climate factors such as temperature, humidity, precipitation and wind speed have a significant impact on the occurrence, transmission and outbreak of major vector infectious diseases. However, the relationship between climate change and changes in the distribution and transmission mechanism of vector borne diseases is very complex. In addition, there are still some spatial inconsistencies in some research results, so more related research is needed in the future to provide a strong scientific basis for the formulation of adaptation strategies.

Weather hazards in crop production are those which are caused by adverse weather conditions. The disaster is caused by many factors, such as temperature, frost, etc. Different from the concept of meteorological disaster, crop meteorological disaster is closely combined with crop, which refers to the meteorological disaster suffered in the process of crop production (Wang Chunyi and Li Yijun, 2011). In recent years, crop meteorological disasters occur frequently with wide damage scope and heavy loss degree (Sun J et al., 1998; Ding Yihui, 2003; Zhai PM et al., 2005), such as the severe agricultural drought in North China from winter 2008 to spring 2009, the severe agricultural drought in Southwest China from autumn 2009 to spring 2010, and the severe flood disaster in South China in summer 2010; the same disasters occur in foreign countries: September 2008 Argentina experienced the most serious drought in 50 years in July 2010, and the drought situation in Argentina was very rare, so there was a lack of measures to deal with the drought, resulting in serious disaster losses. In July 2010, Pakistan suffered the most serious flood disaster in 80 years, Farmland flooding, crop failure and so on all indicate that meteorological disasters have become a major barrier restricting agricultural development and threatening food security. Therefore, the monitoring and early warning of crop meteorological disasters and emergency countermeasures are necessary for the safety of agricultural production. Through years of systematic and in-depth research, remarkable progress has been made in the occurrence mechanism, temporal and spatial distribution, meteorological indicators, diagnosis and prediction technology and defense measures of crop meteorological disasters, and the level of meteorological disaster prevention and mitigation has been improved. Crop meteorological disaster monitoring and early warning is the key to disaster prevention and mitigation in agricultural production. Because of the frequent occurrence of rice chilling injury, Japan is the first country in the world to carry out related research. In recent years, they focus on the mechanism of rice chilling injury, and carry out experiments in large-scale artificial climate laboratory to explore the index of chilling injury and loss evaluation model. The United States, Canada and other countries have also carried out research on rice chilling injury in varying degrees (Wang Chunyi et al., 2005; Zhang Shunqian et al., 2007). At present, the research of crop disaster early warning system has been carried out a lot, which greatly improves the prediction ability of crop disaster. Many research results of monitoring and early warning have been applied to the operation and service of agrometeorological disasters, and achieved good results. But the precise and dynamic monitoring and warning of crop meteorological disasters is still a big problem (Zhang J, 2004). Crop meteorological disasters have the characteristics of "mass occurrence". Sometimes several disasters occur at a certain time or in a certain area at the same time, which poses a great threat to crop production. For a long time, the research on crop meteorological disaster monitoring and early warning has paid more attention to the single disaster research, without focusing on the mass occurrence of crop meteorological disasters, the multiple relationships of influencing factors and the physical background of their complex mechanisms, without paying attention to the synchronous research on environmental impact and biological stress resistance, and lack of interdisciplinary high-level research on major agricultural meteorological disasters These researches are difficult problems of crop meteorological disaster monitoring and early warning (Wang Chunyi and Li Yijun, 2011).

The technology of crop meteorological disaster impact assessment and risk zoning has been widely studied by scholars at home and abroad, and the impact of single disaster or comprehensive disaster has been deeply studied. The United States established a statistical model to evaluate the disaster area of crops by using field observation and hail data, and built the risk type level of hail singing according to hail daily frequency and crop loss data. Finnish scholars study the correlation between climate change and hail weather change. Through the different crop development stage, the defoliation ratio simulates the impact of hail damage on the later yield, and has made great progress. However, there are still many difficulties to be solved in the impact assessment and risk zoning of crop meteorological disasters. (1) The accuracy of the impact assessment of single disaster crop meteorological disaster and the refinement of comprehensive disaster crop meteorological disaster impact assessment are the urgent problems to be solved in the future crop disaster impact assessment. It is still a very complex problem to evaluate the effects of crop meteorological disaster on the basis of the mechanism of crop meteorological disaster. In order to solve this problem, we need to strengthen the field test and test the possible situation by obtaining reliable data, so as to establish a quantitative system to evaluate the impact of disaster. (2) Standardization of crop meteorological disaster impact assessment. It mainly includes the standardization of evaluation index system, the standardization of evaluation methods and the standardization of evaluation characterization. The standardization of crop meteorological disaster impact assessment involves many departments and has many interdisciplinary problems. It is a very difficult problem not only involving scientific research but also related to all aspects of society. To solve this problem, the national authority should take the lead, work together with relevant departments to solve the key issues and propose a national standard. (3) The quantitative development of crop meteorological disaster impact assessment system is one of the problems that need to be solved in the field of agricultural meteorological disaster business service (UN, 2009). The factors of crop meteorological disaster are complex, and are restricted by human, social and economic development. Moreover, crop meteorological disasters are not single occurrence in a certain area, and there are various disasters concurrency. In view of this problem, we should strengthen the research on the impact grade index of agricultural disasters, and integrate the comprehensive disaster impact grade index system (8) according to the regional characteristics according to the occurrence frequency and hazard degree of the main agricultural meteorological disasters in the region. (4) It is still difficult to establish a comprehensive crop meteorological disaster risk assessment system (UN, 2009). The coupling relationship between natural elements and the risk of crop meteorological disaster should be established. Based on the systematic study of the mechanism of crop meteorological disaster risk formation, the index system and evaluation model of crop meteorological disaster risk assessment should be constructed (Wang Chunyi and Li Yijun, 2011).

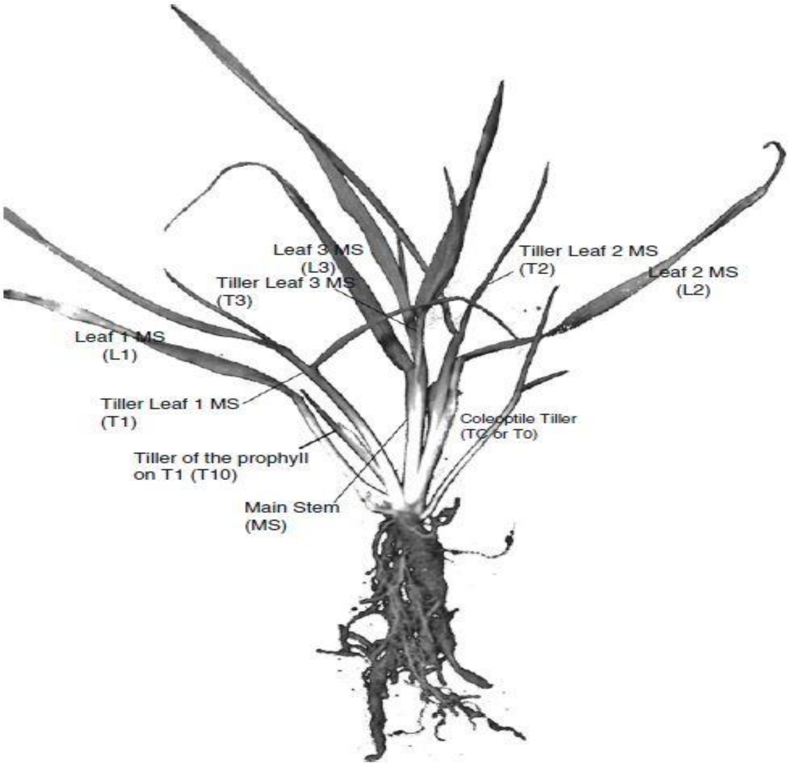
Crop development, crop improvement continuum and long-term breeding

Plant development is the process of crop quantity, yield and quality. Plant development is the process of plant in its life cycle, which has aroused great interest in human history, because it is necessary to know and predict when the harvest part of plant is in the best stage. This kind of knowledge is especially important (even crucial) in medicinal plants, because in plants (such as medicinal plants), the harvest time determines the value of products (such as medicinal plants). This interest increased as groups moved from hunting and gathering to agricultural societies. Crop development can be defined by the number and rate of plant appearance, growth and senescence. However, this definition lacks information about when the transition from vegetative plant to reproductive plant occurs, which is defined by crop phenology. Crop growth and development is the main mechanism for plants to escape biotic and abiotic stresses and adapt to the environment, which is of great significance in agricultural production. At a more practical level, it affects crop management because cultural practices are more effective at specific stages of crop development (Gregory S. et al., 2019).

Major food, feed and industrial crops have been domesticated in a number of centers of origin, including the fertile crescent, America and China. The wild relatives of modern crops have adapted to the environment prevailing in the center of origin. These primitive crops are locally grown in the areas of origin, but some species show a significant ability to adapt to the new environment and spread globally with human migration and trade. For example, wheat was domesticated in the Middle East ("fertile crescent") (Heun M et al., 1997), about 32 °N, and is currently planted between 30 and 60°N and 27 and 40 °S. However, it can grow at low latitudes, high altitudes and even in the arctic circle beyond these limits. This kind of environment makes wheat become one of the most plastic crops. It needs a large number of developmental mechanisms to adapt to this different environment. The photoperiod ranges from 13-14 hours to nearly 20 hours. One of the main achievements of the "green revolution" is the discovery of photoperiod insensitive wheat mutants that can grow in low latitudes. Developmental plasticity is the key to the adoption of crops in a wide range of environments. Although growth and development are related, they are different processes. Development is the initiation and differentiation of organs and the progress of cells, organs and plants in their life cycle, while growth is the change of the size or weight of the initial organs. Biological factors (such as genetics, weeds and diseases) and abiotic factors (such as temperature, light, water and nutrients) affect the occurrence, growth and senescence of plant organs. Since Johann Wolfgang Von Goethe first published the metamorphosis of plant in 1790, people have made extensive research on how plants germinate and mature in an orderly and predictable way. This research has led to a broad conceptual framework for plant development, producing many tools to predict plant development. New shoots of plants are formed by forming a series of almost identical tectonic blocks, which are called vegetations (Gray A, 1879; Bateson W, 1894). A vegetative plant is associated with a leaf, and the plant body is produced on a twig in an orderly manner; for example, the plant body of leaf 2 is formed after the plant body of leaf 1.

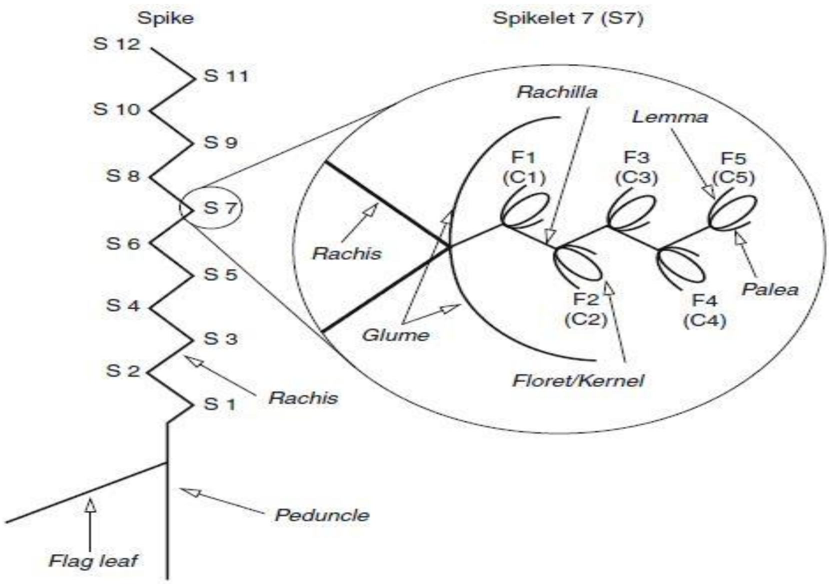
Phenology is the study of the life cycle of plants or animals and how it is affected by seasonal and interannual climate change. The phenology of a crop is defined by a series of stages, which in turn define the phenology. Stem tips may need to be examined at some stages of identification. For example, after germination, the apical meristem produces vegetative structures, such as leaf primordia. When the temperature and photoperiod meet the requirements, the shoot tip will start to start the reproductive structure, such as spikelet and floret primordium. The occurrence rate of plant body and the change of shoot tip are regulated by the heredity, environment and their interaction. The main environmental driving factors of plant development are temperature and photoperiod, and their effects on phenology interact with plant genetic response through photoperiod sensitive genes, vernalization genes and precocity itself. This article covers how plant development is regulated by temperature and photoperiod. Temperate grains are valued because they can adapt to a variety of environments and exhibit a series of adaptive mechanisms to regulate their development. However, before explaining their rules, it is necessary to define the parts of the plant and how to build the canopy, as well as the sequence of events throughout the crop cycle. This article first defines the canopy structure and the event sequence of crop development, and then the latest knowledge about how temperature including vernalization and photoperiod regulate crop development. At the end of this article, there are two important parts: crop development model and future direction. It is very important to establish crop development model, to understand the physiological and genetic basis of crop development, to predict the possible time of key development events as accurately as possible, to assist breeding plan and management practice, and to fine tune varieties according to current and future climate conditions (Gregory S. et al., 2019).

Because plant development is an orderly process, accurate identification of plant parts helps to describe the process and quantify the development rate. Several naming systems for plant parts have been proposed, but most of them are very similar. For example, l (Jewiss O, 1972; Klepper B et al., 1982 and 1983) (Fig.5) can be used to start from the first leaf L1 (Klepper B et al.,1983), and the true leaf of each twig can be top numbered. Similarly, the Jewiss (1972) proposed a system for naming tillers, which has been modified and extended by many people, but the modified system proposed by Klepper et al. (1982 and 19838) is being adopted more and more. This system uses the number of leaf axils of the parent branch to name tillers. The first tender branch in the seed is the main stem. The tillers appearing from the axils of the main stem are primary tillers, named by T and the number corresponding to the number of leaves. For example, the tiller from the first leaf (L1) of the main stem is called T1. Primary tillers can produce tillers called secondary tillers. Secondary tillers can be produced from the axils of petioles of primary tillers, and their second number is zero (Fig. 5).



Crop development related to temperature and photoperiod. **Fig. 5** names the leaves and tillers of winter wheat plants

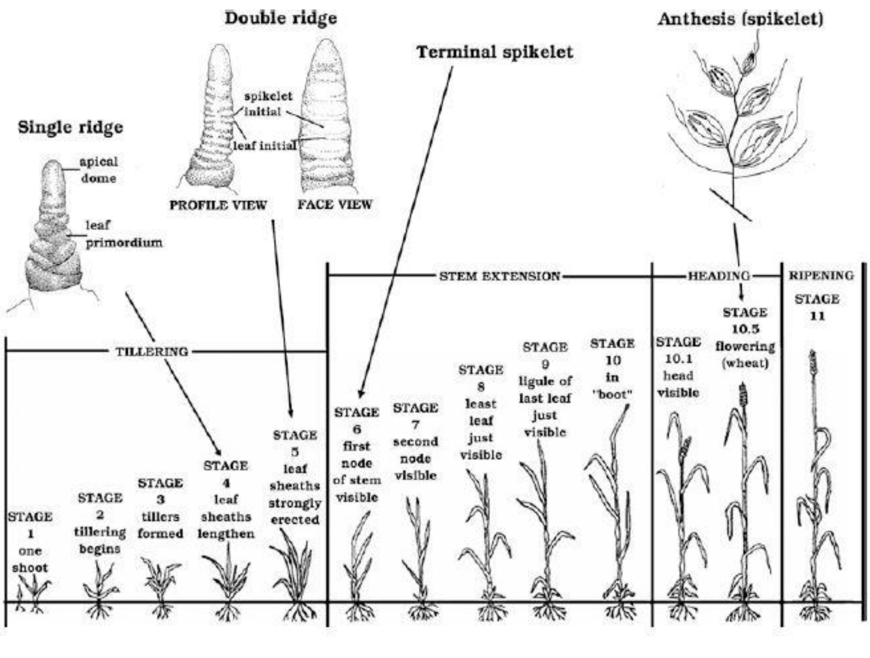
Similarly, the leaf and tiller naming scheme was extended to wheat inflorescences. Klepper et al. (1983) defined a numerical indicator of inflorescence development, which Wilhelm and McMaster (1996) extended to uniquely identify each plant part. Spikelets are named s, followed by the position from the base of spikelet. Then, S1 is the basal spikelet and S2 is the second spikelet from the peduncle (Fig. 6). The florets are named F and numbered upward from the base of the rachis. After fertilization, the letter F for floret is changed to the letter C for caryopsis. This system allows the reproductive structure of grasses, such as wheat, to be named after each spikelet.



The development of crops is related to temperature and photoperiod, **Fig. 6** The position of spikelets is indicated by the letter S and numbered along the axis. The position of floret / caryopsis is indicated by the letter F / C and numbered along the axis (from: Wilhelm and McMaster, 1996)

The reciprocal of thallus is called development rate (DR), which can be summarized as the reciprocal of the time interval between two development events. The relationship between plastids and chloroplasts depends on the species. In wheat, the production of leaf primordia is faster than their appearance, which indicates that different mechanisms are involved in the regulation of each process. The leaf primordium starts from the meristem of the stem tip, where new cells are produced quickly. After the formation of leaf primordium, the number and size of cells continued to increase, but this increase did not occur in the apical meristem, but in the middle meristem of the leaf base. The amount of a leaf growing in a curly leaf until it appears is much larger than the amount of leaf primordium formation, so it is more dependent on available resources such as water, carbohydrates and nutrients (Gregory S., 2019).

The development stage of crops appears in a consistent pattern every year, and there are many methods to describe the phenological characteristics of crops. The most widely used phenological scales of temperate grain are Feekes (Large EC, 1954), Zadoks (1974), Haun(1973) and BBCH (1991). The feekes scale is shown in Fig. 7:



The relationship between crop development and temperature and photoperiod is shown in **Fig. 7** The approximate time of some shoot tip development events (from: McMaster G, 2005)

The abbreviation BBCH derives from the names of the originally participating stakeholders: "Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie". BBCH scale of cereal is mainly based on Zadoks scale, while Han scale mainly describes the development of shoots before the last leaf is fully expanded. The phenological scale considers the basic development stages, such as germination, emergence, tillering, stem elongation, heading, flowering, grain filling and physiological maturity. The differences between the scales are mainly reflected in the characteristics of each stage. Some development phases are not well defined, resulting in confusion in measuring and reporting on these phases. For example, the beginning of stem elongation is usually recorded as the date of extraction or when the first node is visible on the ground; however, when the top is underground, the first node that is easily visible is formed and only visible after the stem is extended enough to raise the top and node to the ground. Similarly, physiological maturity refers to when the maximum dry weight is reached. In wheat, it is a little difficult to determine physiological maturity, because there is no obvious morphological change as corn (and sunflower). In corn, when the maximum dry weight is reached, a black layer appears near the bottom of the grain. The feekes scale defines harvest maturity as the 90% maturity of rice (*Oryza sativa L.*) when it is difficult to segment the grain along the crease, as when the grain can not be dented with nails. These definitions may not be closely related to the maximum seed biomass. Therefore, it is now generally accepted to assume that when all green disappears from the ear, the physiological maturity of temperate grain is assumed. This definition seems reasonable, because leaves and internodes have lost all the green, so no photosynthesis has occurred, and no reports have been made that carbohydrate reserves are now being transferred to the grain (Gregory S. et al., 2019).

Crop development is regulated by environmental factors that interact with plant genetics. Many developmental responses related to temperature and photoperiod are well known and can be well predicted at the crop level. Similarly, the rapidly emerging knowledge in genomics helps to understand the genetic basis of some aspects of crop development. Unfortunately, the quantitative integration of genetic and physiological knowledge is largely unknown, and both genetic and physiological models will benefit from better integration of knowledge. For example, the genetic basis of photoperiod and vernalization pathway is well known. With the development of new genome research, more complex models are being established (Higgins JA et al., 2010) to show the complexity of flowering time. However, the genetic mechanisms described in this entry interact with responses to other environmental factors, which define a highly complex network of response signals that is not yet fully understood. Fortunately, new research on GxE integration is increasingly being reported, which will improve our model. The study of model organisms has greatly promoted the understanding of crop development, but there are also some key differences, such as the lack of vernalization gene FLC (Flowering Locus C) in temperate grains.

For example, four vernalization genes have been described in wheat, but only three have been cloned and located in the vernalization pathway. Completion of this approach will greatly improve the understanding of how temperate crops respond to non freezing low temperatures. At the same time, the physiological response to temperature has been widely studied, and the genetic difference has been well proved; however, the basis of genetic effect is still unclear. Encouragingly, new genes (such as earliness per se (EPS-1) are being identified, but once the main processes (photoperiod and vernalization requirements) are solved, the quantitative variation of crop development needs to identify new genes, which may not be effective. For example, a recent study on Maize found that there was no significant QTL (quantitative trait locus) for flowering time in nested mapping population (Buckler ES et al., 2009). Although no major epistatic or environmental interactions were found, individual QTL effects were different in the original lines of the population (Buckler ES et al., 2009). In order to establish quantitative genetic model, it is necessary to determine QTL or gene effect accurately.

The global population growth rate has exceeded the linear growth rate of food production, so the Food and Agriculture Organization of the United Nations (FAO) estimates that 70% more food must be produced in the next 40 years (FAO, 2009) to fully feed the estimated population of more than 9 billion by 2050. The consequences of climate change and changes in crop production systems have greatly reduced the possibility of achieving this unprecedented growth (34), which requires increasing the historical linear growth of annual food production by 37% (Tester M, 2010).

Frequent droughts and floods, such as the recent drought and flood in the horn of Africa (5), are symptoms of the severe impact of extreme weather conditions on crop production and food security. Chatham House (Evans A, 2009), based on data from the United Nations Intergovernmental Panel on climate change (IPCC), concluded that the direct consequences of climate change would lead to malnutrition in another 40 million to 170 million people. In fact, the overwhelming prediction is that extreme weather events, such as heavy precipitation, heat waves and sea level rise, will occur in many parts of the world in the 21st century (IPCC, 2012), and the resulting floods, droughts and salinization are the most serious consequences. Because of the different types and degrees of problems, the strategies developed to address these constraints will vary from region to region. For example, although there is a consensus that global rainfall will generally increase, annual rainfall will actually decrease in some places, and the seasonality of rainfall and the timing of crop cultivation will also change. What is more worrying is that the frequency and duration of extreme weather events are expected to increase. Table 1 summarizes some of the expected negative impacts on crop production in various regions of the world.

Table 1 some expected negative impacts of climate change on crop production in different regions (FAO, 2010)(Adapted from the second report on the state of plant genetic resources for food and agriculture in the World) From: repositioning crop improvement to adapt to changing climate conditions in the 21st century

ASIA
Crop yields could decrease by up to 30% in Central and South Asia
More than 28million hectares (ha) in arid and semi-arid regions of South and East Asia will require substantial (at least 10%) increases in irrigation for a 1 °C increase in temperature.
AFRICA
One of the most vulnerable continents to climate change and climate variability
With many semi-arid regions and projected increase of 5% to 8% by the 2080s, likely reduction in the length of growing seasons will render further large regions of marginal agriculture out of production
Projected reductions in crop yields of up to 50% by 2020
Fall in crop net revenues by up to 90% by 2100
Population of 75 to 250 million people at risk of increased water stress by the 2020s and 350 to 600 million people by the 2050s
AUSTRALIA AND NEW ZEALAND
Agricultural production may decline by 2030 over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire
Change land use in southern Australia, with cropping becoming non-viable at the dry margins
Production of Australian temperate fruits and nuts will drop on account of reduced winter chill
Geographical spread of a major horticultural pest, the Queensland fruit fly (Bactrocera tryoni), may spread to other areas including the currently quarantined fruit fly-free zone
Crop productivity is likely to decrease along the Mediterranean and in south-eastern Europe
Differences in water availability between regions are anticipated to increase
Much of European flora is likely to become vulnerable, endangered or committed to extinction by the end of this century
Increased climate sensitivity is anticipated in the south-eastern USA and in the USA corn belt making yield unpredictable
Yields and/or quality of crops currently near climate thresholds (for example, wine grapes in California) are likely to decrease
Yields of cotton, soybeans, and barley are likely to change
Risk of extinctions of important species
By the 2050s, 50% of agricultural lands in drier areas may be affected by desertification and salinization
Generalized reductions in rice yields by the 2020s
Reductions in land suitable for growing coffee in Brazil, and reductions in coffee production in Mexico
The incidence of the coffee leaf miner (Perileucoptera coffeella) and the nematode Meloidogyne incognita are likely to increase in Brazil's coffee production area
Risk of Fusarium head blight in wheat is very likely to increase in southern Brazil and in Uruguay
Subsistence and commercial agriculture on small islands will be adversely affected by climate change
In mid- and high-latitude islands, higher temperatures and the retreat and loss of snow cover could enhance the spread of invasive species including alien microbes, fungi, plants, and animals

It takes a lot of time, resources and manpower to introduce the genetic diversity of wild species into food security varieties. This is a long process, starting from the field, where genetic resource experts, botanists and taxonomists locate, identify and collect breeding materials. Then, it is preserved and identified by gene bank manager; further identification and evaluation, character and gene discovery and verification are carried out by geneticists, agronomists and pathologists; finally, it is carried out by pre breeder or germplasm enhancement program, and variety development breeder. These products then go into the seed system (formal and informal) and eventually into Farmers' fields (Hannes, 2017).

Crop wild relatives (CWRS) are closely related to crops and are potential sources of important traits including insect resistance or disease resistance, yield improvement and / or stability (Perrino, 2020). It must also be taken into account that they are key components of plant genetic resources for food and agriculture (PGRFA), although they are ignored for conservation purposes, and in situ and ex situ conservation methods should be used to ensure their availability (Zair W, 2020). In terms of currency, CWR has made significant contributions to agriculture and horticulture as well as the world economy (Maxted, N. et al., 2008 and 2009). Pimentel et al. (Pimentel, D., 1997) estimated that wild related plants contribute about $20 billion annually to increasing crop yields in the United States and $115 billion worldwide. Phillips and Meilleur (1998) pointed out that the loss of rare wild plants has caused huge economic losses to agriculture. It is estimated that the annual wholesale value of the farm of relatives of endangered food crops is about 10 billion US dollars. Although these studies show clear differences, they highlight the major global economic value of CWR diversity to mankind. According to Maxted et al. (2006), CWR is a taxon belonging to the same genus as cultivated species. In this way, about 80% of European and Mediterranean plant species are CWR, which is important from a socio-economic point of view (Kell, S.P., 2008). However, genetic rather than taxonomic approaches suggest that only those species that can hybridize with cultivated species should be considered CWRS. According to Harlan and De wet (1971), gene pool represents a diversity pool, which can be used by organisms to adapt to the changing environment, and can also be used by breeders to improve crops. Wild relatives of a particular crop are considered to be in the same gene pool, and they can exchange genes with their related cultivated taxa even if they look different in taxonomy. Unfortunately, not all wild relatives are ready to do so. Therefore, based on the ability to exchange genes with cultivated species, CWR can be divided into three categories (The primary gene pool: GP1, The Secondary gene pool: GP2, The Tertiary gene pool: GP3) (Harlan, J.R and De Wet, 1971). In Italy, according to the concept of taxon, 43 CWS are at risk of insufficient protection in situ or in other places. However, if the endemic species in Italy were not taken into account, the number of 43 species fell to 14. In addition, according to the concept of gene pool. From the point of view of plant breeding, the number of gene pool decreased from 14 to 8. For the latter species, this paper describes their geographical distribution, conservation level, ecology, including vegetation and habitat 92 / 43 EEC, characteristics, gene pool and measures to avoid further genetic erosion. So as to improve the in situ and ex situ conservation of species and habitat. The ultimate goal is to strengthen the management and utilization of genetic resources, promote sustainable agriculture and environmental protection through special research, and make recommendations for each of the 14 chemical weapons considered to be at risk. (Perrino, E.V., 2021).

Crop wild related species (CWR) include the ancestors of crops and other more or less closely related species. In the process of domestication, crops will experience a genetic bottleneck, resulting in much less genetic variation than wild species. This genetic alignment makes crops more vulnerable to biotic and abiotic stresses. CWR has been used in formal crop improvement programs for more than 100 years (e.g., Mujeeb Kazi and Kimber, 1985, Large, 1940), especially in improving resistance to pests and diseases. For example, they have been used to enhance resistance to wheat false smut mites (Malik et al., 2003), potato late blight (Pavek and Corsini, 2001) and rice grass dwarf disease (Brar and Khush, 1997). Wild relatives of crops have been used to improve tolerance to stress abiotic conditions, such as drought tolerance in Wheat (Faroq and Azam, 2001), and heat tolerance in rice has been tested (Sheehy et al., 2005). They are also used to improve the nutritional value of some crops, such as protein content in durum wheat (Kovacs et al., 1998), calcium content in potato (Bamberg and hanneman, 2003) and provitamin A in tomato (Pan et al., 2000). Due to the latest progress of molecular technology, which improves the efficiency and accuracy of transferring the required traits from CWR to crops, it is expected that the application of CWR in breeding will increase (Hajjar and Hodgkin, 2007).

Climate is one of the main factors controlling the distribution of wild plant species, directly through physiological constraints on growth and reproduction, or indirectly through ecological factors such as resource competition (Shao and Halpin, 1995). The relatively mild climate change in the past century has had a significant impact on the distribution, abundance, phenology and physiology of many species. Many examples have recorded the species range moving up to the poles or altitudes, as well as the gradual advance of seasonal migration and reproduction (e.g., Walther et al., 2002, Parmesan and Yohe, 2003, Root et al., 2003, Parmesan, 2006). Global warming has accelerated in the past 30 years (Osborn and Briffa, 2005) and is expected to be between 1.1 and 6.4 ° C by 2100 (IPCC, 2007). Simulation studies (e.g., Thomas et al., 2004) show that climate change may lead to mass extinction. In view of the potential impact of climate change on global food production (Rosenzweig and Parry, 1994, Hijmans, 2003, Jones and Thornton, 2003), and the importance of crop wild genetic relationships in breeding new varieties, the adaptability of these new varieties to biotic and abiotic stresses has been improved, and the full protection of crop wild relatives is essential. The protection and utilization of CWR to broaden the genetic basis of modern crops is crucial for adapting agricultural systems to the impacts and consequences of climate change (Sheehy et al., 2005). However, due to climate change, these genetic resources themselves may face the threat of extinction in the wild. Therefore, assessing the potential impact of climate change on coal water slurry and formulating appropriate conservation strategies are the key activities to maintain agricultural production. The climate envelope model provides a method to assess the potential impact of climate change on wild species by predicting the range change. The climate envelope model uses the environmental data of the location of the discovered or undiscovered species to infer their climate requirements. These inferred requirements can be used to classify the applicability of any other location (Guisan and Thuiller, 2005).

Many studies have applied climate envelope based species distribution models to understand climate change impacts by using current and future climate data (Thomas et al., 2004) and past climate data (Ruegg et al., 2006). These methods basically transfer species adaptation in time, on the one hand, it is assumed that there is no greater plasticity than currently observed, on the other hand, no evolution is assumed, and many methods ignore the possible consequences of changes in biological interactions such as competition (Lawler et al., 2006). More and more studies have evaluated the suitability of applying species distribution models to predict range changes and assess the risk of extinction in the face of climate change (Thuiller et al., 2004, Araújo et al., 2005a, Araújo, et al., 2005b, Araújo and Rahbek, 2006, Hijmans and Graham, 2006, Lawler et al., 2006).

Although there is uncertainty in the application of species distribution models to understanding the possible impacts of climate change on species survival, the results are still important because they can help to select and prioritize actions to mitigate the negative impacts. Further investigation is needed to better understand the potential impact of climate change on wildlife species. First, different climate envelope models should be used and the results analyzed to verify the consistency between the models. Different GCM models and scenarios should also be used to further determine where the consistency of model results converges or disagrees. These measures may contribute to the uncertainty in the estimates, or may reduce that uncertainty. Second, experimental research can help to better understand the true adaptation of wild species to climate change. Peanuts, for example, are found in some of the hottest and driest regions in Latin America. Climate change is expected to create new climates that have not yet been found on the continent. The adaptation of these species to these new very high temperatures is unclear and can be tested by experiments similar to those proposed by Zavaleta (2006). The experimental research can make use of the advantages of land migration collection to conduct common garden experiments on different climate environment (representing current and future climate) in order to understand the physiological basis of climate adaptation from mechanism. Although there is uncertainty in the application of species distribution models to understanding the possible impacts of climate change on species survival, the results are still important because they can help to select and prioritize actions to mitigate the negative impacts. In this paper, we use climate envelope model to evaluate the potential geographical changes of the distribution of wild species in three cultivated crops. Using three migration scenarios, we evaluated potential range size changes and fragmentation of these climate appropriate areas. It is worth noting that even in CWR group, there are significant differences in the impact between species. Which means that conservation planning in the context of climate change should be analyzed by means of a level between species as a starting point for priority conservation of species in the field. However, our results are most related to the methods of offsite preservation of seeds stored in gene banks. Climate change must be a basic consideration for conservation management, and the selection of new reserves and existing areas management plans needs to take into account their expected impact (Jarvis, A. et al., 2008).

As a new source of genetic diversity, the wild close relatives of the wild close relatives of the plant species have been used in plant breeding for decades, and contribute to a wide range of beneficial agronomic and nutritional traits (Hajjar, R., 2007). Due to the continuous improvement of species and their diversity information and the progress of breeding tools, their utilization is expected to increase (Tanksley, S. D., 1997). However, this expectation is based on the assumption that the wild relatives of crops will be available for research and plant breeding at any time, which requires that they be preserved in the gene bank as germplasm resources and functional mechanisms to obtain such diversity (McCouch et al., 2013). A preliminary assessment of the overall conservation of wild related species in the gene bank shows that there is a huge gap (Vincent, H. et al. 2013), and a series of species are threatened by the transformation of natural habitats to agriculture, urbanization, invasive species, mining, climate change and / or pollution (Jarvis, A., 2008). Therefore, for biodiversity conservation and food security goal (Dempewolf, H. et al. 2013), it is timely to work together to improve the conservation and utilization of wild related species of crops, as the window of opportunity to address these deficiencies will not be opened indefinitely (FAO, 2010).

The distribution of wild relatives of crops is simulated to occur in all continents except Antarctica, and most tropical, subtropical and temperate regions except the driest and polar regions (Fig. 8).

The map shows overlapping potential distribution models for assessing wild relatives of crops. Dark red indicates that the distribution of potential taxa has greater overlap, that is, there are more wild relative taxa in the same geographical area.

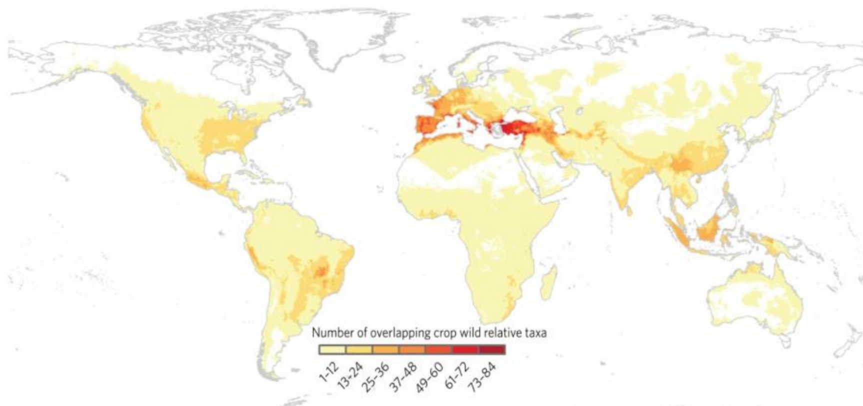


Fig. 8 Relative taxon richness of wild crops.
From: Global priorities for the protection of wild related species of crops

The most abundant taxa were simulated in the Mediterranean, near and southern Europe, South America, Southeast Asia and East Asia, and Central America, with as many as 84 taxa overlapping in a 25 km^2 grid. These richness hotspots are largely consistent with the traditionally recognized centers for crop diversity (Vavilov, 1926), although the analysis also identified some less well-known areas, such as central and Western Europe, eastern United States, southeast Africa and northern Australia, which also have considerable richness. Hot spots in tropical and subtropical regions are basically consistent with the areas with high abundance of recorded endemic flora and fauna, and have experienced abnormal habitat loss (Myers, N., et al., 2000). Temperate regions identified by the same criteria, such as California and Cape Floristic provinces, southwest Australia, central Chile and New Zealand, overlap much less with areas of rich crop wild relatives. Practical strategies for field collection and subsequent ex situ conservation have led to increased availability of plant breeding germplasm, and policies for managing germplasm collection and exchange need to be negotiated, 30. Assess the risks of field work (e.g., wars and civil strife in areas with high diversity of wild related species), coordinate the time schedule of field work to maximize the collection of viable seeds and other propagules, give priority to the target crop gene pool according to the interest of the breeding community in the use of wild germplasm, and determine the wild species in the relatively difficult gene pool to maintain Quality resources. Although the seeds of most wild related species can be preserved under standard conditions for long-term ex situ preservation, some wild related species will produce stubborn seeds or no seeds at all. Such wild related species may require more expensive methods (e.g., in vitro preservation or cryopreservation), especially for such taxa, alternative conservation strategies such as establishing in situ reserves may be more effective (Castañedaet al., 2016).

By providing wild genetic diversity to breeders in a more directly available form, pre breeding is a key step in linking the valuable characteristics of CWR with the development of modern varieties (Stander, 1993; Valkoun, 2001; Haussmann et al., 2004; Sharma et al., 2013). Pre breeding includes basic research and applied research. It is difficult to quantify the accuracy of CWR in prebreeding. A meta-analysis of research literature and variety release reports is helpful to fully understand the application trend of CWR in crop improvement (Harlan, 1976; Stalker, 1980; Prescott Allen, 1981 and 1986; Hajjar and Hodgkin, 2007; Maxted and Kell, 2009; Hunter and Heywood, 2011). However, these estimates are limited. By definition, pre breeding does not produce a variety for release, which is a key indicator of the success of breeding programs. On the other hand, once a useful trait is introduced, it is likely to spread rapidly through breeding programs, but it is difficult to quantify the progress in the number of varieties, because the early introduced breeding population is often not well documented, and many modern varieties are released by private companies, and the pedigree is usually not disclosed. Although growers sometimes publish release notes along with new varieties, the materials being developed by public research institutions are underreported. Usually, new variety publications include limited pedigree, ignored or unknown history and ancestral hybridization with CWR. Of course, the breeding projects being carried out by private enterprises are commercially sensitive and therefore more difficult to estimate. It is difficult to estimate the economic value of CWS due to the lack of mechanism to accurately track the genetic contribution and phenotypic effect of CWS to a specific variety, which will be a useful tool to provide information for decision-making. Existing assessments (Prescott - Allen and Prescott - Allen, 1986; Pimentel et al., 1997; Hein and Gatzweiler, 2006; Hunter and Heywood, 2011) show extensive estimates of economic value, which may underestimate the potential value of wild species, and do not reflect the breadth of ongoing CWR work. Clearly, there is a need to improve the mechanisms for monitoring wild species use in breeding programs.

There are several ways to use wild diversity, and two main ways can be distinguished: (I) "first selection": selection of wild materials expressing a certain trait of interest according to phenotype, genotype or collected local data, and use for directional hybridization, and then evaluation of hybrid offspring; or (II) "hybridization priority": hybridization of wild and domesticated materials with a wider range, and in domestication The characters of interest were screened out under the background of genetic transformation. According to different traits, the first method can explore agronomic traits data (directly expressed observable traits), genotype data (known alleles related to a specific trait), or combine the two by using statistical genetics tools through targeted pathological screening. This concept has been described in the literature as a predictive feature (Thormann et al., 2014). Once traits of interest are identified in wild species or individuals, they need to be transferred to the crop background. Or, first of all, cross between wild and domesticated taxa, and screen their progenies (as F1 or progeny materials) for beneficial traits. The latter strategy, although the initial focus is much smaller, may reveal unexpected sources of diversity, which can only be revealed in the context of domestication (Hannes et al., 2017).

Once the allele of interest is transferred to the target background, a certain amount of backcross is needed to dilute the harmful diversity usually associated with CWR introduction. When these non designable features are associated with the features of interest, they are usually called chain resistance (Zamir, 2001). There are many traits related to poor agronomic traits in wild species, which are systematically selected from their domesticated close relatives. These may include, among other things, low yields, broken seeds, and smaller seed or fruit sizes (Salamini et al., 2002). These characteristics bring many practical problems to breeders, such as the difficulty in recovering enough seeds, the inability to use standard equipment, or the need to meet different agronomic or horticultural requirements. Linkage resistance remains an important obstacle to the use of wild species in many crop improvement projects, although in some cases intensive genetic mapping and marker assisted selection (MAS) can be used to help solve this problem.

Despite these difficulties, experts surveyed are generally optimistic that wild species will play an increasingly important role in crop improvement. Our in-depth literature review of past use of CWR is the most comprehensive of such studies to date, and extends the work of Hajjar and Hodgkin (2007) 10 years ago, who focused on 19 crops, including extensive breeder interviews, as well as Maxted and Kell (2009) and earlier reviews, Robert and Christine Prescott Allen reviewed the application of CWR in plant breeding for the first time in 1986. Now we've provided an online resource （http://www.cwrdiversity.org/checklist/）It includes 4157 potential or confirmed "uses" of CWR in crop improvement, distributed in 127 different crops and 970 CWR taxa. They are divided into seven "breeding utilization categories" as follows: agronomic traits (485), abiotic stress (700), biological stress (2427), fertility traits (272), morphological traits (20), phenological traits (54) and quality traits (199) (Fig. 9-10-11).

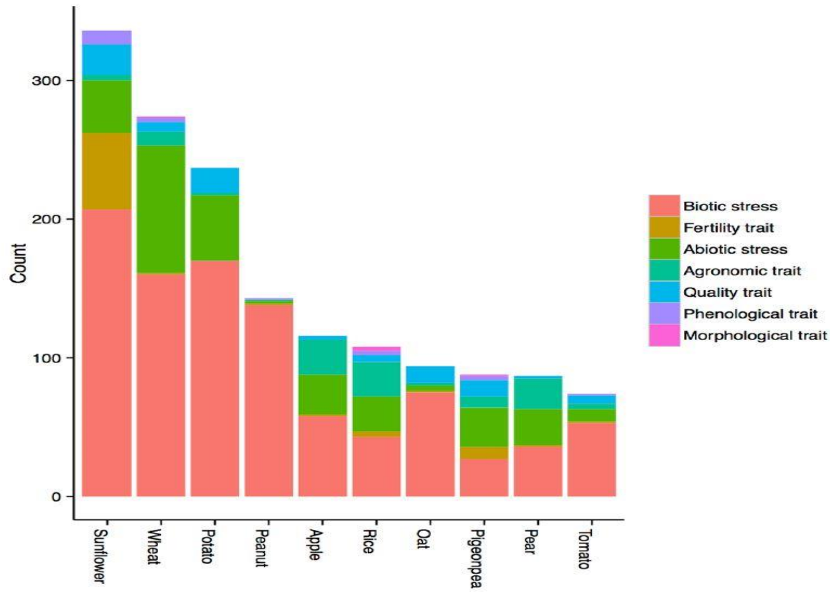


Fig. 9 Identified and potential "breeding uses" of 10 crops, with most "breeding uses" cited in the literature, are classified in the trait category (Hannes et al., 2017).

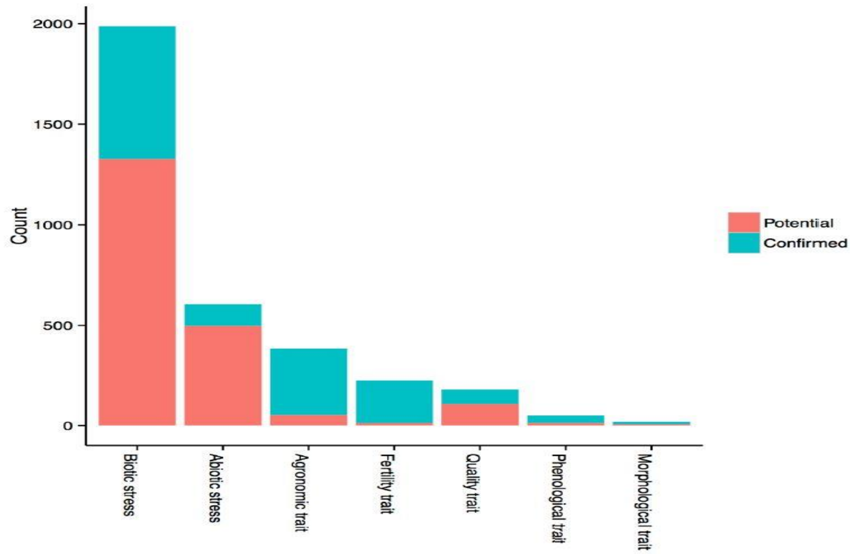


Fig. 10 Identified and potential "breeding uses" of 10 crops, with most "breeding uses" cited in the literature, are classified in the trait category (Hannes et al., 2017).

As shown in Fig. 9, sunflower (*Helianthus annuus L.*), wheat (*Triticum aestivum L.*) and potato (*Solanum tuberosum L.*) are the most common crops for CWR breeding. For sunflower, after biological stress, the biggest "utilization" category is fertility characteristics, which can be explained by the historical important role of CWR in identifying cytoplasmic male sterile sources for breeding hybrid sunflower. For wheat and potato, abiotic stress types seem to be particularly strong, which indicates that CWR of potato and wheat, unlike most other crops, seems to have been significantly utilized in abiotic stress resistance. Overall, the number of "used" references seems to be increasing over time, especially since the beginning of the century (Figure 11).

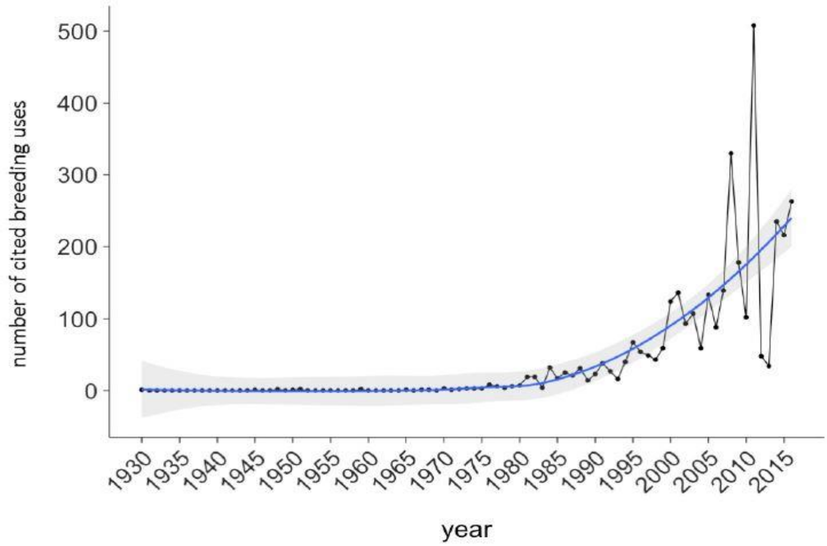


Fig. 11 The number of breeding uses (black line) quoted in each year from 1930 to 2016 was fitted with local weighted scatter smoothing (blue curve).

This shows that the scientific community has a higher and higher understanding of the value of these species. In 2011, due to the publication of wild crop genetic relationships: genome and breeding resources, the number of breeding uses cited reached its peak (Kole, 2011). The application range of CWS varies with crops. Crops with long breeding history of wild related species continue to benefit most from wild genetic diversity (Fig. 11). Rice (*Oryza sativa L.*), tomato (*Solanum lycopersicum L.*) and wheat (*Triticum aestivum L.*) especially have large-scale and mature pre breeding projects, which use advanced genomic tools and diversified characteristics and evaluation data, and pay special attention to CWR (Hajjar and Hodgkin, 2007; Kilian et al., 2011; Nemeth et al., 2015).

The main crops in the global high-yield temperate crop regions are facing the increasing threat of climate change, especially the drought and high temperature in the critical development period of crop life cycle. The research to solve this problem usually focuses on trying to identify foreign genetic diversity with obvious stress tolerance or stress avoidance, clarify and introduce responsible genetic factors, or find potential genes as the basis of targeted genetic modification. Although this method is occasionally successful in specific stress environments, such as by regulating root depth, major gene modifications of plant structure or function are often highly environment dependent. In contrast, the long-term genetic gain obtained by conventional breeding gradually improves the yield of modern crops by accumulating beneficial and small effect varieties, and these varieties also provide yield stability through stress adaptation. Here, we review the breeding progress of main crops and the effects of long-term conventional breeding on climate adaptation and yield stability under abiotic stress. Looking ahead, new approaches need to be outlined and improved to complement traditional breeding in order to maintain and accelerate the breeding process, despite the challenges of climate change as a prerequisite for sustainable future crop productivity (Snowdon, 2020).

Crop growth and performance are affected by a complex interaction of multiple interacting environmental (E) and management factors (M), and climate change accounts for a significant part of global crop yield change (Ray et al., 2015). Both E and m have strong interactions with plant genotypes (G), so higher-order G* E* M interactions must be considered in breeding and agronomy (Cooper et al., 2020). Considering that G * E * M interaction can affect all physiological processes under quantitative genetic control, such as water and nutrient absorption or transportation, dry matter production and distribution, organogenesis and flowering. The effects of senescence or maturity on source sink efficiency and yield performance under environmental stress are very complex. Therefore, a better understanding of the genetic and physiological interactions between the molecular and developmental processes of crop response to climate change is considered to be the key to minimizing crop adaptive response limiting yield potential (Fernie et al. 2020). However, in order to identify useful and selective breeding traits, it is extremely difficult to understand the complexity of G * E * M interaction. Therefore, in the past century, yield performance has generally been regarded as the final result of all possible G * E * M interactions in arable crop breeding. In many crops threatened by climate change, a lot of efforts have been devoted to pre breeding and introduction programs in recent decades, especially focusing on the identification and implementation of variations that may be useful for climate adaptation traits. The most deeply studied abiotic stress in all crops is drought, which reflects the main threat of climate change to global yield performance (Snowdon, 2020).

This classical conventional breeding method is the basic basis for the more or less linear increase of genetic gain in the past century. A large number of studies have been carried out on many different crops in different regions, such as wheat (Crespo Herrera et al. 2018; Fischer and Edmeades 2010; Peltonen sainio et al Al. 2009; Sanchez Garcia et al., 2012), maize (Badu apraku et al., 2015; Ci et al., 2011; duvick 2005; Russell et al 1991), rape (Stahl et al., 2017, 2019), soybean (Rincker et al., 2014; Ustun et al., 2001), barley (Laidig et al., 2017), sugar beet (Loel et al., 2014) and rye (Laidig et al., 2017). The breeding duration of cultivated crops, from the initial hybridization to the subsequent fixation of the required genetic components in the parents to a stable variety, can usually be as long as 10 years. Therefore, it seems that the traditional selection process for testing breeding progenies in multi environment phenotype assessment over the years is essentially very suitable for selection to adapt to gradual climate change, which will also develop in the process of several years or decades. On the other hand, if severe yield inhibition caused by severe drought and high temperature (Lobell et al. 2011) becomes the norm rather than the exception in important temperate crop regions, the breeding process of these specific target traits must be accelerated faster than before to make up for the severe productivity loss caused by climate change. Therefore, in order to optimize the future genetic gain in the face of climate change, it is necessary to consider how to further optimize the selection process in order to capture genome-wide, small effect variance more effectively. These variances have a positive impact on the long-term adaptation of key abiotic stressors, and will not inadvertently have a negative pleiotropic impact on yield performance. Since genetic diversity provides a necessary basis for maintaining long-term genetic gain, breeding programs must pay attention to managing selection intensity and effective population size to reduce the risk of losing adaptive alleles that may be useful for future climate scenarios. The modern hexaploid wheat breeding pool shows a considerable initial effect, which is represented by the differential sub genome diversity pattern related to the directional selection of important phenology, plant height or resistance traits (Hao et al. 2020; Voss Fels et al. 2015; Zhao et al. 2019). For example, Voss Fels et al. (2016) found that the linkage resistance caused by preferential selection of loci affecting flowering after Vernalization of European winter wheat erodes the diversity of two closely linked QTLs for root biomass and strongly limits the phenotypic diversity of root traits which may be important in future varieties facing climate change. Therefore, it is still an important aspect of modern breeding program to recover allelic diversity from the sources of unadapted primary gene pool or exotic wild relatives (He et al. 2019) in order to maintain genetic diversity for a long time.

A common assumption about genetic diversity in the gene pool of modern high-quality crops is that the emphasis of breeding on high yield may inadvertently lead to the loss of important genetic diversity of climate adaptation traits. Which may be necessary to ensure sustainable breeding progress in the face of climate change. This assumption is based on a reasonable concern that the consequences of climate change are a relatively new phenomenon in the world's most productive arable areas. Where relatively predictable and favourable climatic conditions that have dominated the past century have been a key factor in building highly productive agricultural production systems. However, today, at a critical time of crop growing season, long-term and severe abiotic stress also threatens those regions that benefit from a century of great breeding progress under favorable climatic conditions. The plant breeding program with the goal of high-yield planting system logically focuses on maximizing the yield under the main production conditions. Since water and nitrogen supply are the main limiting factors of grain yield, historical yield growth is usually related to more water and nitrogen consumption rather than genetic gain (Sinclair and Rufty, 2012). This is sometimes interpreted as indicating that modern elite varieties reduce water and nutrient efficiency, even if empirical studies show the opposite (e.g., Badu Apraku et al. 2015; Hatzig et al. 2015; Voss Fels et al. 2019).

As high-yielding traditional farming systems usually optimize plant nutrition and health through adequate application of mineral fertilizers and chemical plant protection, it can be expected that genetic variation related to performance may be eliminated from modern breeding pools through genetic drift due to lack of selection advantage under suboptimal input conditions. For example, Kahiluoto et al. (2019) asserted that the reduction in "reactive diversity" of European winter wheat cultivars they explained was due to the reduction in genetic diversity caused by breeding, although there was no data to support this claim. However, in direct contrast, various empirical studies actually show that the genetic diversity in the elite gene pool of European wheat has not decreased in recent decades (Van de wouw et al. 2010; Voss Fels et al. 2019; Würschum et al. 2018).

Although there is evidence that this is not the case, non breeders often focus on improving grain or biomass yield, believing that this is related to the neglect of sustainability related traits such as disease resistance, nutrient or water use efficiency. Possibly because people mistakenly believe that these traits are not related under high yield conditions, because yield is suppressed through intensive management Control factors can be minimized. This argument chain is often expressed in mass media sources, but rarely supported by empirical data from peer-reviewed publications. However, in sharp contrast to this hypothesis, empirical studies on the retrospective breeding progress of different crops actually draw the opposite conclusion (Badu Apraku et al. 2015; e.g.Chen et al. 2013; Voss Fels et al. 2019). At the same time, some studies also revealed the genetic structure of long-term yield progress of crop production under suboptimal growth conditions, and provided insights to guide future breeding to maintain breeding progress in the face of climate change. These examples demonstrate the importance of empirical data to document the consequences and potential of breeding to improve adaptation to suboptimal production environments.

Based on the above review of breeding progress, the results of Voss Fels et al. (2019) showed that, due to the breeding results, the yield performance of varieties had obvious linear genetic gain pattern over time. In addition, the increase in yield over time was also reflected in the corresponding incremental improvement patterns for almost all other traits (Fig. 12). Most interestingly, these traits not only include traits that are expected to lead to continuous improvement through continuous selection in long-term breeding, such as important fungal resistance, grain quality, harvest index, and key major yield components, such as grains per panicle (Fig. 12). In addition, in complex, low heritability traits, clear evidence of continuous and increasing genetic gain can also be observed, because breeders do not have the resources for specialized long-term selection. For example, nitrogen use efficiency and photosynthetic efficiency of new varieties are higher than those of old varieties, although these traits are difficult to show and expensive in large-scale breeding population multi environment experiments. The obvious explanation is that traits that affect more efficient use of resources, such as water, nutrients, and light, contribute significantly to the overall performance of intensive cropping systems in highly competitive environments. On the contrary, it is helpful to accelerate the genetic gain and keep the yield stable to clarify and consider the related physiological components and their potential quantitative genetic structure in breeding activities.

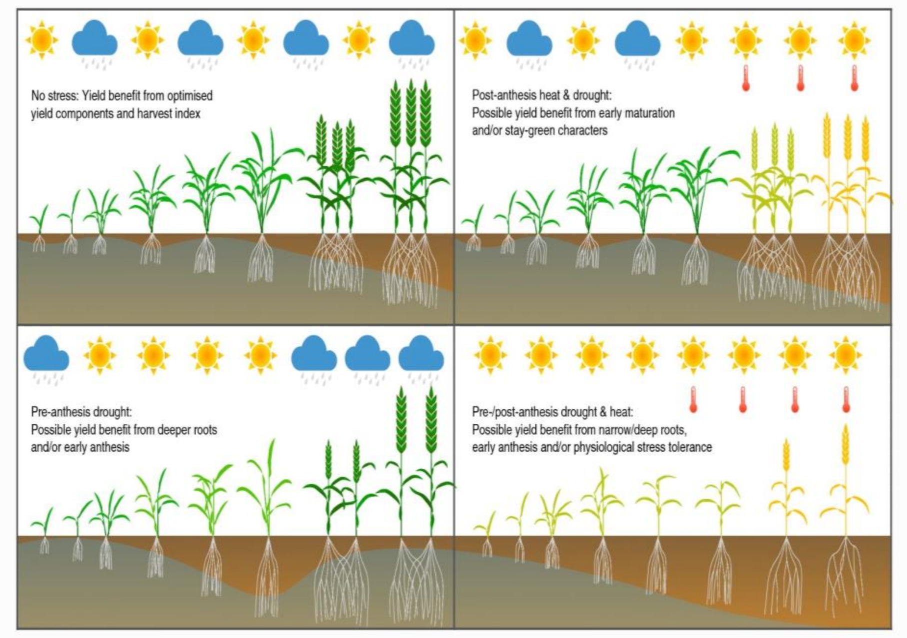


Fig. 12 From: Crop adaptation to climate change as a consequence of long-term breeding (Snowdon, 2020)

Climate change may have very different effects on crop performance, depending on the time point and duration of drought events, and whether drought stress occurs simultaneously with heat stress or alone. According to the type and intensity of stress, different genetic responses may be more conducive to the performance of varieties. This means that there is no single, simple solution to overcome the potential impact of drought stress caused by climate change. Selection performance and yield stability may be the best way to maintain crop performance and reduce risk under the expected stress scenario that usually occurs in a specific target area. Yield selection in the target environment also improves complex stress response characteristics and yield stability (Voss Fels et al., 2019).

In response to climate change, "silver bullet" breeding, in the form of new or induced genetic variation for beneficial phenological and physiological responses, can certainly play an important role in environment-dependent crop stress adaptation. And new tools such as gene editing provide breeders with new opportunities to accelerate the implementation and accumulation of beneficial variants of important target traits. However, the major genes of most key adaptive traits are usually rapidly fixed in high-performance modern crop gene banks. The pleiotropic interactions associated with severe changes in plant phenology mean that breeders need to be cautious in promising huge returns from technological breakthroughs at the single gene level. On the other hand, the traditional selection process in plant breeding, driven by years of testing and selection in different environments, has proved to be very suitable for modern varieties to gradually adapt to changing environmental conditions. Just as the same method has achieved great success in adapting globally successful crops to various ecogeographical and climatic conditions, which are far beyond their origins The natural habitat range of the center.

The accumulation of beneficial alleles for complex quantitative traits affecting yield and quality is the basis of all crop breeding historical processes, which will also play an important role in crop adaptation to climate change in the future. However, in most cases, retrospective breeding progress for climate adaptation is only a positive by-product of long-term, multi environment, high-yield selection and variety registration policies that encourage high and stable yield (Snowdon et al., 2019). This is because breeders in the past could not obtain the resources and tools that can effectively elucidate, dissect and select key adaptive target traits under complex genetic control. These traits have small genome-wide effects. Today, there are many more opportunities to capture and exploit the time complexity of important environmental life cycle characteristics. Automatic phenotype analysis, remote sensing and image analysis are constantly improving. With the continuous expansion of phenotype and genome data base, genome selection strategy is expected to grow, which makes it more and more feasible to use the great power of new prediction methods based on artificial intelligence and "deep learning". With the continuous expansion of world population and the increasing demand for crop products, yield performance as a result of G * E * M interaction will continue to be the most valuable target trait for breeding progress in the face of climate change. At the same time, breeders' methods to maintain yield progress are increasingly enriched by powerful new technologies and techniques, which help to identify, introduce and recombine new genome-wide diversity of complex adaptive traits in high-yield environments. However, even with the continuous development of breeding technology, classical breeding theories and methods will continue to ensure long-term breeding progress to ensure sustainable crop productivity in the face of climate change (Snowdon, 2020).

Today's world is experiencing climate change, and agricultural production in humid, arid and semi-arid areas will face unprecedented challenges. Serious planning and strategic research are needed to deal with these challenges. In order to meet the challenges of improving agricultural productivity and environmental sustainability in complex marginal systems, it is necessary to change the traditional research and development model. This shift will involve a shift in research objectives towards enhancing adaptive capacity by adopting a more participatory approach, adopting key principles of multi-scale analysis and intervention, and using a variety of systems analysis, information management and impact assessment tools.

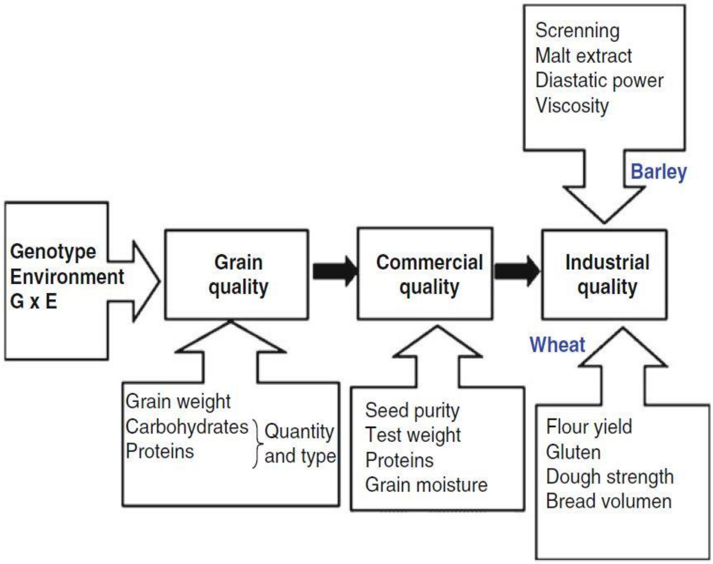
Agriculture responds to climate change in terms of its impact on crop growth and development. The distribution of plants all over the world proves that climate is the decisive parameter for the effective growth of plants. Climate change will have positive and negative effects on plant growth and yield. The impact of climate adequacy is not only limited to growth and development, but also extends to the field of product quality, in which climate also affects the quality of feed or grain or products. Changing clothes can also affect the emergence of insects or diseases, thereby affecting the yield and quality of plants. There are two time scales for the impact of climate change on crops: one is the long time scale that may affect crop cultivation; the other is the seasonal time scale reflected by weather patterns that will affect the growth and development of crops and the pressure they face. Regional models are needed to provide fine scale climate information for impact studies, especially in areas with diversity and heterogeneity. Most parts of the world are rich in natural resources, economic challenges and human settlements, as well as poverty and insecurity. Climate change is becoming a new threat, which has not been fully prepared. The decline of crop production is not only the impact of climate change, but also the complex interaction among social, political, economic, cultural and environmental factors.

The trend of climate warming is not enough to cause large-scale changes in crop producing areas in the United States. Management methods may change to adapt to higher temperatures during part of the growing season and the expansion of growing areas for populations of different maturity. Water resources management will become a greater factor in crop production in various regions, where the importance of water shortage is generally fully recognized. The trend of summer drought in various regions will bring additional risks, because soil water reserves may be insufficient to achieve optimal crop production. Developing the practice of removing only the required water from the soil profile and then limiting the drainage process to increase the water storage for the remaining growing season in the soil profile will prove beneficial to crop production. Due to increased precipitation during the autumn harvest, crop production faces additional risks, which increases the problem of timely harvesting and quality food. Water management in many areas with limited precipitation must improve crop water use efficiency by increasing soil water storage capacity. Increasing soil organic matter content and soil water holding capacity is a potential way to improve soil water availability and accumulation. It will be a challenge to develop deep-rooted crops that can make better use of soil profiles. A challenge for plant scientists and agronomists is to assess more comprehensively the interactions between genetic resources and environmental conditions, soil and atmosphere. What is likely to happen in the context of climate change will constitute a new pattern of stress, requiring a broader understanding of the interaction between genetics and the environment.

The diffusion effect is caused by the increase of carbon dioxide concentration, temperature, precipitation pattern change, water resource utilization rate change, extreme weather including flood, rainstorm and drought frequency increase, climate induced soil erosion and sea level rise. Although some of these effects have been studied in isolation, the complex interactions between different factors, especially extreme events, are still not well understood.

The synergistic improvement of grain yield and quality

Firstly, the concept and importance of grain quality are put forward. In field crops, the quality of the final product is traditionally related to the composition and structure of the seed at harvest maturity. The seed composition and structure at harvest time are determined by genotype, environment and crop management measures adopted in crop growth cycle. The quality of a grain can not vary with the end use of any product. There is an appropriate quality standard for each specific end use and for each stage of the business chain of each crop, from field harvesting to grain dealers to industry. In this case, quality will be considered according to the standards adopted in all aspects of food growth and utilization. For example, for wheat and barley (Fig.13), grain quality at field harvest is related to grain size (and weight) and carbohydrate and protein composition. When grain is sold to grain dealers, seed purity, test weight, grain moisture and protein percentage are the main characteristics of rewards (Fig. 13). After this stage, other attributes may be relevant and they will depend on the industry involved. For the baking industry, wheat flour yield and dough strength will be the most important, while malt extract and saccharifying power will be considered for malting barley, which is related to nitrogen content. The purpose of this item is to summarize the key elements of grain structure, grain growth and main grain composition synthesis of field crops, so as to highlight the main attributes affecting grain quality. Other quality attributes currently considered by consumers, such as the sustainability of production systems that produce grains, will not be considered in this entry. We will not consider aspects related to organic production or the existence of genetically modified organisms. These problems will affect customers' views on grain quality, but they are not within the scope of this article (Déborah P. et al., 2019)



To improve the grain quality of oil and cereal crops, **Fig. 13** Schematic diagram of wheat and wheat post harvest processing and storage, barley production and main quality indicators of each link (from: Déborah P. et al., 2019)

The grain structure needs to be further developed. The harvested cereal and oil seed organs may include true seeds (soybeans, canola) or fruits (seed and maternal accompanying structures, such as sunflower achenes or Caryopsis of wheat, barley, rice, corn and sorghum). The seed is developed from the fertilized ovule and consists of three genetically different tissues: (a) zygotic embryo (diploid, representing the next generation), (b) endosperm (usually triploid), (c) testa formed by integument, representing the maternal tissue of ovule (Boesewinkel FD and Bouman F, 1995). The proportion of these three components in the mature seeds of cereal and oil is different. The endosperm of cereal is dominant, and the embryo of oil is dominant. Except for a few exceptions, the development of endosperm always precedes the development of embryo, and the development of seed coat always precedes both. These genetically different parts interact closely in the process of development and germination. Recent studies have proved the complexity of connection and regulation between different seed tissues (Berger F, Grini PE and Schnittger A, 2006). After fertilization and seed setting, grain is the main sink of plants. Grain filling requires a large amount of photoassimilates, which are provided by the parent plant through actual photosynthesis and / or carbohydrate storage transferred from the nutritional structure. There is no vascular connection between the mother plant and the developing embryo (Meyer CJ, Steudle E, Peterson CA, 2007). Therefore, grain growth can be maintained through the movement of cell membrane, water and solute regulated by the mother plant and the seed. Seed attachment structure includes seed coat (seed coat and tegmentum) and other different material origin structures, such as lemma and palea in cereal, pod in soybean, silique in rape and shell in sunflower (ovary wall attached to receptacle). These structures have great influence on the evaluation of grain quality. The influence of seed coat color of different types of Soybean (Phaseolus vulgaris L.) on consumers varies from region to region, which leads to the exclusion of some genotypes although they have good nutritional characteristics. Sorghum caryopsis with or without tannins is another example of the importance of husks affecting seed quality. Some seed coats provide nutrients, such as B vitamins and micronutrients in cereal membranes. In addition, they have other important biological and technological functions to protect seeds from mechanical damage after harvest, or by affecting industrial grain processing (wheat grinding, barley malting, rice cooking). Seed coat can also affect seed dormancy and germination process (Baskin JM and Baskin CC, 2004). In recent years, seed attachment structure has attracted special attention due to its effect on potential grain size and volüme (Lizana XC et al., 2010).

Seeds store carbohydrates (starch), oil (triacylglycerol) and proteins (soluble and insoluble). The storage locations of cereal and oil seeds vary greatly. In cereals, the tissue that stores starch and protein is the endosperm. On the contrary, oilseed has no special storage tissue; oil and protein are accumulated in embryo and cotyledon cells. The starch endosperm of cereals is well developed with a aleurone layer, which accounts for 80% of the dry weight of mature seeds. Mature endosperm consists of dead cells, which are filled with starch granules embedded in protein matrix. The embryo is relatively small, accounting for only 1-2% of the dry weight of wheat seed, usually located on one side of the seed, close to the attachment point between the seed and the mother plant (Boesewinkel FD and Bouman F, 1995). The non endosperm true seed of oilseed consists of a large embryo and hypocotyl. Most of the reserved materials were stored in cotyledons, which accounted for 70% (sunflower) to 90% (soybean and rape) of the dry weight of seeds (Egli DB, 1998). Grain structure is important because it determines the quality of grain and industrial processing. The structure of cereal endosperm is determined by the number, shape and size of starch grains and the number and type of protein in protein matrix. Endosperm structure classifies wheat according to its hardness (soft and hard), which affects its industrial processing quality (milling capacity and flour yield). In addition, the structure of endosperm is based on the quantity and distribution of pollen endosperm and horny endosperm (horny endosperm accounts for a large proportion of chert maize). Other endosperm structural characteristics that affect grain quality are transparency and color, which are important for corn, rice, bread and wheat. Grain structure is also an important factor to determine the quality of oilseeds. In sunflower, the ratio of shell to embryo is an important factor to determine the oil yield. Because shell does not store oil, the oil concentration in embryo is reduced. In the past 30 years, genetic improvement has reduced the shell ratio of sunflower seeds and increased the oil content of the whole seed (Putt ED (1997). However, in the process of industrial processing, thin shell is usually difficult to remove, so other improvement strategies are needed to increase the percentage of sunflower seed oil. Therefore, the grain structure has a strong impact on the commercial and industrial quality of grain. Therefore, the grain sales regulations of all countries in the world stipulate the attribute of grain structure.

Grain quality has become one of the most important objectives of breeders and growers (Ceoloni, C., 2017; Camerlengo, F., 2017), because it is essential to obtain high-quality prices and meet the market demand for grain products (Troccoli, A., 2000). Protein content, color and gluten strength of grain are considered to be the most important characteristics in the production of pasta and bread. It is well known that the protein content of grain is affected by climate parameters, genetic factors, nitrogen dosage, nitrogen application time, soil residual nitrogen and effective water in filling period (Campbell, C.A., 1981; Rao, A.C.S., 1993; Uhlen, A.K., 1998; Rharrabti, Y.2001). Yellow is caused by carotenoid content in the whole grain, which is considered as the yellow index in coarse flour commercially. Carotenoids, as an important aesthetic parameter, also have important nutritional and health characteristics (Ficco, et al., 2014). Although the yellow index is influenced by weather conditions, varieties, nitrogen application amount and nitrogen application time (Garrido et al., 2005; Ficco, et al., 2014; Fagnano, 2014), little is known about the influence of nitrogen source and sulfur fertilizer on the yellow index. The strength of the gluten helps the dough maintain shape during baking. Gluten strength is usually estimated by SDS precipitation test, which provides good cooking quality index for pasta according to protein quality (Dexter et al., 1980; Carter et al 1999; Ercoli et al 2011). Ercoli et al. (2011) found that SDS values increased with the increase of inorganic N (from 120 to 180 kg ha^{-1}) and S (from 0 to 60 kg ha^{-1}) rates. The use of nitrogen fertilizer is generally considered to be a key factor in grain crops. Many studies have been carried out on the optimal nitrogen application amount and application timing. In fact, if it has been proved that nitrogen has a positive impact on grain yield and quality, on the other hand, nitrogen management is essential to avoid nitrogen loss caused by leaching, runoff, denitrification or volatilization (Alcoz et al., 1993; Garrido et al., 2005; Barraclough et al., 2010).

Taking into account all these factors, the use of organic nitrogen fertilizer may be another option, reducing nitrate pollution and improving environmental sustainability of traditional agricultural systems, in conjunction with other planting management and practice (Fagnano, 2014). Therefore, another feature can be added to the definition of grain product quality (Mäder, 2007). In addition, in organic crop management (e.g., wheat), fertility management is the key factor limiting yield and grain protein content (Mayer, J. et al., 2015). Fertility management is the key factor to limit yield and grain protein content in organic wheat management. The results of the study emphasized the importance of adequate supply of soil organic fertilizer and the necessity of improving the availability of organic nitrogen (Bilsborrow, P., et al., 2013). The latter option can be achieved by regulating the degradation and mineralization of organic matter (OM) in soil, which is the traditional role of heterotrophic microorganisms (Kirchman et al., 2012). The number of these microorganisms was found, especially the number of sulfur oxide microorganisms: (I) larger in some sunshine layers (e.g., canola and wheat) than in the large soil control (Graystone et al., 1990); and (II) stimulated by sulfur fertilizer and soil om (Gemida et al., 1993). A recent study in the Canadian grassland has shown that biomass production of common wheat in organic systems is positively correlated with the S concentration of plant tissues among other factors (Dai M. et al 2014). Sulfur is the basic element of all organisms because it exists in many molecules (amino acids, oligopeptides, vitamins and many secondary metabolites) and participates in a variety of biochemical processes. The key steps for plants to absorb sulfate ions (SO_4^{2-})from soil solutions and use them for metabolism (Scherer et al., 2001).

Crop yield and quality are two major topics in crop science research. However, for a long time, due to the increasing pressure of population growth on food demand, the focus of food crop research is on high yield. In recent years, people have paid more attention to the quality of crops, cultivated high-quality varieties to meet different needs, and studied the supporting high-quality cultivation techniques. However, in many cases, high yield and good quality are not coordinated, high yield is often accompanied by quality decline, and good quality is mostly at the cost of yield reduction. It is a very important period for scientific research and crop quality improvement in the future (Yu Zhenwen, 2006).

The current situation of yield and quality research of Chang has been the focus of crop physiology and cultivation. The first step to increase crop yield is to increase the production and accumulation of photosynthetic products, and to improve the crop biomass. Secondly, it is necessary to improve the operation and distribution of photosynthetic products, increase the proportion of photosynthetic products to the grain, and increase the harvest index (Gifford RM, et al., 1984). The production, accumulation and distribution of photosynthetic products are different due to the genetic characteristics of crop varieties. Environmental conditions and cultivation techniques have significant regulatory effects on them (Fageria NK, et al., 2006). To improve soil conditions, the application of leaf age model (rice, corn) cultivation technology, fine seeding (sparse planting) and high accumulation cultivation technology of small groups of individuals (rice, wheat), live planting late harvest and yield increase technology (corn). Nitrogen fertilizer backward transfer and yield increase technology (rice, wheat) are all high-yield and high-efficiency cultivation measures The yield of crops can be increased by increasing the accumulation of photosynthetic products or improving the distribution of photosynthetic products.

Crop quality is closely related to the content and proportion of protein and starch in grain. The connotation of different crop quality is different, so the requirements of grain protein and starch content, components and other indicators of different crop quality are very different. For example, the wheat used to make high quality bread and noodles requires high protein content in grain, appropriate composition of high molecular weight glutenin subunits (HMW-GS) (generally 2 *, 5 + 10, 17 + 18). Large proportion, large amount and proportion of glutenin macropolymer (GMP) and low amylose content

(Li Shuobi et al., 2001; Chen Jixian et al., 2000; Cao Weixing et al., 2005). The nutritional quality of rice was mainly related to protein and lysine content, and the eating quality was mainly related to amylose content (Tian ZX et al., 2009). Grain quality traits are first determined by the genetic genes of varieties, but environmental conditions and cultivation techniques have significant effects on them (Zhang T et al., 2010). The effects of temperature, light, fertilization, irrigation and other factors on grain protein content were mainly through the effects of root absorption and transportation of nitrogen, enzyme activities related to grain protein synthesis, production, accumulation and distribution of photosynthetic products, grain filling rate and duration, and plant senescence process.

Effect of high temperature on yield and yield components

Some biennial crops (such as carrot, Chinese cabbage, celery, sugar beet and black henbane, etc.) and some winter annual crops (such as winter wheat, winter rye and winter rape, etc.) must undergo a period of low temperature induction during the vegetative growth period to turn into reproductive growth and then blossom and bear seeds. This characteristic is called temperature sensitivity of crops, This process is also known as vernalization. According to the range and time of low temperature requirements, the temperature sensitivity of crops can be divided into three types: winter, semi winter and spring. In the process of flower differentiation and formation in crops, photoperiod induction is also necessary (especially in annual and biennial crops), which is called photonu. According to the response to photoperiod, crops are generally divided into three types: long day crops, short day crops and day neutral crops. Low temperature is the main condition of vernalization, its effective temperature is 0 ~ 10 ℃, and the vernalization time is from several days to dozens of days. The specific effective temperature and low temperature duration depend on crop or variety. If the temperature is lower than 0 ℃, the metabolism will be inhibited and vernalization can not be completed; if there is high temperature before the end of vernalization, the effect of vernalization will be weakened or even eliminated. Vernalization is usually completed at seed germination or seedling stage, such as winter wheat. A few crops such as carrots can only pass vernalization when the green seedlings grow to a certain size. The parts of crops affected by low temperature are the growth point of stem tip and tender leaves, that is, mitotic cells (Liu Chunlei, 2011).

Vernalization may promote flowering through negative regulation of flowering locus C(FLC). With the extension of low temperature treatment time, FLC transcription level became lower and lower until undetectable level (Liu Lina et al., 2003). There are also three genes involved in vernalization in arabidopsis, namely VRN1, VRN2 and VRN3. The expression of VN3 in winter Arabidopsis thaliana could only be detected after a period of low temperature treatment. When the low temperature condition of vernalization changed to normal growth environment, VN3 closed down rapidly. When VN3 was induced, the expression of FLC was inhibited. The function of vn1 and vn2 is to maintain the persistent inhibition of FLC expression after vernalization, i.e. the inhibition of FLC expression activated by vin3 protein (Sung s, 2004).

Two vernalization related genes, VRN1 and VRN2, were also isolated in winter wheat, which were different from those in Arabidopsis thaliana. VRN1, a flowering promoting factor, encodes a protein containing MADS box (MCM1 comes from Saccharomyces cerevisiae, Saccharomyces cerevisiae; Agamous from Arabidopsis thaliana; Defects in snapdragon (Sommer h et al., 1990); SRF (Serum Response Factor) from (Homo sapiens), which is induced to express by low temperature. VRN2 encodes a zinc finger domain protein, which is a flowering inhibitor. Its main function is to inhibit the expression of VRN1 (Yan L et al., 2004). Vernalization is a complex process of flower induction, which involves multiple pathways, multiple signals and multiple genes. At present, the upstream regulation of vernalization and the expression mechanism of related genes are not clear, which increases the difficulty of research. It is of great practical significance to study the mechanism of vernalization. If we have a clear and complete understanding of vernalization, it is possible that crops can pass vernalization through simple manual control instead of being treated at low temperature, which will bring new life to crop breeding and cultivation. The sensitivity of crops to photoperiod is related to the sensitivity of crops to photoperiod. Many experiments have proved that the critical dark stage is more effective for flowering. If the photoperiod was interrupted by a short period of darkness, the induction of flowering was not affected; but if the photoperiod was interrupted by flash, the flowering of short day crops could not be induced, but the flowering of long day crops was induced. So long day crops are short night crops, short day crops are long night crops (Li dequan, 1999).

It is predicted that by the end of this century, the global surface temperature will rise by about 2-5 °C, which will lead to significant changes in crop productivity, water supply and related economic values (IPCC 2007). An overall increase of 2 °C in temperature and 7% in rainfall will lead to a loss of nearly 8% in farm net income. These changes have taken place. Another major change is the westward shift of the monsoon pattern; this limits rainfall to certain areas and may lead to flooding, which in turn leads to food shortages for many people. The impact of global warming on food security in India may be more serious than in other parts of the world. If the temperature rises by 2 °C, GDP will decrease by 5%, while if the temperature rises by 6 °C, GDP will decrease by 15-16%. In Haryana, the yield of wheat (*Triticum aestivum L.*) decreased from 4106 kg/ha in 2001 to 3937 kg /ha in 2004. In the past seven years, the maximum temperature (booting stage and grain filling stage) in February and March increased by about 3 °C (Gahukar, 2009).

Temperature rise would affect crop calendar in tropical regions (Abrol and Ingram, 1996). In the tropics, higher temperatures may shorten the length of the growing season, especially in areas where more than one crop is grown each year. In the semi-arid area and other agro ecological areas where the daily temperature variation is large, the annual average temperature variation is small, which can significantly increase the frequency of high temperature injury. Abiotic stress is the main cause of crop loss, which reduces the average yield of most major crops by more than 50% (Boyer, 1982; Bray et al., 2000). Recent studies on the potential impact of climate change on agriculture in developing countries provide an equally grim prediction. Consider the following example (ETC, 2008):

Due to climate change 3-4 °C (especially higher than 30 °C) increase in temperature, such as when corn at flowering, may lead to a 15-35% decrease in crop yields in Africa and Western Asia and a 25-35% decrease in crop yields in the Middle East (FAO, 2008). About 65 countries in the southern hemisphere, mainly in Africa, are likely to lose 280 million tons of potential grain production, worth US $56 billion (UNNC, FAO, 2005).

Due to the increase of night temperature higher than (> 21 °C), the rice yield in Asia will decrease greatly. Under warmer conditions, photosynthesis slows down or stops, pollination is stopped, and dehydration begins. Rice yield decreased by 10% with the increase of nighttime temperature highr than (> 21 °C) (IRRI 2004: Peng et al., 2004).

Close relatives of wild crops are particularly vulnerable to extinction due to climate change. CGIAR (2007) reported that by 2055, 16-22%

of the wild related species of cowpea (*Vigna unguiculata L. walpers*), peanut (*Arachis hypogaea L.*) and potato (*Solanum tuberosum L.*) will be extinct, and the geographical scope of the rest wild species will be reduced by more than 20%. Wild related species are important sources of resistance genes for crop improvement in the future, but their habitats are threatened, and only a small number of species are preserved in the gene pool.

Temperature is the most important environmental factor leading to plant development, growth, fertilization and grain yield. It also includes the ecological, epidemiological and distribution effects of insects, which are particularly important for insects that interact with plants. Plant viruses and Fungi are highly responsive to humidity, rainfall and temperature (Coakley et al., 1999). The relative importance of mean and extreme temperatures varies geographically. High temperature stress is a complex function of intensity (temperature in degrees), duration and heating rate. Production is expected to decrease by 70% in some equatorial regions due to high temperatures and low latitudes. On the other hand, the current colder temperatures in some areas (high latitudes) limit crop production and will benefit from higher temperatures. Generally speaking, high temperature stress, either alone or in combination with drought, is a common constraint in flowering and filling stages of many cereal crops in temperate and tropical regions. Compared with the vegetative growth process, the reproductive process affecting yield is very sensitive to high temperature. The most sensitive and vulnerable reproductive stages to high temperature stress include: (a) pre flowering stage and (b) flowering and fertilization stage. Cereal and legume crops are sensitive to short-term high temperature stress in these periods. These two stages are clearly defined in cereals (e.g., grain sorghum, Sorghum *bicolor (L.) Moench*, Prasad et al., 2008a, Fig. 14) and legumes (e.g., peanut, Prasad et al., 1999a; Prasad et al., 2001; Fig. 14).

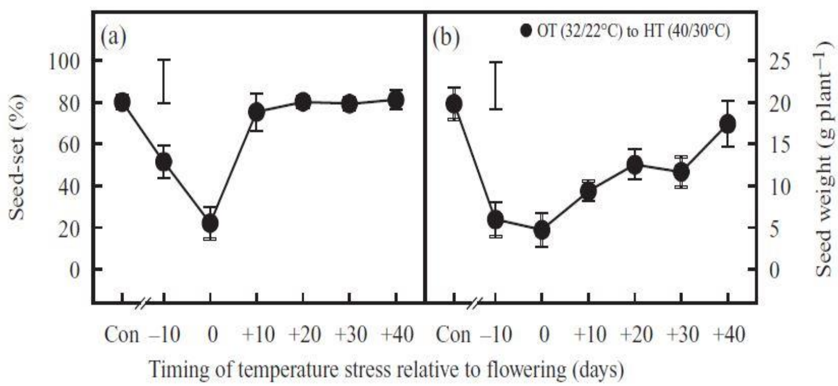


Fig. 14 Effects of short-term (10 day) high temperature on seed setting rate and grain weight of sorghum (hybrid dk28-e) at different stages of reproductive development expressed by flowering days under controlled environmental conditions.

The line on the symbol represents the standard error of the average, and the vertical line represents LSD, which is used for comparison processing. The results showed that 10 days before flowering and flowering stage were the two most sensitive periods to high temperature stress. (adapted from Prasad et al., 2008a; Rishi P. Singh, et al., 2011).

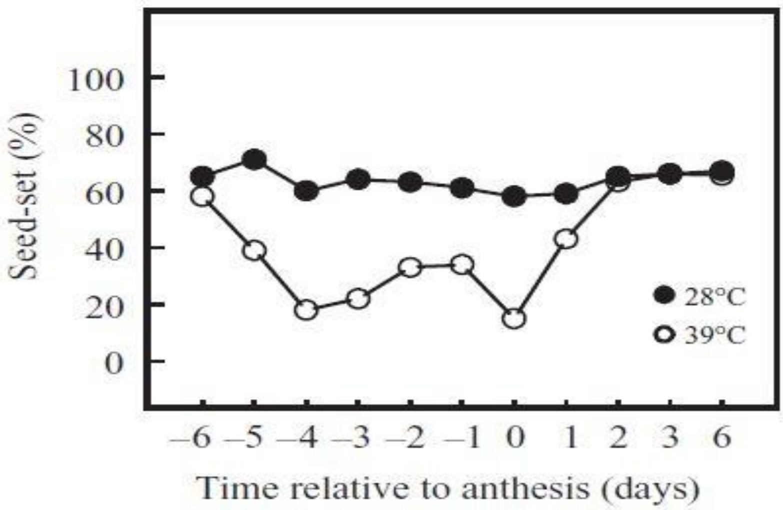


Fig. 15 Under controlled environmental conditions, the effects of high temperature of flower bud (39 °C) and optimum temperature of flower bud (28 °C) on fruit setting rate of Peanut (variety 86015) were studied at different stages of reproductive development.

The line on the sign represents the standard error of the mean. The results showed that the most sensitive period to high temperature stress was 4 days before flowering and fruit setting (Fig. 15). (adapted from Prasad et al., 2001; Rishi P. Singh, et al., 2011).

During a period of time before flowering, high temperature stress can lead to the loss of vitality due to microsporogenesis (pollen) and Megasporogenesis (ovule) (about 7-14 days before flowering, depending on crop species). High temperature stress at flowering stage led to pollen senescence, destroyed pollination, reduced pollen germination ability and reduced pollen tube growth rate. These negative effects will destroy fertilization and reduce the number of seeds. Studies on peanut have shown that high temperature stress on the first day of flowering can reduce seed set, especially when high temperature occurs in the first 6 hours of the day (Prasad et al., 2000). Temperature higher than 33 ℃ significantly reduced peanut seed set (Fig. 16). Recent studies on Rice (Oryza sativa L.) have shown that high temperature stress (above 33 ℃ for several days) can significantly reduce pollen viability, therefore, seed set (Jagadish et al., 2008, 2010). Short term or long-term exposure to high temperature during grain filling also accelerated senescence, reduced seed set and seed weight, and reduced pulse beans (Siddique et al., 1999) and wheat (Prasad et al., 2008b).

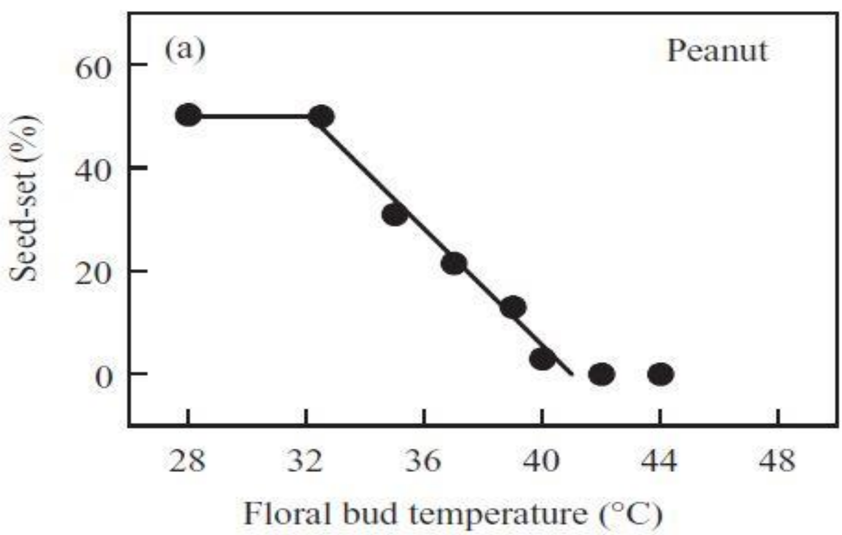


Fig. 16. Response of peanut seed setting to temperature under controlled environment.

The results showed that when the temperature of flower bud was higher than 33 °C, the seed setting rate decreased with the increase of temperature, and reached zero when it was close to 40 °C(adapted from Prasad et al. 2000) (Rishi P. Singh, et al., 2011).

The results of long-term high temperature study showed that it was similar to rice (Baker and Allen 1993; Baker et al. 1995; Prasad et al. 2006a), soybean (Glycine max (L.) Merr; Boote et al. 2005), and common soybean (Phaseolus vulgaris L.). Prasad et al., 2002), peanut (Prasad et al., 2003), cotton (cotton; Reddy et al., 2000), sorghum (Prasad et al., 2006b) and wheat (Prasad et al., 2008b). The typical optimum temperature for grain yield of rice, soybean and peanut was 25 °C. With the increase of temperature, the yield decreased gradually; the yield of rice and sorghum decreased completely at 35 °C and the yield of peanut and soybean decreased completely at 39-40 °C (Boote et al., 2005). When the average temperature increased to above 23 °C, the seed growth rate, seed size and seed distribution intensity (seed HI) of soybean decreased until it reached zero at 39 °C (Thomas, 2001). Baker et al. (1989) reported that in rice, seed size (single seed growth rate) gradually decreased above 23 °C, while fertility decreased above 30 °C, resulting in a decrease in seed harvest index (HI) at temperatures above 23 °C or 27 °C. Boote et al. (2005) reported that hi of soybean was zero at 39 °C. The critical temperature is the daily average temperature at the beginning of growth. The knowledge of low threshold temperature is very important in physiological research and crop production. High temperature threshold is particularly important in tropical and subtropical climate, because high temperature stress may be the main factor limiting crop production. The results show the critical temperature of some important economic crops. Persistent heat stress affects Wheat Productivity in developing countries, and 40% of temperate environments (covering 36 million hectares) have terminal heat stress problems (Reynolds et al., 2001). Lawler and Mitchell (2000) pointed out that the increase of 1 °C (> 21 °C) would shorten wheat growth period by 6%, grain filling period by 5%, and correspondingly reduce grain yield and hi. Bender et al. (1999) analyzed spring wheat grown in nine locations in Europe, and found that the yield decreased by 6% when the temperature increased by 1 °C; Lobell and Field (2007) found that when the temperature was higher than the optimal temperature (about 21 °C), the global average yield decreased by 5.4% when the temperature increased by 1 °C, especially in the reproductive development stage. Prasad et al. (2008b) reported that the increase of nighttime high temperature (higher than 20 °C) during wheat reproductive development significantly shortened the grain filling stage, resulting in the decrease of grain yield.

The researchers made similar observations on other crops. Laing et al. (1984) found that the yield of common bean was the highest at 24 °C, but decreased sharply at higher temperature. Peng et al. (2004) reported that for every 1 °C increase in the minimum temperature in the dry season, rice yield would decrease by 10%. According to the reports of these researchers, their report provides direct evidence that an increase in nighttime temperature (from 22 °C to 24 °C) associated with global warming causes a decline in rice yield. In the past century, with the steady increase of atmospheric greenhouse gas concentration, the daily nighttime minimum temperature has increased faster than the daily maximum temperature (Easterling et al., 1997). Lobell and Asner (2003) showed that the yield of American Maize (Zea mays L.) and soybean decreased by 17% for every 1 °C increase, and reported the confounding effects of other yield limiting factors. In a recent assessment of the response of global maize production to temperature and rainfall over the period 1961-2002, Lobell and Field (2007) reported that for every 1 degree Celsius increase, the yield would decrease by 8.3%. According to the prediction of various global climate change scenarios, if the temperature rises by 2-6 °C in this century, crop breeding failure will be a major problem. Major cereal crops can only withstand a narrow temperature range; temperatures beyond this range during flowering will hinder fertilization and seed production, resulting in a decline in yield (Porter, 2005). The response of plants to temperature also depends on genotype parameters. Some genotypes were more tolerant to high temperature stress (Crufurd et al. 2003; Prasad et al. 2006b). For example, rice variety n-22 is tolerant to long-term (Prasad et al. 2006b) and short-term (Jagadish et al. 2008) high temperature stress. These different genotype responses indicate the importance of genotype adaptation to mean and extreme temperature changes.

To sum up, high temperature had adverse effects on photosynthesis, chlorophyll content, pollen viability, seed setting rate, seed number and grain weight of rice, leading to yield decline and quality decline. In the period of climate change and variation, the cultivation of heat-resistant varieties is very important to ensure the successful production of crops. Some physiological characteristics that contribute to high temperature tolerance include canopy temperature depression (CTD), enhanced membrane thermal stability, increased photosynthetic rate, prolonged green leaf duration, increased fecundity through pollen viability and seed setting rate, and changed flowering time to avoid high temperature. Breeding programs should measure these traits to assist in the selection of heat-resistant varieties (Rishi P. Singh, et al., 2011).

Light and crop yield and quilty

More than 99% of the world's energy input comes from solar radiation. Nearly half of them are directly converted into heat, 23% of them provide energy for evaporation and precipitation, and about 0.02% of them are used for photosynthesis (Vinck, 1975).

The advantage of high light intensity in arid areas is partly offset by shorter day, higher night temperature, increased dark respiration and higher light respiration rate in white sky. Due to the interaction of these factors, C3 species performed better in temperate climate or cool seasons, while C4 species performed better in warm regions and summer conditions. The light energy needed to regulate growth is different at different growth stages. In many cases, especially in arid areas, the large amount of incident light required by plants at certain growth stages may have adverse side effects (McDaniel, 1982). Light intensity and crop yield. Evans (1973) divided the effect of light on yield into two stages: during the early vegetative growth and differentiation of storage organs; during the period when storage organs were full of assimilates. The direct contribution of assimilates stored in the early stage of plant life to economic yield (seed, fruit, tuber) is very small, while economic yield mainly depends on simultaneous assimilation. However, the early light environment may indirectly affect the yield by determining the potential storage capacity. And the time of development cycle related to the seasonal variation of radiation. In desert areas, the sky is usually clear. This is conducive to high sunshine in the daytime and rapid radiation at night. Due to the heating of the land during the day, the rising air flow causes a typical "dust storm". Warm air often rises high enough to cool to dew point and form clouds; however, these may result in less precipitation reaching the ground. If it reaches the surface, the rain is usually local, rainstorm and transient (Debenham, 1954). When the sun shines through the crevices of the clouds, the reflection of the clouds may increase in a short time, or even double the intensity of the incident radiation, while the light clouds may completely intercept the direct radiation and reduce it to zero (Slatyer, 1967). Cloudy days may reduce direct radiation and reduce light intensity to about one fifth of sunny days, while photosynthesis will not decrease proportionally, because the uniform distribution of light (De Wit, 1967) the duration of light is crucial to the growth and development of plants. The effect of photoperiodicity - the relative length of the daily light and dark periods - on nutritional and reproductive development stages is well known. The most typical tropical crops are those with short days (flowering requires long nights), while those in high latitudes are usually those with long days. In different periods of a year, the sunshine length in a specific place is the minimum variable of climate factors, so it is the most reliable prediction value of normal climate conditions in a specific time of a year. Sensitivity to sunlight (photoperiodicity) enables plants to ensure that their life cycle is as close to favorable climatic conditions as possible, so it is of great significance to agriculture. In this case, sunshine length is the main component of light environment (Evans, 1973), which is the most important climatic factor for crops to adapt to a given latitude.

One of the main objectives of crop management is to maximize the light interception of crop canopy. This can be achieved in a variety of ways (EUROCONSULT, 1989): (a) choice of location. For example, the most sunny hillside is clearly the best location for the vineyard and is a major factor in productivity and wine quality. On the contrary, a row or rows of trees may have a significant effect on the amount and intensity of light reaching crops in adjacent fields. (b) It is one of the main methods for farmers to adjust the density and direction of plant population in order to maximize the use of crop canopy interception light. (c) Pruning. Pruning can reduce the light competition between different parts of plants and among plants, which is widely used in many horticultural crops. (d) Artificial lighting can be used to increase photosynthesis or regulate the photoperiod. Photosynthesis requires considerable light energy, and artificial lighting for this purpose is rarely justified economically. In contrast, regulating photoperiodicity requires low power input and is widely used in flower cultivation to ensure that flowers are ready for market at the most favorable time. (e) Alternatively, some crops, such as coffee or cocoa, may need to provide shade, which is grown under the canopy of a suitable tree crop. Cigar tobacco grows in the shade provided by a special cloth cover. Sometimes it is best to prevent light from reaching certain parts of the plant, such as celery or asparagus, in order to "bleach" the marketed product. This is done by ridging the soil on the plant rows. High yield breeding refers to the manipulation of physiological and morphological traits to improve photosynthetic efficiency. In cultivated plants, it is often necessary to modify the photoperiodic plant response. One of the important goals of plant breeders is to change the photoperiod response to the direction of indifference to daylength, so as to expand the adaptability of varieties (Arnon I.,1992).

Generally, the change of sunshine hours may lead to premature or late physiological maturity of some crops. Further analysis is needed to examine climate change during the planting cycle and equate it with possible crop responses. For example, high altitude crops (and therefore the farmers who grow them) may react differently than low altitude crops. However, this problem largely depends on the complexity of the cropping system (i.e. location, photoperiod, variety and technology, planting date, etc.) and needs to be addressed separately for each crop, geographical area and possible farming system (Andy Jarvis et al., 2011).

There are three types of receptors for plants to distinguish day from night: phytochrome, cryptochrome and phototaxin. Phytochrome is the receptor of red light and far red light, which is encoded by gene proline hydroxylase (PHY) in Arabidopsis thaliana; cryptochrome and phototaxin are the receptors of blue light, cryptochrome is encoded by genes CRY1 and CRY2, and phototaxin is encoded by phototropin1 and phototropin2. cry2, phyA and phyB may be the main photoreceptors in photoperiodic reaction (Sha Haihua et al., 2006). The integration of light signal and biological clock signal is the premise of controlling flowering time by photoperiod. Early Flowering3 (ELF3) is a gene that can inhibit the signal transduction from light signal to biological clock. ELF3 protein level is regulated by the circadian clock and reaches a higher level at night, which makes the circadian clock insensitive to light at night, thus ensuring that the circadian clock can readjust its rhythm in the early morning. Zeitlupe (ZTL) may be another gene integrated with light signal and circadian clock signal. It can degrade Timing of CAB expression1 (TOC1) protein in circadian clock regulation pathway at night and form strong rhythmic changes in circadian cycle (Mas P et al., 2003). Co gene encodes a transcriptional regulator, which controls flowering time by regulating the expression of flowering gene ft. FKF1 protein accumulated to a high level from noon to dusk, which promoted the transcription of CO gene at a high level. PhyA and cryptochrome were activated under light, which promoted the stability of CO protein. In the early morning, phyB can inhibit the action of phyA and cryptochrome and promote the degradation of CO protein. At the same time, at night, CO protein will be degraded by an unknown mechanism. These factors eventually make co protein accumulate to a higher level from dusk to early night. High level accumulation of CO protein activated the expression of flowering gene ft, which promoted the flowering of Arabidopsis thaliana. Under the condition of short day, CO gene was transcribed at a high level only at night, but due to the instability of CO protein at night, it could not accumulate at a high level and induce flowering. The co gene homology was also found in rice, but its function was opposite to that in Arabidopsis, i.e. it inhibited flowering under long day and promoted flowering under short day (Sha Haihua et al., 2006). At present, the mechanism of photoperiod has been preliminarily understood, but there are still many problems to be solved. For example, how does light cause changes in CO protein activity? Degradation mechanism of CO protein? Is the mechanism of photoperiod conservative among different long day crops or different short day crops? FT gene is expressed in leaves, but how is it transported to shoot tip? It is believed that with the solution of these problems, people can control the flowering of crops through simple operation in the future, which is of great significance to crop breeding, introduction, ornamental and horticultural crop cultivation (Liu Chunlei, 2011).

The light regulation of the new shoots development of higher plants seems to involve the complex interaction between many photoreceptors and the factors in the downstream signal pathway. The complexity of the system lies in the number of functional redundant photoreceptors, and the possibility that downstream signal transduction pathways directly affect the output response of light regulation or function by inputting signals to biological clocks. These signaling pathways ultimately affect many major aspects of bud morphogenesis, including cell elongation, photosynthesis and flowering transition. In Arabidopsis, there are five photosensitive pigments (photosensitive pigments a[phya], phyB, phyC, phyD and phyE) that absorb red / far red light and at least two cryptopigments (CRY1 and CRY2) that absorb blue / UV-A light (Chory, 1997; Cashmore et al., 1999). These two photoreceptors control many aspects of photomorphogenesis, and their functions overlap in controlling physiological responses (Cashmore et al., 1999). Signal transduction networks that respond to these photoreceptors have begun to be elucidated, and several factors of photopigment signal transduction have been defined (Whiteram et al., 1993; Ahmed and Cashmore, 1996; Wagner et al., 1997; Genoud et al., 1998; Ni et al., 19981999; Choi et al., 1999; Fankhauser et al., 1999; Halliday et al., 1999; Hoecker et al., 1999; Hudson et al N et al., 1999; Smith, 1999). The different roles of phyA and phyB in plant development may be due to their different structural activities, phyA is not light resistant and phyB is not light resistant, in part because of the different correlations between the downstream signal pathways activated by these two photoreceptors (Quail et al., 1995). These differences lead to the widespread belief that phyA is the main sensor of continuous far red light, and phyB mainly mediates the reaction to continuous red light (Chory, 1997).

In plants, the clock regulates many aspects of development, including hypocotyl elongation and photoperiodic induction of flowering (Kreps and Kay, 1997). Recently, some Arabidopsis genes related to biological clock (such as CCA1, LHY, FKF1 and ZTL) have been involved in the control of photomorphogenesis in plants, including the control of hypocotyl elongation and flowering time (Schaffer et al., 1998; Wang and Tobin, 1998; Nelson et al., 2000; Somers et al., 2000). In addition, photoreceptors regulate the band of light / dark cycles by endogenous circadian oscillators and the regulation of circadian clock functions (Millar et al., 1995; Somers et al., 1998). However, the relationship between these clock related genes and photoreceptors that regulate the clock to recognize light / dark periods is unclear.

Previous studies have shown that Arabidopsis ELF3 mutants have defects in light perception or light-mediated signal transduction; when growing under constant light, they also have defects in circadian rhythms, but not in constant darkness (Hicks et al., 1996; Zagotta et al., 1996). Recently, Reed et al. (2000) reported the possible independent effects of early flowering 3 (ELF3) and phyB on controlling the elongation and flowering time of hypocotyls. In this study, our aim was to elucidate the role of ELF3 in signal transduction pathways related to photoreceptor function and clock regulation. We found that ELF3 is a part of phyB signal complex, which controls the elongation of hypocotyl, while ELF3 and photosensitive pigment control flowering through independent signal transduction pathway. This makes it possible for Zagotta et al. (1996) to interact with cryptopigments or other potential blue light receptors (such as FKF1 and ZTL) to regulate photoperiod induction of Arabidopsis flowering. Many aspects of plant development are regulated by photoreceptor function and biological clock. Loss of function mutations in the early flowering 3 (ELF3) and phytochrome B (phyB) genes in Arabidopsis lead to early flowering and affect the activity of circadian clock regulation. Here we demonstrate the relative abundance of ELF3, a new nuclear localization protein, which shows circadian regulation following the circadian accumulation pattern of ELF3 transcripts. In addition, ELF3 protein interacted with phyB in yeast two hybrid test and in vitro test. Genetic analysis showed that ELF3 needed phyB function in early morphogenesis, rather than flowering regulation. This suggests that ELF3 is a component of phyB signaling complex, which controls the early events of plant development, but ELF3 and phyB control flowering through independent signal transduction pathways (Liu XL et al., 2001).

Canopy light interception (LI) is an important environmental factor determining dry matter production and crop development (Chenu et al., 2005, Escobar Gutiérrez et al., 2009). Photosynthetically active radiation (PAR) is solar radiation with wavelength of 400-700 nm (Asrar et al., 1989). Par is a part of the light radiation spectrum of green plants producing dry matter through photosynthesis (Marini and Marini, 1983). The amount of light intercepted by crop canopy reflects the physiological process, microclimate and hydrodynamics in canopy (Singer et al., 2011).

Light interception by crop canopy is complex and is affected by solar angle, plant row direction, canopy structure, diffuse proportion of incident radiation and leaf optical properties (Wagenmakers and Callesen, 1995, Giuliani et al., 2000, Mariscal et al., 2000, Nouvelon et al., 2000). In particular, canopy structure, which is influenced by plant internal structure characteristics and canopy management practices, has a great impact on Li (Wiechers et al., 2011, Zhang et al., 2015a). In order to quantify the light intensity in the canopy, beer's law was used to calculate the light intensity in each layer of the canopy at a specific height (Monsi and Saeki, 1953). The vertical distribution of par in crop canopy is a mathematical function of extinction coefficient (k) and leaf area index (LAI). Therefore, many studies focus on these two parameters (Nilson, 1971, Suits, 1972, Ross, 1981, Goel and Strebel, 1984, Campbell, 1990, Wang et al., 2007).

However, the observed results do not satisfy this mathematical function (Wilson et al., 1992).

At the same time, 3D digital methods based on information technology have been used to simulate light distribution in plant canopy (Mariscal et al., 2000, Chenu et al., 2005, Munier Jolain et al., 2013). These studies include Ross and Marshall (1988), Chelle and Andrieu (1998), Chelle and Saint Jean (2004). However, these models do not consider the interaction between plant organs (Andrieu et al., 1995). In addition, these methods have a large amount of calculation and data storage, and it is difficult to obtain the model parameters. In order to consider spatial heterogeneity, Munier jolain et al. (2013) created a multi-year weed dynamic model florsysfor to simulate Li in heterogeneous canopy. However, this model is too complex to be universal.

Geostatistics provides a multi-functional tool for environmental disciplines with high spatial heterogeneity, such as agriculture, aquaculture, hydrology, geology, meteorology, soil science, ecology, petroleum engineering, forestry, meteorology and Climatology (Francescangeli et al., 2006, Fortin et al., 2012, Griffith, 2012, Arbia, 2014). Recently, we have successfully measured canopy light using geostatistics, and quantified the spatial distribution of light in heterogeneous cotton canopy based on geostatistical sampling (Zhi et al., 2014).

Water sapply

Water is now a natural resource and needs to be used very carefully for any purpose. Wise water management should be instilled in human habits. Water is important to every area of our lives, and the approach is now shifting from global water management to the local level. The world's six billion people already account for 54% of all available freshwater reserves. It is predicted that the share of human beings will reach 70% by 2025. The World Water Resources Development Report 2003 of the United Nations development program only accounts for 8% of the global water consumption. The agricultural sector is the world's largest water user, accounting for about 70% of total freshwater extraction. However, it is estimated that industrial water demand will increase and capture the share of households and the agricultural sector. In fact, in high-income countries, industrial water already accounts for about 60% of total freshwater consumption, almost twice as much as agricultural water. Therefore, even if more and more countries begin to choose industry rather than agriculture as the key to economic growth, it may become a global trend. This estimate reflects how we need to allocate more water to humans. Agricultural water accounts for nearly 70% of the world's water use, most of which is used for irrigation (Ajai Singh, 2017).

Water pollution in The Soil–Plant–Atmosphere System (SPAS), may occur in a variety of preparations: (1) biodegradable products and organic substances; (2) chemicals (minerals, heavy metals, acids and bases); (3) non biodegradable organic products (plastics, detergents, pesticides and other petrochemical products). These pollutants enter the food chain of the ecosystem at some stages and can reach human beings. The serious problem is heavy metal poisoning, such as lead, mercury, arsenic and cadmium. For still or semi still water, such as lakes and dams, the term eutrophication is usually used to indicate the increase of ion concentration in water, especially for nutrients, such as those containing nitrogen, nitrogen and phosphorus. This organic (industrial, urban, or agricultural) or inorganic (industrial) source creates an imbalance in these ecosystems. Some species of plants, such as algae, develop in a worrying way compared to others, changing oxidation conditions, light penetration, temperature, fauna and flora. In fact, eutrophication is an irreversible process. In a few cases where measures can be taken, a lot of money has been spent on its recovery (Klaus Reichardt and Luís Carlos Timm, 2020).

Global and regional climate has begun to change. Climate change is directly or indirectly attributable to human activities that alter the composition of the global atmosphere, as well as to natural climate change observed over comparable periods of time (Karmakar et al., 2016). A model describing global climate is a mathematical representation of physical and dynamic processes used to simulate the interactions between the atmosphere, land surface, ocean and sea ice (Dettinger, 2005). IPCC (2007) reported: "from pre industrialization to 2005, the concentrations of carbon dioxide, methane and nitrous oxide in the global atmosphere have increased. The annual average growth rate of CO_2 concentration in the past 10 years (1995-2005, 1.9 ppm per year) is higher than that since the start of continuous direct atmospheric measurements (1960-2005, 1.4 ppm per year), although the growth rate varies year by year. ". In order to limit global early warning to 2 ° C above pre industrial levels in 2100, annual emissions from the agricultural sector must be reduced by 1 gigaton of CO_2 equivalent per year by 2030 (Wollenberg et al., 2016). Currently available interventions, such as the sustainable intensification of dairy production and alternate wetting and drying of irrigated rice to achieve emission efficiency, and innovative policies to promote soil carbon sequestration are necessary (Cole et al., 2018).

Water is one of the most important materials in the earth's crust, which plays an important role in life and physical and chemical processes. In the liquid and solid phases, it covers more than two-thirds of the earth. In the gas phase, it is part of the atmosphere and exists in every part. Without water, life as we know it would not exist. Organisms originated from water medium, and they are absolutely dependent on water medium in the process of evolution. Water is a component of protoplasm, and its proportion can reach 95% or more of the total weight of living organs. In protoplasm, it is involved in important metabolic reactions, such as photosynthesis and oxidative phosphorylation. It is a versatile solvent that makes most chemical reactions possible. In plants, water also has the function of maintaining cell expansion, responsible for vegetative growth.

Therefore, understanding its physical and chemical properties is very important for studying its function in nature, especially its overall behavior in soil plant atmosphere system (Klaus Reichardt and Luís Carlos Timm, 2020).

Water is the key and fatal factor in plant production. The lack or excess of water directly affects the growth and development of plants. Therefore, reasonable management of water is a necessary condition to maximize agricultural production. Any crop in its growth cycle will consume a lot of water, of which up to 98% of the water can only reach the atmosphere through plants and transpiration. However, this kind of water flow is essential for the development of plants. Therefore, the water flow rate of each crop must be kept within an appropriate limit. The water fixed by photosynthesis is the smallest relative to transpiration, and is incorporated in the formation of sugar and finally into dry matter. According to the needs of the plant, the water in the reservoir can be sent back to the soil temporarily. Since the natural recharge of the reservoir including rainwater is discontinuous, the amount of water available to plants is variable. When the rainfall is too large, its storage capacity will be exceeded, and a huge loss will occur. These losses may be due to soil erosion caused by surface runoff or loss to groundwater due to deep percolation. From the point of view of the factory, the leachate is lost, but from the point of view of the underground aquifer, the leachate is obtained. One drawback is that the drainage carries all the nutrients and organic compounds such as soluble salts. When there is not enough rain, the soil acts as a necessary reservoir for plant growth. When the crops run out, the reservoir needs to be manually reloaded, which is irrigation. Therefore, the correct management of water resources is the basis of rational agriculture. In arid and semi-arid areas, proper management means water-saving policies and salt care practices. In over wet areas, the fundamental problem is the leaching and drainage of soil materials. In areas with abundant rainfall, distribution problems often occur, leading to periods of water shortage. In these areas, the most important thing is to improve crop water use efficiency and supplementary irrigation as much as possible (Klaus Reichardt and Luís Carlos Timm, 2020).

For many years, the concept of plant available water has caused controversy among researchers. The main reason for the controversy may be the lack of a physical definition of the concept. Veihmeyer and Hendrickson (1927, 1949, 1950, 1955) pointed out that soil moisture is equal in the range of water content from the upper limit (field capacity FC to the lower limit (permanent wilting point PWP (θ_{PWP}). The PWP was defined by veimeyer and Hendrickson (1949) as soil moisture content, under which wilting plants could not recover their expansibility even after 12 hours in saturated atmosphere. It is generally assumed that the soil moisture content corresponds to a matrix potential of - 15 atm (- 1.5 MPa). These authors assume that the biological function of plants is not affected in this range, and the sudden change exceeds the lower limit (curve “a” in Fig. 17).

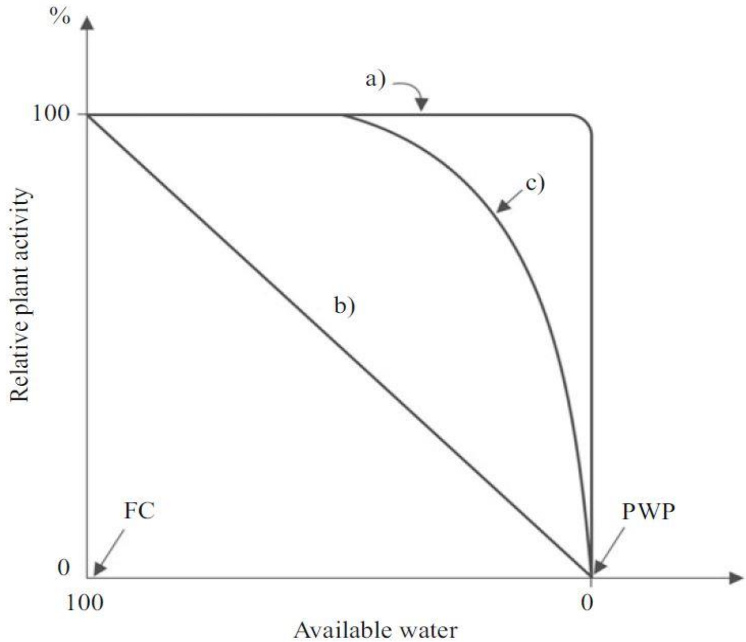


Fig. 17 different views (points) on soil water availability
(From: Klaus Reichardt and Luís Carlos Timm, 2020)

Other researchers, especially Richards and waldleigh (1952), have found that there is evidence that water availability of plants decreases with the decrease of soil water content, and plants may lack water and reduce growth before reaching the permanent wilting point. Other researchers do not agree with these two views (curve “b” in Fig. 17). They try to divide the range of available water into two intervals, one is "immediately available water" and the other is "available water". Look for a "critical point" between the field capacity and the permanent wilting point as an additional criterion for the definition of usability (curve “c” in Fig. 17). None of these schools can base their hypothesis on well founded theories. Through a few experiments carried out under specific conditions, these authors have reached a general conclusion. When it is found that different plants have different responses to soil water, the problem becomes more complicated, which makes researchers realize that soil water content alone is not a sufficient standard to determine the effectiveness of soil water. The attempt to solve this problem by associating the energy state of water in plants with the state of water in soil is an improvement in terms of its potential. Therefore, the soil "constant" is defined as the generally applicable potential (-1 / 3 atm (-33 kPa) for θ_{FC} and -15 atm (-1.5 MPa) for θ_{PWP}). However, although the use of these energy concepts represents considerable progress, it is still necessary to consider the soil plant atmosphere system as a continuous and extremely dynamic system. Considering the inherent complexity of space-time relationship involved in the process of plant water absorption, it is difficult to accurately describe the water absorption of plants with a well founded theory. Roots grow disorderly in the most different directions and spaces. The traditional method of measuring θ and ψ is based on sampling relatively large volume of soil. Because of these and many other difficulties, this phenomenon can only be analyzed semi quantitatively. In the second half of the 20th century, the interpretation of the relationship between soil plant and water changed fundamentally. With the development of theoretical knowledge of water state in soil, plant and atmosphere, as well as the development of experimental technology, we can give a more solid explanation to this problem. It is becoming more and more clear that in such a dynamic system, static concepts, such as equivalent water content, permanent wilting point, critical water content, capillary water, gravity water, etc., are usually meaningless, because they are based on the assumption that the processes occurring in the magnetic field point to this static state (Klaus Reichardt and Luís Carlos Timm, 2020).

This development makes us improve the classical concept of water use in the original sense. Of course, there is no qualitative difference in water holding capacity under different soil potentials. And the amount of water that plants absorb is not just a function of their potential in the soil. This amount depends on the ability of roots to absorb the soil water in contact with them and the soil properties of supplying and transferring water to roots, and its proportion meets the requirements of transpiration. It can be seen that this phenomenon depends on soil factors (the relationship between hydraulic conductivity, diffusivity, water content and water potential), plants (root density, depth, root growth rate, root physiology, leaf area) and atmosphere (saturation deficit, wind, effective radiation). Denmead and Shaw (1962) confirmed the effects of dynamic conditions on water uptake and subsequent transpiration by experiments. The transpiration rates of potted and field maize under different irrigation and evaporation conditions were measured. When the evapotranspiration is equal to 3 – 4 mm day^{-1}, the actual evapotranspiration rate ET_c is lower than the etc rate, because the average soil water content corresponds to a soil water potential of about 2 atm. Under more extreme weather conditions, ETc varies from 6 to 7 days, and the decrease of ET_c has been verified by the potential of soil moisture equivalent to 0.3 atm. On the other hand, for very low values of etc, less than 1.5 mm day^{-1}, no decrease in ET_c was observed before the potential reached -12 atm.

Although the processes involved in water flow, i.e. infiltration, redistribution, evaporation and absorption by plants, are independently studied, they can and do occur simultaneously. In order to study the water cycle of crops or any ecosystem, it is necessary to consider the water balance including these processes. WB is just the sum of the amount of water entering and leaving the soil volume elements in a given time interval, so as to obtain the remaining net water in the soil. In fact, water balance is the law of conservation of mass, which is closely related to energy balance, because the process involved needs energy. Conversely, energy balance is also the law of conservation of energy. From an agronomic point of view, water balance is the most basic, because it defines the water conditions under which crops develop or are developing at each phenological stage (Klaus Reichardt and Luís Carlos Timm, 2020).

The difference of water absorption during grain filling also affected photosynthesis, thus affected carbohydrate supply of mature grains. For example, there is a good relationship between RLD of deep soil and harvest index (indicating grain filling) of chickpea, especially under severe drought conditions (Kashiwagi et al. 2006). A similar phenomenon may be common in sorghum. In sorghum, maintaining green phenotype is related to better grain filling. One of the hypotheses is to maintain physiological activity and green leaves under extreme water stress, as well as the lowest water absorption, and maintain grain filling under extreme drought. This is consistent with the deep rooting of green genotypes observed under water stress (Vadez et al., 2014). The amount of water needed to maintain grain filling may be relatively small, which is due to the slight difference in root development (depth, RLD). This difference is difficult to capture by current measurements of root growth (biomass, rld, root length), but can be measured by assessment of water absorption, which will "synthesize" the benefits of slight RLD differences over time.

Water use efficiency (WUE) can be defined as several levels: (1) instantaneous carbon fixation / transpiration ratio (A / E) at the cellular level, (2) biomass / water transpiration ratio (TE) at the plant level, and (3) yield or aboveground biomass / transpiration ratio (WUE) at the field level. Here we will discuss te, which is usually the main part of moisture, although in some dryland situations soil evaporation may be a large part of evapotranspiration (Vincent Vadez et al., 2011).

Due to the higher VPD, the shorter crop planting period and the faster water use of soil profile, the temperature related differences in canopy development will have a negative impact on the overall water balance of soil profile. From the perspective of water availability, the strategy of determining successful genotypes suitable for limited water resources in climate change scenarios needs to be based on the following two basic requirements: (1) maximize transpiration and water capture. (2) Ensure water supply at the critical stage of crop development, especially after flowering. An exception to the emphasis on reproductive growth is that climate change is predicted to reduce the likelihood of rainfall at the beginning of the growing season in southern Africa, thereby shortening the length of the growing season (Tadros et al., 2007). If we can develop crop genotypes that can withstand early droughts, it will enable them to sow under limited rainfall conditions, and it will be earlier than waiting for a good start. Studies on wheat, lupin and broad bean showed that as long as there was enough rain for germination and emergence, the seedlings could endure for as long as one month without follow-up rain. For this drought / climate change situation, screening for differences in seedling survival without water would be a simple and effective solution. The reproductive stage of crops is extremely sensitive to any type of stress (Boyer and Westgate, 2004). First of all, we think that the reproductive stage is a series of events from the appearance of flower bud to the beginning of grain filling. It is important to understand the water supply dynamics of these stages under stress, whether there are any genotypic differences in the dynamics, and how these differences are related to yield.

If we can manipulate the planting geometry (changing the number of plants per unit area without affecting yield or the number of plants per hectare), we can save a lot of water. If we increase the number of plants by changing the planting geometry, we need more water, but the yield per unit area will increase. It depends on how we plan our course of action. If the availability of water is not a limiting factor, it is possible to grow more plants per unit area and thus achieve more yield (Ajai Singh, 2017).

Water management is becoming more and more important in the case of low water supply. In order to avoid underestimating or overestimating crop water consumption, it is necessary to understand the exact water loss caused by actual evapotranspiration for sustainable development and environmentally sound water management (Shideed et al., 1995).

Silva et al. (2009) gave an example of estimating the amount of water extracted from coffee plants. Another example is Rocha et al. (2010), who tested a macro model of soil water extraction by roots based on micro scale processes and described the experimental results of plants dividing roots into soil layers with different hydrological characteristics. Another significant factor affecting the estimation of soil water storage is its spatial variability. Soil water content changes in space, level and depth, which is caused by the changes of pore space arrangement and the quality and size of matrix particles. As a result, problems arise concerning the form and quantity of samples required to obtain representative values of water content and the resulting storage capacity. These aspects are discussed by Kachanoski and de Jong (1988) and Turati and Reichardt (1991). In addition, Reichardt et al. (1990) and Silva et al. (2006) discussed how the spatial variability of water storage affects the estimation of water balance.

Less effort has been made to study the input side of water balance, that is, to obtain water from the soil. It has been known for a long time that the hydraulic conductivity of roots is variable (Henzler et al., 1999). In addition, the water conductivity of root cell membrane may be reduced by the blocking of water channels or aquaporins in root cell membrane. These transporters have received extensive attention in the past few years (Kjellbom et al., 1999).

Root zone soil hypoxia seriously affects crop growth and reduces crop yield and quality. Subsurface drip irrigation will aggravate soil hypoxia. Subsurface drip irrigation (SDI) is an efficient water-saving irrigation method developed to improve drip irrigation technology (Camp, C. R. 2003). SDI can keep the surface soil dry, effectively prevent and control the loss of soil water, control the overgrowth of weeds, reduce surface evaporation, surface runoff and deep infiltration, improve irrigation water efficiency, promote crop growth, and improve crop yield and quality In order to alleviate the pressure of water shortage (Camp, C. R. et al., 1998; Lamm, F. R. et al., 2007; Paris, P. et al. 2018; Phene, C. J. et al. 1991), we should reduce the use of pesticides and use unconventional water for irrigation.

However, SDI not only provides water and nutrients for crops, but also eliminates the air in the root zone pores, thus forming a temporary or long-term anaerobic environment in the root zone (Bhattarai, C.J. et al., 1991). Under the condition of high soil moisture, the diffusion rate of dissolved oxygen (do) from water to deep soil layer decreased significantly, resulting in the decrease of soil oxygen content (Armstrong, W. et al., 2007). When the oxygen content in soil is insufficient, one of the earliest stress responses of plants is stomatal closure (Gao, P et al., 2003), which in turn has adverse effects on crop photosynthesis (Kimball et al., 2002). When hypoxia stress occurs, the relative transpiration of crops decreases greatly immediately. Persistent hypoxia can cause many adverse effects on crops, such as nutritional deficiency, metabolic inhibitors and the incidence rate of root diseases (Vartapetian et al., 1997). Under hypoxia stress, the growth of plants decreased, the formation of new leaves was hindered, the number and area of leaves decreased, the leaves turned yellow rapidly, wilted, the dry matter content decreased, and the fruit quality was poor (Bennicelli, R.P. et al, 1998; Lopez et al., 2003; Guo, S. et al., 2008).

Through the SDI whole pipeline system, the water and oxygen needed for crop growth were transported to the root zone, which effectively improved the lack of soil ventilation and the oxygen environment of crop root zone, and promoted the growth, yield and quality of crops. Previous studies used air compressors or air ejectors as forced air intake systems to deliver air to the root area of crops (Bhattarai et al., 2006; Li, Y. et al., 2016; Niu, W., et al., 2016) through buried pipelines. Forced air intake could alleviate the anoxia in rhizosphere, increase the dry weight and activity of roots, and enhance the water absorption of roots (Bhattarai et al., 2005; Li, Y., 2016). The results showed that oxygen application could alleviate soil hypoxia and improve crop yield and quality. When the soil water content is high, the forced air intake mode plays a positive role in promoting crop yield. However, when the soil moisture content is low, this method will have a negative impact on crop yield (20). At present, most oxidation methods focus on adding hydrogen peroxide to irrigation water and using venturi syringe or air syringe (Bhattarai et al., 2015; Lee, J.W. et al., 2014; Li, Y et al., 2015). The air diffusion into the soil through the SDI transmitter is asymmetric in all directions. Air is likely to diffuse into the atmosphere through several preferred channels; this is known as the "chimney effect" (Elder, C.R. et al., 2010), resulting in low gas utilization and short contact time with crop roots.

In drip irrigation system, one of the main design criteria is to minimize the variation of flow (or emitter flow) along the drip line, whether it is horizontal or secondary. By designing a suitable length for a given working pressure, the flow variation of a fixed diameter branch or sub boat can be kept within an acceptable range. The change of flow rate or emitter flow rate is controlled by the pressure change along the pipeline, which is caused by the combined effect of friction drop and pipeline slope. When kinetic energy is considered to be very small and neglected in drip irrigation pipeline, pressure change will be a simple linear combination of friction drop and energy gain or loss due to slope (Wu and Gitlin, 1973; Howell and Hiler, 1974). The transverse length (or sub length) can be designed by step-by-step calculation with a computer. The computer program can be used to simulate different situations to develop design charts, as shown in Wu and Fang Meier, 1974. The shape and slope of the general gradient line are simplified by using the program (Howell and Hiler, 1974). Wu and Gitlin (1974) introduced the design drawing of siding design, but they need to try and error technology in the design process. The purpose of this chapter is to deduce the mathematical expression of the side line or sub body, which will simplify the design technology. The derivation is applicable to different types of uniform slope conditions, in which the ground slope along the radiation length does not change. The derived equation relates the design length to the total head, and its form is convenient to use the computer design method. These calculations can be completed by digital computer or by pocket calculator, so that the design engineer can carry out the correct design on site. You can also develop graphical solutions. While basically still a trial and error technique, the adaptability of these design equations to computer solutions should represent a significant advance in drip irrigation system design.

Through the five pressure distributions, these represent the design conditions generated by siding or sublines laid on a uniform slope. The program to determine the pressure distribution by the slope of the ground and the total friction drop at the end of the pipeline is established. According to the given pressure variation criterion, the equation of design lateral length or submarine is derived. These equations can not be solved directly, but can be solved by trial and error method on pocket calculator or Newton approximation method in computer program. The established mathematical equation can provide reference for the computerized design of drip irrigation system in the future (Victor A. et al., 2017).

Deficiet irrigate and water requirement

English and Nuss (1982) put forward the concept of deficit irrigation, and defined it as "deliberately less irrigation of crops, that is, the irrigation water supply of crops is reduced relative to the amount of water needed to meet the maximum evapotranspiration". The concept of deficit irrigation was further developed from English (1990) to "under irrigation of crops in a planned and systematic way in the whole biological cycle under the condition of a certain yield reduction". His definition also includes an analytical framework to estimate the profit maximizing level of water use. Ferres and Soriano (2007) pointed out that deficit irrigation should be defined according to the water supply level related to the maximum crop evapotranspiration, instead of seeking the maximum yield. Capra et al. (2008) developed another deficit irrigation term as an irrigation application that is lower than the total evapotranspiration of crops. By reducing capital and operating costs, it is possible to improve efficiency and maximize profits. In view of, Chai et al. (2016) pointed out that deficit irrigation is considered as an irrigation practice, which is characterized by the application of irrigation water below the total amount of water required for optimal growth and yield, in order to improve the response of plants to a certain degree of water shortage in a positive way and improve the water use efficiency of crops. Therefore, deficit irrigation is regarded as a key contributor of water-saving technology. Capra et al. (2008) reported that some authors who adopted the English definition of deficit irrigation only dealt with the physiological and agronomic aspects of deficit irrigation, that is, the response of crops to different irrigation systems, without any economic assessment, which caused some misunderstanding.

Irrigated agriculture is the main contributor to food production in Egypt, consuming 85% of Egypt's water resources. Surface irrigation is the main irrigation system of old land, and the water use efficiency of farmland is 50-60%. Farmers are used to sowing in the basin, there, or in the furrow. This practice leads to the application of a large amount of irrigation water. Under furrow irrigation, water runoff may cause soil erosion and fertility loss (Sojka et al., 2007). In addition, fertilizer leaching is also the result of massive irrigation, resulting in groundwater pollution (Abouelenein et al., 2010). On the new land, sprinkler and drip irrigation systems are prevalent, and surface irrigation is prohibited by law. Small areas of new land use canal irrigation originated from the Nile, but most of the new land use groundwater irrigation. However, due to the low utilization efficiency of land and water resources, poor or lack of agricultural background, weak or lack of extension services to deal with the specific needs of new land, most of the reclaimed areas have low income compared with their full potential, poor agricultural credit and low input supply. In addition, there are other problems in the new land, that is, soil degradation caused by salinization. High evapotranspiration and / or combination with high water table in some areas leads to salt accumulation, especially in the northern part of the Nile Delta (Mohamedin et al. 2011).

Recently, water shortage is prevalent in many parts of the world and threatens its population, with nearly 800 million people without access to safe drinking water and 2.5 billion without proper sanitation (Schiermier, 2014). This is expected to get worse in the coming decades, as the world population is expected to grow by 30% in 2050 (Godfray et al., 2010). As a result, it is expected to be more difficult to provide food for the growing population, given the water shortage. More than 40% of global food production comes from irrigated land every year, and 70% of fresh water is extracted (FAO, 2007). Coupled with projected climate change, this situation is likely to be the worst in the future (De Wit and Stankiewicz, 2006). Irrigation is an important measure to obtain high yield potential and increase total yield. Since irrigated agriculture is the largest freshwater user on earth (Gan et al., 2013), irrigation water is over exploited and over used (Chai et al., 2014). In addition, irrigated agriculture is practiced in many parts of the world, and many developing countries do not consider the protection and sustainability of water resources (Ferres and Soriano, 2007). Some countries, such as Egypt, are changing from a water rich situation to a water shortage situation recently. Egypt has passed the threshold of water shortage, reaching 600 m^3 / person / year (Ministry of irrigation and water resources, 2014). Due to the increase of population, the value is expected to reach 500 m^3 / person / year in 2025. Egypt's rapid urbanization has created a conflict between water demand in agriculture and other sectors. Strategic changes in water resource management are taking place in many parts of the world, and the supply available for irrigation is limited to the remaining water resources after all other sectors meet their needs (Ferries and Soriano, 2007). In this case, the water allocation to farmers is usually lower than the maximum evapotranspiration demand, or the water supply must be concentrated on a smaller land area, or the total area must be irrigated at a level lower than the full evapotranspiration (Vörösmart et al., 2010a). Therefore, available water resources for agriculture need to be re rationalized to meet the development needs of other sectors (Vörösmart et al., 2010b). Deficit irrigation is one of the most important management strategies. Fereres and Soriano (2007) defined deficit irrigation as an irrigation strategy, that is, to maximize yield with the minimum amount of water.

Due to the complexity of the effects of water regulation on crop growth, yield and quality, studies before the 1980s generally did not consider whether there was "luxury transpiration" in crops, and ignored the effect of water on quality. They only regarded the crop evapotranspiration under the condition of sufficient water and fertilizer supply and the highest yield as crop water demand, and applied it in farmland In the process of water management. Sufficient irrigation technology with high yield and abundant water is adopted to meet the potential demand of crops for water. With the aggravation of the contradiction between supply and demand of water resources and the decrease of available water per unit cultivated area, the crop water demand experiment began to change from the normal full irrigation experiment to the sub poor full irrigation experiment. A large number of research results show that water stress is not completely negative effect, and moderate water shortage in some specific development stages will not lead to water shortage. In the end the transpiration water consumption and total water consumption of crop growth period were significantly reduced, but the crop yield was improved to a certain extent, and the product quality was significantly improved. On the one hand, it shows that crops have "luxury transpiration" under the condition of sufficient water supply, and this water condition is not the best water requirement of crops. On the other hand, it also shows that from the physiological water demand characteristics of crops, by changing the water supply time and water supply amount. Water deficit (regulated deficit irrigation) can be applied to some specific growth stages of crops In order to meet the water requirement of crop life. Although regulated deficit irrigation has made significant progress in theory, which has changed the passive adaptation of crops to water deficit into active regulation of moderate water deficit. This regulation is only time regulation to a certain extent, and has not fully exploited the physiological water saving potential of crops. In addition, due to the different sensitivity of crop growth stages to water shortage, the water shortage in the previous stage may have an impact on the physiological and biochemical characteristics and growth and development in the later stage or several stages. Therefore, if the regulation is not appropriate, it is bound to have a negative effect. Therefore, it is very important to determine the water demand index and water control index of crop life and health in each growth stage. The most ideal state is to create an environment, so that crops can self perceive environmental changes, regulate stomatal movement behavior. So as to reduce their transpiration water consumption under the condition of meeting the water demand of their own life and health, without affecting the photosynthesis and nutrient absorption of crops. The research results of plant water physiology show that there is a rapid signal transmission system in crops. Whether it is endogenous hormones produced by crop root sensing drought or exogenous hormones sprayed on crop leaves. Crops will quickly transmit these information to the action sites of guard cells, so as to adjust the water swelling degree of guard cells, However, the change of water swelling degree of guard cells will cause the change of stomatal opening (Schachtman et al 2008; Zhang Suiqi, 2010).

Root chemical signal is an early warning system for plant homeostasis and water use optimization. When soil is dry, roots can synthesize and output a variety of signal substances. These signals can be output from the drought affected cells in the form of electrochemical wave or specific chemical substances. Also can be transported from the production site to the action site to promote the opening of stomatal part Closing and inhibiting the opening of closed stomata can control the water and gas exchange between plants and the outside world. Abscisic acid (ABA) seems to play a major role in this information transmission in plants (Davies WJ et al., 1990).

Although people have fully realized the importance of crop life water requirement information and its process control, and made some gratifying progress in recent years. Due to the influence of natural conditions, crop physiological characteristics, irrigation technology and other factors, crop life and health water requirement involves soil, meteorology, plant water physiology, agriculture and so on At present, there are still some scientific problems to be solved (Kang Shaozhogn, 2007):

(1) Quantitative expression and standardization of crop life water requirement process. It includes the equipment and monitoring of long-term non-destructive continuous monitoring of plant transpiration, noise interference elimination methods, variation analysis among plants and standardized treatment, etc.

(2) Spatial temporal variation and scale transformation of crop water requirement information. It includes the existing form of spatiotemporal heterogeneity of crop water demand information, the

optimization of sampling strategy, the representative analysis of sampling points, the determination of scale turning point. The identification of dominant factors at different scales, the derivation method of crop water demand information at different scales, and different monitoring methods at the same scale the determination of legal weight and the fusion rules and selection of different scales and different monitoring methods.

(3) Determination of crop life water requirement index system and comprehensive index. It is necessary to design enough water treatment in different regions, different climates and different irrigation methods and carry out continuous experimental research for many years, establish the relationship model between crop water and yield and quality, comprehensively analyze and determine crop life water demand index, water physiological index and soil water control index in each period, a comprehensive discriminant index and discriminant method, which can reflect the crop water status on each link and guide the regulation of crop water demand, are proposed.

(4) The regulation approaches and models of crop physiological water saving and consumption process. This paper studies the process of water deficit signal generation, transmission and response of water loss organs, including drought sensing organs, sensing mode, water deficit signal, signal generation and transmission mode, and response process of water loss organs. On this basis, the induction pathway of water deficit signal is studied, and the regulation pathway and

regulation mode of physiological water saving and consumption process of crops are put forward.

(5) Quantitative characterization of the response of crop life water requirement to environmental change and new technology and mode of precision irrigation based on the process control of crop life water requirement (Sun Jingsheng et al., 2011).

Crop water shortage diagnosis is the basis of precision irrigation. Crops will respond to drought in many ways. There are many indicators that can reflect whether crops are short of water. The most traditional and commonly used is soil water index. The research on the determination method and threshold of soil moisture index has a long history. It has experienced the process from soil drying determination to real-time automatic collection by sensors. At present, the rapid measurement technology of soil moisture has been relatively mature, and the application of neutron method, gamma ray method, impedance method, time domain reflection method, microwave method, etc, There is also the near-infrared method which is suitable for large-scale remote sensing measurement. Most of the above measurement technologies can realize real-time automatic monitoring and data acquisition, and the measurement accuracy can basically meet the requirements of precision irrigation. At present, the main research direction is to improve the stability of monitoring equipment and adaptability to various soils, further improve the measurement accuracy and reduce the cost of sensors. In terms of soil water threshold, although there are a large number of experimental research results for different regions and different crops at home and abroad. With the cultivation of crop stress resistant varieties and the application of regulated deficit irrigation, the appropriate soil water threshold for different crops at different growth stages is still a subject to be studied. Soil water index reflects the water status of crop growth environment, and the water status of crop will be reflected more directly and quickly in its physiological process and ecological status. Therefore, it is more accurate to determine whether crops are short of water by measuring the physiological and ecological indexes of crops. However, it is still a difficult problem to determine which physiological and ecological indicators are suitable for crop water shortage diagnosis and irrigation decision-making, how their sensitivity, stability and representativeness are, and how to realize the automatic measurement of crop physiological and ecological indicators. At present, the main physiological and ecological indicators of crops include: stem diameter variation (İsabel et al., 2000), stem sap flow (Ali AA et al., 2001), photosynthetic rate, leaf temperature and canopy air temperature difference (Yuan Guofu et al., 2001). The measurement method of stem diameter micro change is relatively simple, non-destructive to crops, and can realize continuous automatic monitoring. At present, there are research reports on using stem diameter variation to diagnose crop water status and make irrigation decision at home and abroad. Crop canopy air temperature difference can be measured by hand-held or positioning infrared thermometer, or by aerial or satellite remote sensing, which makes it more advantageous in regional drought monitoring (Yu Keshun et al., 1999). Compared with the research of soil moisture index, the real-time, reliability and stability of crop physiological and ecological index monitoring are relatively poor due to the great influence of environmental factors such as sunshine, temperature and wind speed. As an index of crop water shortage diagnosis and irrigation decision-making, the reasonable threshold range for different crops is a hot and difficult research topic. Crop irrigation prediction and decision-making is the core of precision irrigation. The traditional irrigation forecast is mostly based on the principle of soil water balance in root zone, and the crop irrigation schedule is formulated according to the measured soil water content and the calculated crop water demand. Representative models include CROPWAT software package recommended by food and Agriculture Organization of the United Nations (FAO) (Fernandez et al., 2001), ISAR model (Sellami et al., 2003) and IRRIWAT model (Xie Hua et al., 2001). Although this kind of model can well simulate the change of soil moisture, calculate crop water demand and irrigation water demand, and formulate optimal irrigation schedule, it can not meet the requirements of precise irrigation dynamic decision-making.

Another problem of precision irrigation research is how to solve the problem of spatial variability. There are obvious spatial differences in the growth environment and development status of farmland crops, including uneven terrain, different soil texture, different density of crops, different crop varieties or genes, etc. In order to achieve the goal of "spatial positioning management and variable input according to demand" in precision irrigation. İt is necessary not only to study the reasonable layout of field crop and soil moisture monitoring sensors, but also to put forward higher requirements for field irrigation facilities and control system as well as irrigation water transmission and distribution technology. In recent years, the variable technology developed in the world can solve the control problem of precision irrigation on field irrigation facilities. The variable technology of precision irrigation refers to changing the structure parameters or performance parameters of irrigation system directionally or randomly according to the basic variable parameters input by expert decision system or user experience, so as to achieve the purpose of real-time and precision irrigation. For example, the circular and flat moving sprinkler installed with advanced equipment such as computer intelligent control system, differential global positioning system (DGPS) and geographic information system can timely and automatically adjust the spraying water volume of the sprinkler or the walking speed of the machine according to the field position, so as to realize local variable rate irrigation and fertilization, and avoid mixing water, fertilizer and pesticide Spray to unnecessary places, resulting in water and fertilizer loss and non-point source pollution. The research of variable rate technology for precision irrigation is not mature, and it can only be realized with the help of variable rate equipment with excellent performance (such as variable rate emitter, variable rate water supply equipment, pressure regulator, variable rate spraying chemical equipment, controller, positioning equipment, etc.) (Liu Yu, and Xu Di, 2011).

Deficit irrigation (DI) refers to the application of water less than the transpiration demand of crops. Therefore, compared with full irrigation, irrigation water demand can be reduced and the saved water can be used for other purposes. Although DI is only a technology to optimize economic output in the case of limited water resources (Sinclair TR and Seligman NG, 1996), reducing irrigation supply in an area can cause many adjustments to the agricultural system. Therefore, DI practice is multifaceted, which causes changes at the technical, socio-economic and institutional levels. In humid and sub humid areas, irrigation supplement rainfall is a tactical measure to stabilize production during drought. This approach is known as supplementary irrigation (García-Vila M et al., 2009), although it uses limited water due to relatively high rainfall, the goal is to achieve maximum production and eliminate yield fluctuations due to water shortage. Rainfall replenishment through one or more irrigation in arid areas is a di form, as maximum production is not sought. When the irrigation rate is lower than the transpiration rate under soil water stress, the crop will extract water from the soil reservoir to compensate for the deficit. Then there are two possible situations. In one case, if sufficient water is stored in the soil and transpiration is not limited by soil water, even if irrigation water is reduced, consumption utilization (ET) will not be affected. However, if the soil water supply is insufficient to meet the needs of crops, the decrease of growth and transpiration and the decrease of DI induced et are lower than its maximum potential. The difference between the two cases is of great significance in basin scale (Sophocleous M, 2005). In the first case, DI will not lead to net water saving and yield should not be affected. If the extracted storage soil water is supplemented by seasonal rainfall, di practice is sustainable and has the advantage of reducing irrigation water. In the second case, di reduces water use and consumption (ET), but in the case of production directly related to ET, the output may be negatively affected. There are several strategies to impose water deficits on DI, but there are basically two options (English MJ,1990). One is to impose the same level of deficit (continuous or continuous DI) throughout the irrigation season, while the other focuses on some of the crop growth stages (regulating DI, RDI) that are considered least sensitive to water stress. Deficit irrigation helps to cope with supply constraints by reducing irrigation water. In field crops, when full irrigation is not possible, a well designed DI system can optimize WP in a region. The results show that ET is linear with the yield of main field crops, which will reduce the yield to some extent (Bergez JE et al., 2004). In many horticultural crops, if trees and vines, RDI has been shown not only to improve wettability powder, but also to farmers' net income as well. Because different crops respond to water deficit differently, it is important to study the basis of positive response to water deficit without affecting yield. Although DI can be used as a tactical measure to reduce irrigation water when water supply is restricted by drought or other factors, it is not known whether DI can be used for a long time considering that the decrease of water application may lead to a large accumulation of salt in the profile. It is necessary to study the sustainability of DI through long-term testing and modeling work to determine how much DI can promote permanent reduction of irrigation water (Elías Fereres and Margarita García-Vila, 2019).

In commodity agriculture, farmers' choice of crops is a complex decision, which is based on the related factors of production economy and marketing, followed by other socio-economic and biophysical factors. Water related factors such as crop water use are most important when supply is lower than expected demand. Crop consumption and utilization mainly depend on evaporation demand, season length and the proportion of incident radiation intercepted by crop canopy. There are great differences among different kinds of crops. These differences are also affected by the climate type of crop growth. In this regard, there are significant differences between tropical and temperate climates. In the tropical climate, the reference et is relatively constant throughout the year, and irrigation is used in the dry season; the key problem here is the duration of the growing season, and the goal is to produce a variety of crops in one year. In tropical climate, daily yield is the best indicator of efficiency, and crops must follow the order of optimal use of land and water (Elías Fereres and Margarita García-Vila, 2019).

Water shortage is an increasingly important issue as it will determine the next generation of global food and feed production. Under the condition of water shortage, the key factors for sustainable growth and production of annual and perennial (fruit) crops are very important. Nitrogen is the most important limiting factor for crop production worldwide after water deficit. Therefore, it is very important to know how to increase the yield of different crops by adding nitrogen fertilizer. In the crop development cycle, the dynamics of crop demand for nitrogen, the time of soil nitrogen supply determined according to soil characteristics, climate and soil agronomic management, the response of crops to different intensities, and the timing of nitrogen deficiency are all important issues. Using diagnostic and decision-making tools to manage the time of crop nitrogen application, in order to optimize the relationship between crop yield reduction and environmental impact balance. In an increasingly volatile and changing climate, the next generation of high-yield crops will rely on genetic interventions based on process understanding, selection of target traits in management environments, and high-throughput phenotypic and genotyping. Therefore, it is very important to understand the latest progress of plant high-yield breeding and the main limitation of abiotic stress on productivity (Elías Fereres and Margarita García-Vila, 2019).

Crop water requirement is an important index for agricultural irrigation, and its complexity lies in its dynamic change. Different crops and different varieties of the same crop have different water requirements; in the process of crop growth and development, due to the difference of individual size and water demand of physiological process, the water demand of crops varies with different development stages. The main and more unstable factor affecting the change of crop water demand is atmospheric conditions, which determines the energy of crop water consumption. The greater the energy, the greater the water demand. The determination method of crop water requirement includes direct measurement and theoretical calculation. Lysimeter is the main instrument for direct measurement, which is used to measure the water consumption of crops under the condition of unrestricted water. However, the crop water requirement varies greatly in different years, and the application of this measurement value in production practice is limited. It can not predict crop water requirement and guide irrigation. Therefore, the theoretical calculation is very important, it fully considers the influence mechanism of crop water demand, can predict crop water demand under different environments, and provides the basis for scientific irrigation scheme (Elías Fereres and Margarita García-Vila, 2019).

From the late 1940s to the early 1970s, the calculation method of crop water demand developed rapidly. Penman published the calculation method of water surface evaporation in 1948 in the Journal of the

Royal Society. However, this method is very rough when applied to farmland and pasture. Monteith derived the Penman Monteith formula (P-M) (Monteith JL, 1965) by introducing the concept of surface resistance, which opened up a new way for the study of unsaturated underlying surface evaporation; Jensen proposed the logarithmic relationship between the soil water correction coefficient estimated by potential evapotranspiration and the soil available water content (Jensen ME, 1974); Priestley and Taylor The formula (Priestley CHB, 1972) for estimating evaporation in humid climate is derived. Although these studies have laid a solid foundation for the estimation of crop water demand, they all belong to the calculation of actual water consumption rather than water demand.

It was not until the concept of crop coefficient was proposed that the calculation of crop water demand was started. The calculation formula is $ET_P = k_c ET_0$ (1), in which K_C is the crop coefficient; ET_0 is the reference crop evapotranspiration; ET_P is the crop water demand. Reference crop evapotranspiration is a kind of evapotranspiration calculated by penman sing Monteith formula when the height is 12cm, the canopy albedo is 0-23, and the leaf stomatal resistance is 100s / m. In this way, the crop water demand at any time can be calculated for different atmospheric conditions. This solves the water demand of a standard crop. Other crops can refer to this standard, and calculate the water demand of different crops by a correction, which is the crop coefficient. However, there are still many problems in determining crop coefficient and crop water demand. (1) The food and Agriculture

Organization of the United Nations (FAO) has always recommended the use of the formula above to calculate crop water demand, but the change in crop coefficients is very complex because it includes the effects of soil and crop characteristics. When the crops are not fully covered, the soil is exposed, and the water demand of crops includes ecological water (soil evaporation) and physiological water (crop transpiration). If the surface soil is dry and the root area is full of water, the problem is more complex. In practice, the change process of crop coefficient is generalized into several stages. According to the variation law of leaf transpiration and soil surface evaporation in each stage, the average value of a period is used to represent the crop coefficient in this stage. That is, $K_C = K_CB + K_e$. K_CB is the basic crop coefficient, which is the ET_0 of the soil in the root area when the surface soil is dry and the average soil moisture content meets the transpiration of the crops. Ke is the coefficient of soil surface evaporation, which reflects the influence of soil surface evaporation intensity on etc in a short period due to the wetting of surface soil after irrigation or rainfall. In fact, the above segmentation method of crop coefficient is very rough, and the crop coefficient can be divided into basic crop coefficient reflecting crop leaf transpiration and coefficient reflecting soil surface evaporation, namely $K_C = K_CB + K_e$. K_CB is defined as the ratio of Crop Evapotranspiration to reference evapotranspiration when soil is dry and transpiration is carried out at potential rate. Allen was equal to the KCB formula in 1998, which considered the influence of wind speed, relative humidity of air and crop height. Ke is the evaporation coefficient when the soil is wet after irrigation or precipitation, which represents the ratio of evaporation water to the whole crop water demand. Therefore, it is related to crop coverage. Allen et al.(1998) And Vu et al. (2005) have proposed the calculation method of K_e. (2) The advantage of formula (1) to measure crop water demand is that the dynamic prediction of crop water demand can be carried out as long as the weather conditions, crop types and crop development period are known (Doorenbos J et al., 1992; Akinbilel et al., 2010). But it is still unclear how universal crop coefficients are. FAO recommends a set of crop coefficient calculation methods under standard conditions. The so-called standard condition refers to the situation that large area crops with good soil fertility and good soil moisture condition without pests and diseases, and can obtain the highest potential yield under certain climate conditions. In practice, the growth conditions of crops are often different from the standard ones. If there are water shortage, low soil fertility, salt, disease and disease, waterlogging, or different management levels (mulching or crop interplanting, etc.), the crops will grow under non-standard conditions. How to adjust K_C reasonably according to the actual environmental conditions in the non-standard condition to calculate the crop coefficient under the non-standard condition? Some scholars have calculated the crop coefficients of different crops under non-standard conditions in different climatic regions, but these methods have some theoretical shortcomings. For different climate areas, how is the difference of crop coefficient between planting a crop? It is unclear whether the comparison of different areas can be solved by using large-scale steaming meter. (3) There is still such a dispute about the concept of crop water demand. Is soil water not limited and other conditions are suitable, and the water consumption is equal to the crop water demand? Many experiments have shown that, in certain stage of crop development, when the soil is under light water stress, the normal growth and development of crops are not limited, and better product quality may be obtained. Therefore, the water demand of crops described in formula (1) should be modified. The method can be used for different crops and different development periods. However, the inconsistency of soil and crop conditions in the field will bring great difficulties to the test. (4) If there is a reference crop (usually represented by alfalfa), under soil water stress, ET_0 in the formula is replaced by the actual evapotranspiration of reference crops. Can the left ET_P be considered as the actual crop water consumption? If this relationship is true, the actual water consumption can be inferred by the measurement of the steamer. It also needs relevant theoretical inference and experimental research to confirm (Shen Shuanghe, 2011).

Nutrition uptake

In 1840, Justus von lieberg, a famous German chemist, put forward the "theory of plant mineral nutrition", that is, mineral elements are essential basic nutrients for plants. This not only created the basic theory of plant nutrition and became the cornerstone of the development of modern plant nutrition, but also directly led to the rise of chemical fertilizer industry and promoted the development of traditional agriculture The development of agriculture to modern agriculture. So, how do crops absorb and utilize nutrients (N, P, K, CA, Mg, S, Fe, Mn, Cu, Zn, B, Mo, etc.) from soil? What are the ways and mechanisms for different crop species to absorb and utilize soil nutrients? Are they identical or similar? These became important scientific problems in early plant nutrition research. In 1952, American scientists Epstein and Hagen found that the curve of ion absorption by roots is similar to the curve of the relationship between the rate of enzymatic reaction and the concentration of substrate in chemistry, so they put forward the theory of enzyme kinetics of ion absorption, and believed that there are carriers responsible for ion absorption on the protoplasm membrane of plant root cells, just like enzymes, which play the role of absorbing and transporting mineral ions (Epstein E et al., 1952) . In 1972, Epstein and bloom found that there were two different absorption curves of potassium ions in plant roots when the medium potassium concentration was very low (0-0.20 mmol / L^{-1}) and very high (1-50 mmol / L^{-1}), which meant that there were different types of carriers (proteins) in the absorption of certain ions on plant cell membrane (Epstein E et al., 1972). In addition, the German scholar marschner proposed that there are two different mechanisms of iron absorption in plants: Mechanism I and mechanism II. Mechanism I is possessed by dicotyledons and non gramineous plants, while mechanism II is possessed by gramineous plants. These important breakthroughs have greatly improved people's understanding of the mechanism of crop nutrient absorption and utilization, reflected the genetic differences of crop nutrient absorption and utilization, and promoted the development of chemical fertilizer industry and the rational application of fertilizer.

With the development of agricultural modernization, the application of chemical fertilizer has become one of the most important cultivation measures in modern agricultural production. In 2006, the amount of chemical fertilizer (pure nutrient) in China exceeded 50 million tons, accounting for more than 30% of the total amount of fertilizer in the world (Xu Fangsen and Wu Ping, 2011).

Accelerate the depletion of mineral resources, and a large number of residual fertilizers in the soil with soil erosion, environmental pollution, such as water eutrophication is a huge potential threat. Therefore, it has become a hot topic in the field of agriculture at home and abroad to improve the efficiency of soil nutrient absorption and utilization. Especially, to reveal the molecular mechanism of crop nutrient efficient utilization, to excavate excellent germplasm resources or important functional genes for crop nutrient efficient utilization. To cultivate new crop varieties with high nutrient efficiency and high yield plant nutrition, crop breeding, molecular biology and other disciplines is another scientific problem to be solved. This is of great social, economic and ecological significance for the countries with increasing population and shortage of resources to realize the sustainable development of a resource-saving and environment-friendly harmonious society (Xu Fangsen and Wu Ping, 2011).

The process of crop nutrient utilization includes four aspects: activation, absorption, transportation and utilization of soil nutrients. The research on efficient utilization of crop nutrients and its mechanism is reflected in two aspects:

① the ability and mechanism of crop to activate, absorb, transport and utilize soil nutrients efficiently under the condition of nutrient deficiency

② the ability and mechanism of crop to activate, absorb, transport and utilize soil nutrients efficiently under the condition of adequate or sufficient nutrients, The potential and mechanism of nutrient metabolism to maximize crop yield.

The difficulties and key points of the research mainly focus on the first level. With the development of plant physiology, molecular biology and other disciplines, the research on the efficient use of nutrients in crops has gone from physiological and biochemical mechanisms to the molecular level. In 1992, Anderson and sentenac cloned the KAT1 and AKT1 genes of Arabidopsis thaliana (Anderson JA et al., 1992; Sentenac H et al., 1992). Since then, a large number of transporter genes and their regulatory factors related to the absorption and transportation of mineral nutrients in plants have been cloned (Yin Lipng et al., 2006), and important progress has been made in the mining of excellent germplasm, gene mapping cloning and variety breeding of rice, wheat, soybean, rape and other crops.

Soil resources are the material basis for human survival and development. They have a certain degree of self purification ability and can maintain relatively stable. However, if the external influence is beyond its tolerable range, it will lead to degradation of soil properties and functions. At present, the concept of soil degradation is more common: the process that leads to the agricultural production capacity or potential of land use and environmental control. That is the decline of soil quality and its Sustainability temporary and permanent, and even the complete loss of physical, chemical and biological characteristics of soil, which is caused by various natural and especially human factors, It includes the degradation processes of the past, the present and the future. Soil degradation means reducing or losing its biological and economic productivity. Besides the soil circle, soil degradation can also have adverse effects on other circles. For example, soil degradation caused by deforestation and land use changes will eventually aggravate greenhouse effect. All groundwater and most of the pesticide residues in surface water come from soil.

The causes of soil degradation include natural factors and human factors. The soil degradation can be caused by the natural factors such as topography, climate, vegetation conditions and soil parent materials. The high and low mountain areas are prone to geological disasters such as soil gravity erosion, landslide and debris flow. The basin, the gentle slope flat and various depressions are easy to form the salinization of soil. Climate drought is the key factor leading to desertification, such as the largest Sahara desert in the world. The climate in the region is extremely dry, and the annual precipitation in most areas is below 50mm. If the vegetation coverage is low, it will lead to the weakening of wind and sand fixation capacity, increase of soil erosion and even desertification. In recent years, the proportion of soil degradation caused by human factors has become more and more large, such as deforestation and deforestation. Overgrazing leads to the decline of vegetation coverage, soil erosion and soil erosion; intensive agricultural management and high-intensity fertilization lead to a series of soil quality, such as soil nutrient imbalance, soil acidification, biodiversity decline, accumulation of soil harmful substances, etc Degradation. With the expansion of global population and the improvement of people's consumption level, the development and utilization of soil will be intensified, which makes the problem of soil degradation increasingly serious and urgent to be solved.

According to the classification standard of global soil degradation assessment of the United Nations Environment Programme, there are about 1.2 billion hm^2 of vegetation covered land in the world with moderate or more soil degradation, of which 300 million hm^2 land has been seriously degraded, and its inherent biological function has been completely lost. In terms of regional distribution, the area of soil degradation in Asia is the largest, accounting for 38% of the total area of global soil degradation (GLASOD, 1990).

Cultivated land is the basic resource for human survival. The quantity and quality of cultivated land is related to World's food security and people's health. However, due to the population pressure, the deterioration of the global environment and the unreasonable use of cultivated land, the phenomenon of cultivated land degradation is extremely serious. Cultivated land degradation includes soil erosion, soil desertification, soil salinization, soil pollution, deterioration of soil properties and non-agricultural occupation of cultivated land.

Cultivated land fertility is the basic attribute and essential feature of cultivated land soil. İt is the comprehensive reflection of natural and man-made fertility. The ability of soil to supply and coordinate nutrients, water, air and heat for plant growth, and a comprehensive performance of physical, chemical and biological properties of soil ventilation, water permeability, water retention, mineral content, humus content, pH and other physical, chemical and biological properties (Brady NC, 1996). The following points are the formation and evolution of cultivated land fertility, mainly including:

① The original soil forming process, that is, the rock weathering is original soil or fine soil with the participation of plants and microorganisms;

② Organic matter accumulation process, including grass felt or spot felt, humification and peat;

③ The process of clay, that is, the process of clay particles formed by coarse to fine;

④ The process of decalcification and calcium deposition. Leaching leads to decalcification, while lime and gypsum are used to cause calcium recovery;

⑤ The process of salinization and desalting. The dry area and coastal area are easy to salinize, while irrigation and leaching can make the soil desalination and become normal soil;

⑥ Alkalization and dealkylation process. The results showed that the sodium saturation of soil complex was high when alkalization;

⑦ The ash process. Under the condition of strong acid humus in forest soil, abundant leaching of water leads to leaching of iron and manganese, and the soil is gray. During the process of aluminizing, desilting and desilication of soil occur in the humid hot climate, while aluminum, iron and manganese precipitate in the original soil layer. Soil is bleached because of the effect of iron and manganese removal caused by organic matter reduction and water seepage. The white pulp layer is also called white soil layer, and the process of ripening is also described. It refers to the process of soil fertility under the guidance of human factors. The main factors influencing the formation and evolution of cultivated land fertility include mother matter, climate, biology and human activities (Viets FG, 1977; Oren R. et al., 2001; Havlin JL et al., 2005). Parent material is the basic material for soil construction, the "skeleton" of soil, and the initial source of plant mineral nutrient elements excluding nitrogen. Climate determines the hydrothermal conditions of soil forming process, which not only directly participates in the process of parent material weathering and material leaching, but also controls the growth of plants and microorganisms, and affects the accumulation and decomposition of soil organic matter; Biological factors participate in the geological and biological small cycle of plant nutrients, synthesize and decompose soil humus, nitrogen fixation and transformation of mineral nutrients; human factors have a wide and profound impact on soil fertility, which makes the change speed of soil fertility far exceed the natural evolution process. Soil fertility factors have interaction among water, nutrients, air and heat, such as insufficient water, which limits the release, dissolution and plant absorption of soil nutrients. If the water is too much, the soil gas condition and soil temperature are too low, which affect the growth of plants. The coordination of various fertility factors is the basis of high-yield and stable yield of crops. The goal of coordination of various fertilizer factors and high and stable yield of crops can be achieved through soil configuration transformation such as passenger soil, thickened cultivation layer, etc. Elimination of soil obstacle factors such as acid, salt, alkali, etc., and improvement of water and fertilizer gas and heat status such as fertilization, irrigation, cultivation, etc.

The main progress in the formation and evolution of cultivated land fertility is as follows:

① It is found that the soil fertility is formed under the interaction of biology, climate, topography, geology and human activities on the macro level, and the micro fertility of cultivated land is determined by the relationship between porosity, organic matter, mineral matter and aggregate structure (Luxmoore RJ,1991; Viets FG, 1997;);

② In soil biology, soil biology is found (including microorganisms and higher animals and plants) are the drivers of the cycle process of carbon, nitrogen, phosphorus and sulfur in farmland nutrients, which participate in the processes of biological nitrogen fixation, nitration denitrification, fixed singing mineralization and biodegradation (Mader P, 2002; Dybzinski R, 2008);

③ In soil chemistry, it is found that the primary minerals in weathering or soil forming process are succeeding to secondary minerals, and secondary minerals provide a great deal of soil reaction Some surface sites, soil organic matter can form humus, which is aromatic and aliphatic compounds with multiple functional groups. These functional groups make humus become the largest electronic source and proton source in soil chemical reaction, the strongest binding bond of metal and the coating (forming aggregates) on secondary minerals. This characteristic is for the maintenance and maintenance of nutrient ions and the inclusion of secondary minerals The supply and formation of soil buffer are very important (Viets FG, 1977; Luxmoore RJ, 1992);

④ In soil physics, the law of soil water movement is studied, and the concept of soil water energy is established to determine the best irrigation period and optimal irrigation amount of crops; it is found that soil aeration directly affects the oxygen diffusion rate and redox potential, It is related to soil structure, texture, pore property and water content, and the soil heat status has an important influence on the growth and development of plants, microbial activities, nutrient transformation and other processes (Viets FG, 1977; Luxmoore RJ, 1992; Halvin et al., 2005);

⑤ In soil management, the paper puts forward solutions to the quality of cultivated land fertility under intensive management The principle and technical approaches of soil ripening, soil acidification, soil salinization, soil drought, nutrient imbalance and organic matter decrease are determined (Halvin et al., 2005);

⑥ Long term soil fertility test shows that the effect of organic fertilizer and Fertilizer on yield increase is the same under long-term fertilization, but the application of organic fertilizer can obviously change the physical, chemical and biological characteristics of cultivated land, and under the same fertilization conditions, The yield of the crop can be obtained by rotation ratio. The effect of long-term fertilization on crop yield is higher than that of sufficient fertilizer in the current season (Viets FG, 1997; Stevens GN et al., 2006).

At present, there are some difficulties in the research of the formation and evolution of cultivated land fertility.

(1) The formation and evolution of cultivated land fertility is driven by environmental factors, human factors and soil properties. Even the same type of soil, due to different planting methods, fertilization habits and hydrothermal conditions, the formation and evolution of cultivated land fertility are very different. At present, it is urgent to establish models for soil forming process, soil properties and fertility status, and study the equilibrium points of soil pH and organic matter under intensive cultivation conditions to predict the evolution of cultivated land fertility. Because of the many factors affecting the formation and evolution of cultivated land fertility, it is difficult to deduce from point to surface through geographic information system, global positioning system and remote sensing technology.

(2) Soil biology is the frontier of soil fertility research and the most active research field. In the future, it is necessary to carry out the research on soil biodiversity and soil biological process related to the change of cultivated land fertility; to explore and utilize soil biogenic resources to improve the fertility of cultivated land; to study the role of Rhizosphere Microorganism and the role of microorganism in the nutrient cycle of farmland.

(3) The formation and evolution of soil fertility are closely related to the chemical process of soil. The formation and transformation of soil minerals and humus should be studied by means of modern analytical technology (nuclear magnetic resonance technology and synchrotron radiation technology), the processes of nutrient adsorption desorption, precipitation dissolution, chelation of collaterals and choral, oxidation reduction and their relationship with nutrient bioavailability.

(4) In terms of nutrient management, we must take the road of high yield, high quality, high efficiency and sustainable utilization of farmland. In order to cultivate the fertility of cultivated land, we should study the mechanism and ways of efficient utilization of nutrient resources, develop precise nutrient management technology and best management measures. In addition, long-term soil fertility test spans a long time scale, records rich information of human activities and environmental changes, and is a valuable wealth with great scientific value. In the future, the

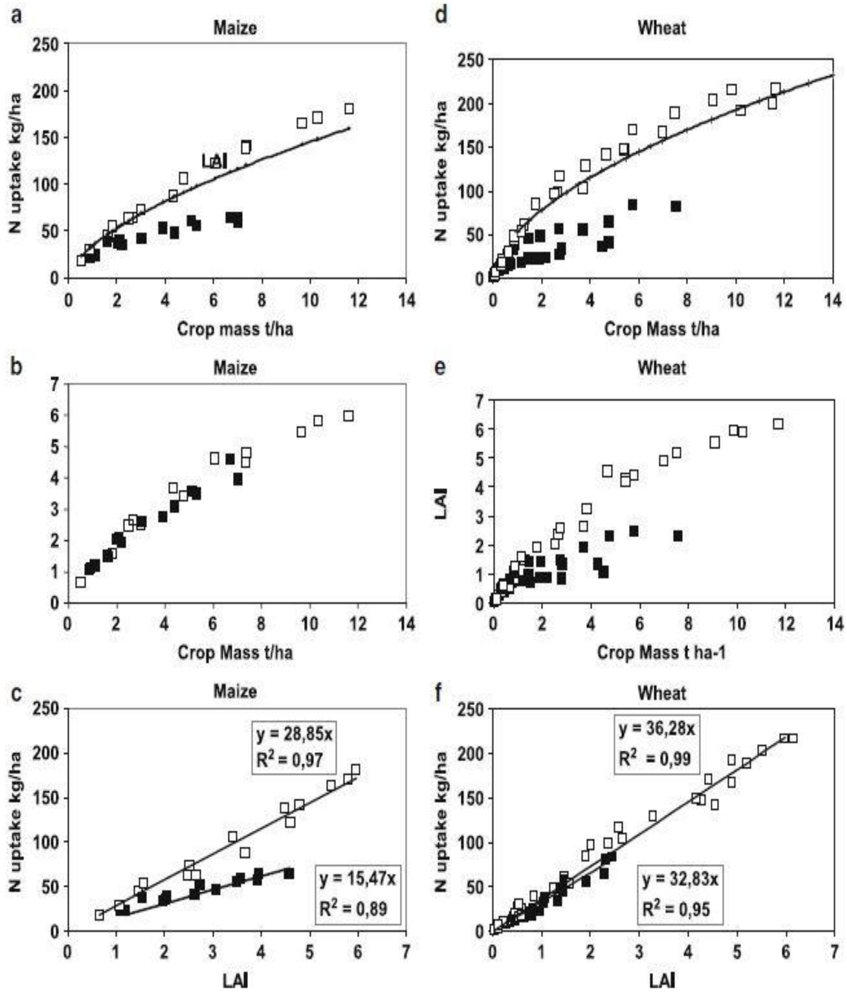
> research on the formation and evolution of cultivated land fertility should continue to develop this huge scientific information base (Zhou Wei et al., 2011).

The premise of analyzing crop response to nitrogen is to determine the content and redistribution of plant nitrogen. How much nitrogen is contained in plants and crops? In which plant tissues? What kind of physiological function? Therefore, based on the answers to these questions, it is possible to determine a critical plant nitrogen condition as the minimum plant nitrogen concentration that allows the maximum plant (or crop) growth rate. It has been proved that this critical plant nitrogen concentration decreases with the growth of the plant, which is due to the ontogenetic development of plant structure. As the plant grows larger, nitrogen compounds are diluted with the increase of the proportion of nitrogen free compounds. This process of nitrogen dilution can be described by a negative power relationship between plant nitrogen concentration and crop quality. This critical nitrogen dilution curve allows the distinction between nitrogen deficiency (below the curve) and nitrogen luxury consumption (above the curve). Therefore, we can calculate the nitrogen nutrition index (NNI) to quantify the nitrogen deficiency or nitrogen deficiency intensity at any stage of crop life cycle. This possibility of determining crop nitrogen status and quantifying nitrogen deficiency in terms of intensity or time allows a completely reversed approach: the problem is not crop response to nitrogen supply, but crop response to nitrogen deficiency. In this way, the check treatment is unrestricted under nitrogen conditions, crop growth potential is limited only by genetics and climate. Therefore, a more general method can be used to study the effects of nitrogen deficiency intensity and time on the growth process and yield components of different plants. This new method of analyzing the effect of plant nitrogen nutrition on crop yield provides physiological, agronomic and genetic approaches for improving crop nitrogen use efficiency (Gilles Lemaire and François Gastal, 2019).

In the world, nitrogen, together with water and phosphorus, is considered to be one of the most important factors limiting crop production. In the past 50 years, a large amount of mineral fertilizer has been used to produce enough food to meet the needs of the growing population (Angus JF,2001; Eikhout B et al., 2006). During this period, the supply of mineral nitrogen in the agricultural system increased sevenfold, and the agricultural grain production doubled. These large amounts of mineral nitrogen are provided by the industrial process of chemical reduction of atmospheric nitrogen, which has a high energy cost associated with a large amount of greenhouse gas emissions. In addition, the extensive use of nitrogen in intensive agricultural production systems has led to major environmental problems, such as freshwater eutrophication (London JG, 2005) and marine ecosystems (Beman JM et al., 2006), groundwater pollution, and gaseous emissions of nitrogen oxides and ammonia in the atmosphere (Ramos C, 1996; Stulen I et al., 1998). Therefore, issues related to sustainable development, global change, environmental protection and global food security are questioning the use efficiency of nitrogen fertilizer in agricultural systems (Cassman KG, 2007). The relatively high product / fertilizer price ratio encourages farmers to apply excessive nitrogen fertilizer to avoid any limitation of crop nitrogen nutrition, thus affecting crop yield. These practices lead to the gradual increase of excess nitrogen accumulation in soil and the risk of nitrogen leaching, which has a serious impact on water quality (Addiscott TM et al., 2008). The use of more limited nitrogen fertilizer is a prerequisite for sustainable agricultural development. However, due to the unpredictability of climate change, soil nitrogen mineralization and crop growth potential are determined. Therefore, in order to reduce environmental hazards and optimize crop production, it is necessary to better understand the regulation mechanism of nitrogen absorption and effective utilization by crops from soil, so as to improve yield and quality. The purpose of this paper is to establish an overall framework of nitrogen economy (i.e. nitrogen absorption and distribution) and plant and crop growth regulation principles, and to develop tools to improve fertilization management and breeding strategies using these principles. First, we suggest that a new ecophysiological paradigm based on the response of plants and crops to nitrogen deficiency should replace the agronomic paradigm based on the response of crop yield to nitrogen supply. Therefore, we theoretically analyzed the relationship between nitrogen demand dynamics and growth potential of plants and crops in crop growth cycle, and proposed and discussed agronomic tools for evaluating nitrogen status of crops. Secondly, we analyzed the physiological and morphological responses of plants and crops to nitrogen deficiency. In the last section, we will explore the concept of nitrogen use efficiency based on the principles previously developed (Gilles Lemaire and François Gastal, 2019).

The response of plant and canopy leaf area to nitrogen deficiency is caused by the expansion of single leaf and the significant decrease of branching or tillering (Vos J et al., 2005). These authors suggest that in many species, nitrogen has little effect on the occurrence rate of leaves and the duration of single leaf expansion. The accumulation of non structural carbohydrates in nitrogen deficient leaves showed that carbohydrate supply was not the reason for the decrease of leaf area expansion under low nitrogen supply (Debaeke P et al., 2012). Nitrogen deficiency changed the rate of cell division and cell expansion, and the final cell length was almost unaffected (Trápani N et al., 1999). The response of crops to nitrogen deficiency is: (I) reducing leaf expansion, and then reducing crop leaf area index and light interception, and (II) reducing leaf nitrogen content per unit leaf area, and then reducing leaf photosynthetic capacity or both (Grindlay DJC,1997). These two types of responses represent a trade-off between resource capture and resource utilization efficiency.

Lemaire et al. (2008) used the relationship between LAI and crop quality (W) in formula 10 to study the different response types of crop species to nitrogen deficiency (see Fig. 18).



Response of crops to nitrogen, **Fig. 18** Comparison of response of maize and wheat to contrast nitrogen supply: open sign corresponds to unrestricted nitrogen, dark sign corresponds to restricted nitrogen, as shown in **Fig. 18**. a and d, in which the critical nitrogen uptake curve NC = a'Wc^{1-b} of each plant was plotted. (b) and (e) represents the relationship between leaf area index (LAI) and W of two varieties, (c) and (f) represents the relationship between nitrogen uptake and leaf area index (redrawn by Lemaire et al., 2007)

It is a worldwide goal to improve the nitrogen utilization efficiency of main crop varieties. Nevertheless, as shown above, nitrogen utilization efficiency is a very complex variable, including a large number of elemental processes and some tradeoffs. A large number of literatures have reported the interaction between the NUE genotype and environment of different crop varieties. However, few allow NUEto be broken down in its three components: NRE, NCE and HI, thus avoiding a clear explanation of the differences between species and genotypes (Gilles Lemaire and François Gastal, 2019).

Three important conclusions can be drawn:

(1) with the increase of plant quality, the NRE and NEC increase due to the feedback control of nitrogen dilution process and plant growth rate on nitrogen absorption. Therefore, crops with high biomass will automatically have higher NRE and NCE than those with low biomass. Therefore, high yield breeding should be the direct result of high-yield breeding.

(2) it is more interesting to select plants with higher NUE under similar crop quality. The variability of the critical N dilution curve between species is low (except C3 and C4), indicating that the intraspecies variability of the NCE may be low and does not represent the realistic goal of the breeding plan. However, the variation of the interspecific NRE seems to indicate that there should be intraspecies differences in the ability of crops to adapt

to their own nitrogen demand under low nitrogen supply conditions. It is a relative breeding tool to sort the ability of genotypes to maintain high NNI under low nitrogen condition.

(3) For grain crops, nitrogen utilization efficiency not only depends on the ability of the crops to accumulate a large amount of nitrogen during flowering, but also depends on the effective transfer of carbon and nitrogen during grain filling. In order to determine the genetic control of these processes, a more detailed analysis is necessary (Thomas H and Ougham, 2014). However, these studies need to be well related to the identification of nitrogen status in flowering crops. In fact, the results of the comparison of the utilization ratio of nucleoside among genotypes reported in the literature mostly involve the increase of grain yield under the unit nitrogen supply, but there is no possibility of decomposition of nucleoside utilization, nucleoside utilization, nucleoside utilization, nucleoside utilization, nucleoside utilization, nucleoside utilization rate, etc. the possibility of decomposition of hi and non-use crops is not existed NNI is used as covariant to correctly explain observed differences (see Sadras and Lemaire., 2014: which part of the differences are explained by differences in crop quality or / or crop nitrogen status, which is corresponding to insignificant impacts, which is the result of intrinsic progress of NRE or NCE or HI? It is a worldwide goal to improve the nitrogen utilization efficiency of main crop varieties. Nevertheless, as shown above,

nitrogen utilization efficiency is a very complex variable, including a large number of elemental processes and some tradeoffs. A large number of literatures have reported the interaction between the nue genotype and environment of different crop varieties. However, few allow nue to be broken down in its three components: NRE, NCE and HI, thus avoiding a clear explanation of the differences between species and genotypes. Three important conclusions can be drawn from the above methods: (1) with the increase of plant quality, the NRE and NCE increase due to the feedback control of nitrogen dilution process and plant growth rate on nitrogen absorption. Therefore, crops with high biomass will automatically have higher NRE and nce than those with low biomass. Therefore, high yield breeding should be the direct result of high-yield breeding. (II) it is more interesting to select plants with higher nue under similar crop quality. The variability of the critical N dilution curve between species is low (except C3 and C4), indicating that the intraspecies variability of the nce may be low and does not represent the realistic goal of the breeding plan. However, the variation of the interspecific NRE seems to indicate that there should be intraspecies differences in the ability of crops to adapt to their own nitrogen demand under low nitrogen supply conditions. It is a relative breeding tool to sort the ability of genotypes to maintain high NNI under low nitrogen condition. （3） For grain crops, nitrogen utilization efficiency not only depends on the ability of the crops to accumulate a large amount of nitrogen during flowering, but also depends on the effective transfer of carbon and nitrogen during grain filling. In order to determine the genetic control of these processes, a more detailed analysis is necessary (Thomas H, Ougham H., 2014).

In fact, most of the comparison results of nucleoside utilization rate among genotypes reported in the literature only involved the improvement of grain yield per unit nitrogen supply, but there was no possibility of decomposition of nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, nucleoside utilization rate, HI and no use of crop nitrogen NNI was used as a covariate to correctly explain the observed differences (see Sadras and Lemaire., 2014: which part of the differences were explained by differences in crop quality or / or crop nitrogen status, which part of the differences corresponded to insignificant effects, and which part of the differences were the results of internal progress of NRE or NCE or HI?.

When analyzing the response of plants and crops to nitrogen deficiency, the first point to emphasize is that all basic processes must be integrated and extended to the whole plant and crop level. Nitrogen metabolism in plants is controlled by many physiological processes, such as nitrate or ammonium transport through root cell membrane, nitrate reduction in roots and leaves, nitrogen fixation in legume nodules, ammonium assimilation and protein synthesis for new tissue synthesis. Each of these metabolic processes is regulated by a certain degree of genetic variation at the molecular level. However, when all these processes are integrated at the whole plant and crop level, the integrated regulation of nitrogen uptake and nitrogen use efficiency can be summarized by a limited number of general rules, for which interspecific variability is reduced. For example, regardless of the source of nitrogen, i.e. nitrate, ammonium or biological nitrogen fixation, the feedback control of nitrogen obtained through aboveground growth seems to be similar and controls the total nitrogen absorption capacity of plants, although the intrinsic capacity of nitrogen absorption per unit root area or root mass is different. Therefore, it seems that the genetic variation of nitrogen absorption capacity that may be observed at the cell or organ level has been "buffered" at the whole plant level, while at the whole plant level, the integrated feedback mechanism is playing a role. In addition, when expanding from a single plant to a plant population, light competition leads to isometric growth, which exerts strong regulation on nitrogen uptake dynamics at the crop level. Isometric growth and nitrogen dilution curve are new characteristics of plant population level, so they have little to do with molecular and genetic control. Therefore, the acquisition and distribution of nitrogen in vegetative period of crops are mainly controlled by the plant plant interaction of light acquisition: the sharing of nitrogen between individual plants is parallel to the sharing of light. Therefore, any attempt to improve the ability of plants to obtain and utilize nitrogen in biomass production by controlling the genetic variation in some basic metabolic processes while ignoring the emergence characteristics of the whole integrated system is unsuccessful. To improve efficiency, genomic tools should be used within a more complete framework of plant and crop functions. The second conclusion discussed the possibility of improving crop nitrogen use efficiency through the application of comprehensive knowledge of crop breeding and agronomy. The primary goal of improving crop nitrogen use efficiency is to improve the ability of crop to absorb and accumulate nitrogen in soil. The ability of plants to absorb mineral soil nitrogen must be studied under low and high nitrogen conditions. As has been proved, under these two conditions, the nitrogen absorption efficiency of plants directly depends on their growth ability, which depends on (I) their own genetic potential, (II) external conditions such as soil and climate, (III) management technology, and (IV) the interaction between these three components. Therefore, improving crop growth capacity through breeding and crop management (such as irrigation, P, K, s fertilization and planting density) will improve nitrogen absorption efficiency. It is more important to improve nitrogen absorption capacity under similar crop quality. In this way, a certain yield can be obtained with less nitrogen fertilizer. This goal requires more effective root system (root length density) to improve the competitive ability of plants to use soil mineral nitrogen against soil microorganisms and weeds. The cultivation of root structure is not easy, but some studies show that it is possible. In order to improve the root development of crops, it is necessary to conduct more in-depth experiments through soil tillage and soil structure maintenance, and to study the quantitative effects on the nitrogen absorption capacity of crops (Gilles Lemaire and François Gastal, 2019).

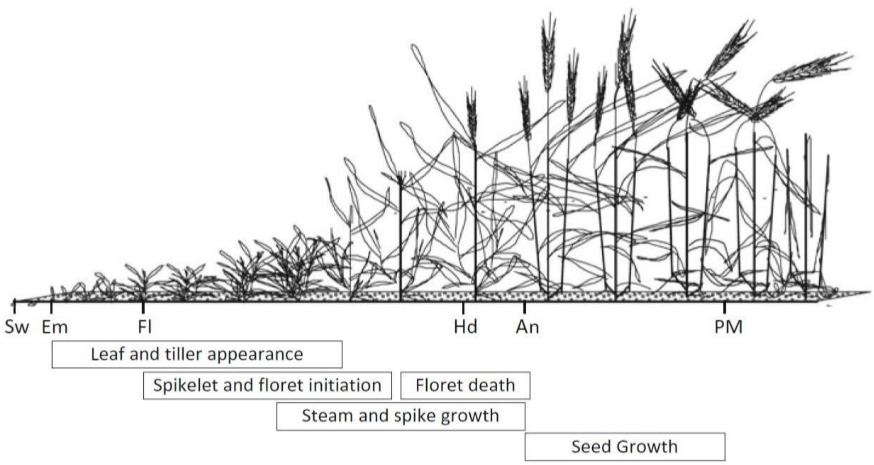
Nitrogen application timing is an important way to improve crop nitrogen use efficiency and nitrogen use efficiency. Because the ability of nitrogen absorption of crops depends on the growth rate of crops to a great extent, it is the best time to apply nitrogen fertilizer before the acceleration of crop growth. Progress must be made in noninvasive and operational tools for rapid diagnosis of crop nitrogen status using NNI method. These tools can monitor the evolution of nitrogen status of plants during the whole growth period. For most crops, high response period or low response period can be determined by studying the effects of short-term nitrogen deficiency time and intensity on Yield and quality. This information can be incorporated into decision-making tools to reduce fertilizer supply and achieve target yields. It is not easy to cultivate plants to improve the nitrogen use efficiency of dry matter production (feed or energy crops), because in addition to the difference between C4 and C3 species, the similarity of critical nitrogen dilution curve also proves that there is no obvious interspecific difference. However, the harvest index and nitrogen harvest index have great differences among genotypes, which may be different if yield and protein content are considered. Identifying the key elements in response to nitrogen deficiency from the perspective of grain development will provide us with more information about the local influence of whole plant nitrogen status on grain formation, grain development and grain filling. Because the nitrogen status of plant itself does not allow to determine the nitrogen status of reproductive meristem, it is necessary to establish more accurate models to describe the distribution and movement of nitrogen and carbon fluxes in plants, so as to consider the close relationship between nitrogen and carbon fluxes at the organ level (Gilles Lemaire and François Gastal, 2019). As described by Hammer et al., (2004), this will require collaboration between plant molecular physiologists, geneticists, agronomists, and bioinformatics experts.

Cereals and legumes are widely cultivated all over the world. There is no doubt that they are important as feed and food sources, mainly as carbohydrate and protein sources. The yield of these crops can be defined as the product of the number of grains per unit area and the average grain weight. The source sink regulation of cereal crops showed that the key period of determining grain number mainly occurred before flowering, while the key period of temperate legumes occurred at grain filling stage. In temperate grains, it is generally believed that the grain weight is almost not limited by the source of assimilates during grain filling. On the other hand, in temperate legumes, there is much less information about the effects of source sink regulation at grain filling stage. Determining the sensitivity of these yield components to source sink operations is essential for designing breeding and management strategies to maximize the yield of these crops (Patricio Sandaña and Daniel F. Calderini, 2019).

The sensitivity of grain crops to source bank regulation was studied to evaluate the key phenological period of grain number determination and whether the yield was source limit or reservoir limit during filling period. These studies provide key information for establishing the concept and mathematical model of yield decision of staple crops, and provide useful tools for crop management and plant breeding. Cereals and cereals are widely grown around the world, and their importance as a source of feed and food is undoubtedly, mainly as a source of carbohydrates (cereals) and proteins (beans). Although in some countries, cereals are also important sources of protein, and beans have been recognized as the relevant source of micronutrients (Graham P and Vance C., 2003).

Due to the differences in phenology and growth habits, there are important differences among these crop populations. In deterministic crops (e.g. temperate grains), it is generally assumed that the determination of grain number and grain weight after flowering has little overlap, while in semi deterministic and uncertain species (e.g. legumes), grain position extends after flowering. In the last group, when the upper node reached flowering stage, the basal node was already in pod stage. Therefore, in a long period of time, the yield and grain number of legumes are more sensitive to the availability of assimilates than cereals. Although this hypothesis is important, few studies have evaluated the yield and component responses of temperate cereals and legumes to different source sink ratios in the same experiment. Therefore, the purpose of this entry is to assess the response of comparative crop groups (i.e., deterministic and semi deterministic / uncertain) to source sink manipulation in order to understand grain yield decisions and sensitivities. With regard to cereal and legume crops, including several species that grow in different seasons of the year, this article focuses on temperate stable food crops, such as wheat and peas, and complements this information with other representatives of these groups. It is also important to emphasize that, despite the great progress in scientific knowledge of source sink response and grain yield measurement, the understanding of different crops is significantly different, as there is much more research on temperate grains than on legumes. Therefore, in the absence of data, it is difficult to compare the yield responses of these crops and infer the research results from specific environments. However, the key responses found in different experiments are useful as tools for crop management and plant breeding of these species. It is necessary to consider the effect of the source sink ratio on crop development. After that, the sensitivity of temperate grains and legumes throughout the crop cycle will be analyzed (Patricio Sandaña and Daniel F. Calderini, 2019).

Wheat plant development includes three main stages: vegetative stage, reproductive stage and grain filling stage, as described by slafer et al. (1994). These stages are defined by sowing flowers, flowering and flowering physiological maturity (Fig. 19). At the sowing and flowering stage, only the leaf primordium was produced in the seed, and four leaves differentiated from the mother plant. After imbibition, the seed began to metabolize again, and the leaf primordium began to continue until the flower began to differentiate. During this period, two more leaves were differentiated. A reproductive morphological marker at the top is the first double ridge, which can only be seen after the beginning of flowering, so it is an indisputable fact that the plant has begun to reproduce.



The relationship between source and sink of cereals and legumes is shown in **Fig. 19** The conceptual model of wheat growth and development shows sowing date (Sw), emergence stage (Em), flowering stage (FI), heading stage (Hd), flowering stage (An) and physiological maturity stage (PM). The box indicates the differentiation or growth period of some organs during vegetative, reproductive and filling periods. (adapted from Slafer GA and Rawson HM, 1994)

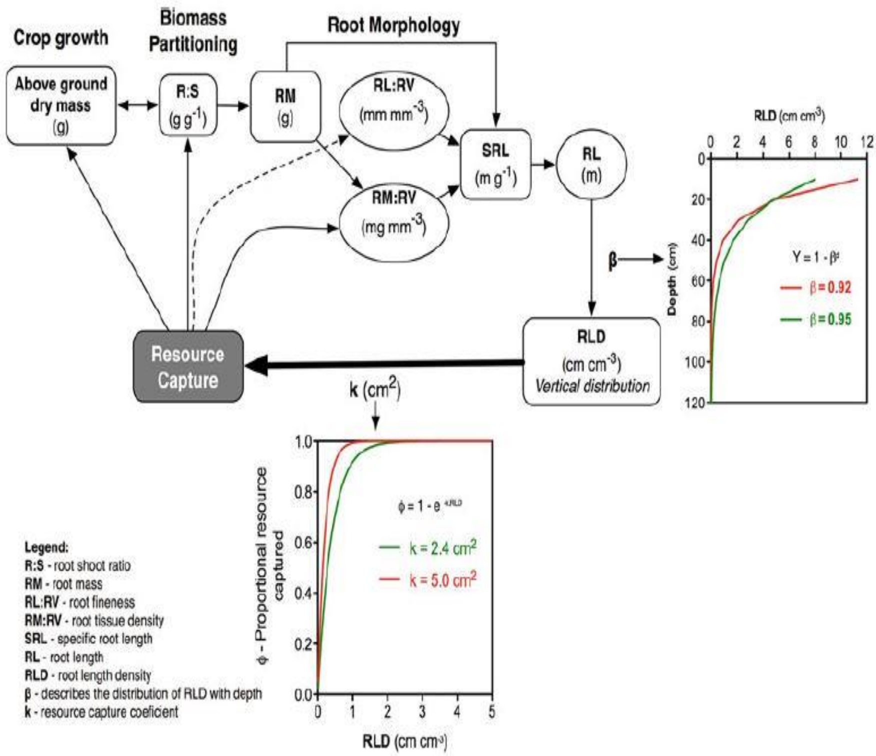
After the flower bud started, the spikelet primordium was developed at the apex, and then the flower bud started from the earliest one. The beginning stage of spikelet ends when the last spike (terminal spikelet) is developed in the meristem of the top of the main stem. At this stage, the maximum spikelets are fixed. From the center spikelet, the beginning of the flower continued to pass through the ear until it started. Anthers are visible outside the glume about a week to 10 days after heading, and this stage is called flowering. Floret fertilization occurs a few days before flowering. Different growth rates were reported according to the position of florets in the spikelets during the whole period of floret growth. The development rate of flowers near the axis is higher than that in the far position. Therefore, only fully developed flowers can fertilize when they bloom. Mirales and Richards believe that the availability of assimilates determines the mortality of florets. Once the fertile florets are fertilized, the grain filling phase begins. The characteristics of the seed collection and fall stage are that the grain development does not increase weight in essence, and is called the "lag period" of endosperm cell development. After the lag period, the effective filling period (linear period) occurred, and the dry matter accumulated rapidly in the form of seed reserve until the physiological maturity. Therefore, physiological maturity is the phenological stage indicating the end of the growth stage of the grain (Fig. 20). It is important to stress that the key to determine grain weight is also found in the pre flowering stage of wheat, and the upper limit of wheat characters (Calderini DF et al.,

1999. This period also has important significance for the grain weight potential of other crop varieties such as barley, sorghum and rye (Ugarte C et al., 2007; Lindström LI et al., 2006; Scott RW et al., 1983; Yang Z et al., 2009). These reports show that the overlap between grain number and grain weight is larger than generally thought, indicating that flowering is not a critical period for grain quantity and grain weight even in crops such as grain.

The evaluation of crop response to different source to sink ratio is a powerful tool to understand the key phenological period of crop yield decision and to develop management and breeding strategies. The temperate grain and legume crops are very sensitive to the source around the flowering period, which has a great influence on the final grain yield. Among these groups, grain production is limited by assimilation sources and soil and climate factors (flowering) that affect the source. However, in temperate cereal crops, higher sensitivity is before flowering, while in cereals such as peas and lupin beans, after this phenological period. Therefore, management aimed at improving food production should focus on these stages based on each group and how crops reach these stages. Differences between the same group of crops also affect the most sensitive time, such as two lines of barley and wheat (Patricio Sandaña and Daniel F. Calderini, 2019).

Nutrient and root development

It is well known that plant response to nitrogen and phosphorus deficiency is achieved by increasing RMR due to the functional balance between root and shoot growth (Robinson D, 2001). Crop roots are plastic and can utilize the uneven distribution of nutrient patches in the soil by multiplying roots (Robinson D et al., 1999). For example, the response of wheat to water and fertilizer was observed within 24 hours of applying water and fertilizer (Jackson RB et al., 1989). Generally, there is a strong correlation between root length and phosphorus uptake. Therefore, it is relatively simple to use "foraging" response to explain root proliferation in phosphorus rich patches. The response of root system to patches rich in nitrogen and phosphorus in soil includes increasing the production of lateral roots and increasing nutrient inflow into patches (absorption rate per unit root length) (Robinson D, 2001). Nitrate uptake from nitrogen rich soil can adapt to the imbalance of nitrate supply in the whole root system. The number and elongation of primary and secondary lateral roots were increased by local nitrogen application (97%). Drew and Saker (Drew MC, Saker LR,1975, 1978 and 1998) proved that barley has a strong response to N and P. Zhang and Forde (Zhang HM and Forde BG, 1998) proved that in Arabidopsis thaliana, the extension of lateral roots in nitrate rich patches is controlled by heredity. Because irrigation and nitrogen fertilizer can lead to root proliferation in topsoil (Robinson D, 1994), the availability distribution of these resources in the early stage of crop growth may change the relative distribution of roots with depth (b) at flowering. For two barley varieties grown in Mediterranean field conditions, the RMR under low nitrogen and phosphorus supply increased (Brown SC et al., 1987) compared with the control treatment with sufficient nitrogen and phosphorus supply. Herrera et al. (2005) showed that high nitrogen supply increased the number of roots in wheat, and root formation stopped earlier when nitrogen was limited. Barraclough et al. (1989) observed the increase of RMR under low nitrogen supply in the field experiment of nitrogen x drought of Winter Wheat in England. The effects of Nitrogen Application on SRL were not consistent. SRL of different species had increasing, decreasing or neutral effects (Ryser P and Lambers H, 1995). Field trials of Jordanian spring barley and durum wheat showed that the response of SRL to three different nitrogen levels was inconsistent (Ebrahim NM, 2008). Under rain fed condition, SRL of durum wheat increased with the increase of nitrogen application rate, while that of spring barley was on the contrary. In the field, there are few studies on the effects of Nitrogen Application on SRL and its components. In addition, it was observed that nitrogen application increased the average root diameter of cereal crops, but decreased RW: RV (Zhu J et al., 2011). Intuitively, thinner roots facilitate access to soil resources, although there may be trade-offs with other root functions such as anchoring, supporting, and transportation (Fitter AH, 1996). Fig. 20 summarizes the relationship between these root traits and resource capture. In addition, it has been reported that the effect of root diameter on resource capture has been shown to be highly correlated with plant dry matter (Hetrick BAD et al., 1988; Ryser P, 1998) and vessel diameter. These main root traits may be affected by abiotic stress during the rapid growth and expansion stage of root system before flowering, thus affecting the resource capture during seed filling.



The absorption of water and nutrients by roots, **Fig. 20** the relationship between these root traits and resource capture (from: P. Carvalho and M. J. Foulkes, 2019)

Root traits and resource capture

The main root characteristics to improve the capture of underground resources were root morphology (root axis number, root depth, root length density), root elongation, root longevity and root function in root length (Doussan C, et al., 2003; Palta J and Watt M, 2009; Foulkes MJ, et al., 2009).

There is no doubt that water is important to plants because it has many physiological and structural functions. The levels all account for 80 – 90% of the fresh weight of herbs, providing a continuous liquid phase in which gases, minerals and other solutes enter cells, move from one cell to another, and move within different plant organs (Kramer PJ, Boyer JS, 1995). Water is the reactant or substrate of most plant biochemical reactions (such as photosynthesis). It maintains the expansion of plants, which is necessary for cell growth, expansion, formation and movement of various plant structures, such as stomatal opening (Gregory PJ, 2006). Crop production is closely related to water consumption. Therefore, it is very important to maintain uninterrupted water supply to leaves for yield maximization. Water capture is closely related to root size, which is usually measured by surface area, volume or length. According to van Noordwijk's (Van Noordwijk,1983) theoretical model, the water uptake rate of plants is mainly limited by the migration of soil to root soil root interface.

Therefore, the root density measured by unit soil volume length (root length density: RLD, cm cm^{-3}) is the most suitable parameter to describe the water absorption of plant roots. More productive roots can capture water more effectively than sparse roots, but the competition between roots sets a natural upper limit for the optimal RLD of cereal crops. Beyond this upper limit, further increase will lead to excessive roots, and roots have no measurable effect on water absorption (Van Noordwijk,1983). The critical RLD (C_{RLD}) of water absorption predicted by theoretical calculation is about 1cm cm^{-3}. This figure is generally consistent with the water absorption values reported by Gregory and brown (Gregory PJ and Brown SC, 1989) and Barraclough et al. (Barraclough PB, et al., 1989), who show that the RLD of 1 cm cm^{-3} is related to the extraction of all available water from spring barley and winter wheat. However, for upland rice, C_{RLD} values were reported to range from 1.5 to 1.6 cm cm^{-3} (Lilley JM, et al., 1994; Pantuwan G, et al., 1997) and as low as 0.30 cm cm^{-3} (Siopongco J, 2005) under controlled environmental conditions. The distribution of RLD with depth mainly depends on growth time (residence time in topsoil is longer than that in subsoil), soil porosity and strength, and water availability (Barraclough PB, 1991). The root length density of wheat is usually lower than the critical root density of ca. 80 cm (Ford KE, 2005) in soil depth, which is about 1 cm cm^{-3}. A simulation study concluded that relatively deep root distribution in the soil profile and reduced SRL would lead to greater water capture and yield at low water use efficiency (King J, 2003). Experimental evidence also supports a relatively deep root distribution strategy to improve water capture under drought conditions. Compared with the recurrent parent (Reynolds M et al., 2007), the water absorption of the synthetic derived wheat lines increased, which was related to the relatively deep root distribution. Compared with the control variety Hartog (Christopher JT, 2008), the drought resistance of spring wheat SeriM82 was related to the relatively deep root distribution. Other root traits favorable for promoting water uptake included increased root longevity and root osmotic capacity after anthesis (Bengough AG, Bransby, 2006), although there was relatively little information on the genetic variation of these traits in cereals. In several crops, the steeper root angle is related to drought tolerance. A strong correlation between root angle and drought tolerance was observed in Rice (Kato Y et al., 2006). The high expression of DRO1 gene in rice is related to the increase of root bending by changing auxin distribution, which leads to the increase of yield under drought stress (Uga Y et al., 2011). The seed roots of drought tolerant wheat varieties grow in narrow angle and deep into the soil. In Australia (Manscadi A et al., 2010), the larger the vertical angle of wheat seedling root, the more the number of root, which is related to the closer and deeper the root system. The root angle of Japanese Winter Wheat Varieties in the controlled environment was related to their vertical root distribution in the field (Olivares et al., 2007). Studies on Maize also showed that in the United States and South Africa, steeper root angles were associated with increased rooting depth in low nitrogen environments

(Oyanagi A et al., 1993). In addition, it is also important that the root angles of rice (Lynch JP, 2013), wheat (Manscadi A et al., 2008) and maize (Lynch JP, 2013) are steeper under drought conditions. In order to optimize the root system of rice under waterlogged condition, the complex interaction between internal aeration adaptation and effective nutrient acquisition adaptation must be considered. A model developed by Kirk (2003) provides a consistent representation of rice roots in submerged soils and predicts a system consisting of coarse. Aerated primary roots whose impermeable walls conduct oxygen to short, fine, and aerated lateral branches, providing the best compromise between the need for internal ventilation and the need for ventilation, and the maximum possible absorption surface per unit root mass.

Water and nutrient absorption should be considered together, as nutrients reduce dryness as soil is lost. Nitrate profile is easy to be leached, so rooting depth is an important index of soil nitrogen acquisition. For a long time, due to its high mobility in soil, nitrogen supply is considered to be independent of root characteristics. It is assumed that only material flow and diffusion are the related mechanisms of plant nitrogen absorption (Herrera JM et al., 2005). The role of crop root system in nitrogen absorption is still a controversial topic. Robinson et al., 1991) showed that only 4-11% of root length was involved in nitrogen absorption. On the other hand, the results of 15 N labeling tests on Wheat by Palta and Watt (2009) showed that at 0.2m at the top of soil profile, the active roots absorbed about 60% n compared with the non active roots. In addition, positive correlation between nitrate and water absorption and root long density was found in Maize (Cooper PJM et al., 1987) and some captured crop species (Thorup-Kristensen K, 1993). These studies show that the higher the root length density, the better the nitrogen absorption effect. The low availability of nitrate limits the growth of plants. However, the lower nitrate availability has a relatively small effect on the elongation of primary and lateral roots and does not prevent roots from reaching the deep layer of the soil profile (Linkhor BI, et al., 2002). Usually the ratio of root to crown increases. It is reported that the rooting depth of maize genotypes with low crown root number increased by 45%, and nitrogen absorption increased (Saengwilai P et al., 2014). The biggest difference of nitrogen acquisition among genotypes of cereals lies in deep layer, which emphasizes the importance of deep root system for more effective nitrogen acquisition. In addition, some studies have shown that the capture of nitrate depends on the response capacity of root to the supply of space-time nitrogen (Robinson D, 2001). The absorption capacity of nitrogen mainly depends on the relationship between nitrate content and root morphology in soil. Nitrate is supplied to the root system through mass flow (ions carried in transpiration flow) and diffusion (ions move down the concentration gradient, through a large amount of soil water or along the water film around the particles). About 50% of nitrogen absorbed by wheat crops can be transported through mass flow (Gregory PJ et al., 1979). As for water absorption, the competition between roots sets a natural upper limit for the best RLD of nitrogen absorption of cereal crops,which is about 1 cm cm^{-3} (Robinson D et al., 1999).

RLD distribution with depth is mainly determined by growth time, including the retention time of topsoil is longer than that of subsoil, soil porosity and strength, and the availability of nutrients and water (Barraclough PB et al., 1991). King et al. (2003) concluded that under low nitrogen availability, the relative deep distribution of root system in soil profile and the increase of SRL will bring more nitrogen capture and yield. Similar to water absorption, the root characters which are beneficial to nitrogen capture include prolonging root life after flower and enhancing root permeability (Bengough AG et al., 2006), although the genetic variation information of these characters is relatively small. Barraclough et al. (1989) found that water absorption increased with the increase of N due to the decrease of soil evaporation due to higher RLD and higher ground cover in the field experiment of N x drought of Winter Wheat in the UK. The positive correlation between nitrogen capture and RLD was also found in Maize (Wiesler F, Horst, 1993) and hard grain wheat and barley (Ebrahim NM, 2008) Responses of root and shoot growth of durum wheat (*Triticum turgidum L. var durum*) and barley (*Hordeum vulgare L.*) plants to different water and nitrogen levels. Although higher nitrogen supply usually increases the total rld and N absorption of crops, this usually results in a reduction in N absorption efficiency (crop N absorption / N availability) (Cabrera et al., 2007), which leads to a potentially greater loss of nitrate to the environment. A recent simulation study has shown that higher rld and deeper rooting depth will reduce the residual nitrate in highly leached soil (Dunbabin V et al., 2003). Forde and Clarkson (1999) concluded that there was no strong evidence that the root system's ability to absorb nitrate or ammonium ions changed significantly with age.

Nutrient uptake may also be affected by root membrane transport system. Recent studies have shown that there is a balance between the active uptake of nitrate by the plasma membrane and the net uptake of nitrate by the cell. Two different gene families of nitrate transporters, nrt1 and nrt2, have been identified (Forde and Clarkson,1999) (in Arabidopsis genome). Some members of the nrt1 and nrt2 gene families are nitrate induced, expressed in root epidermis and root hairs, and may be responsible for nitrate uptake from soil (e.g., Lauter FR, Ninnemann et al., 1996). If Arabidopsis root screening can adapt to the larger and different structure of wheat roots, then in the long run, there is still a prospect to transfer these information to wheat to improve nitrogen uptake efficiency (UPE). A broad review of this area is beyond the scope of this document. Fortunately, there are excellent reviews in this subject area (Bucher M, 2007). The root length may be more important for the absorption of relatively fixed ions such as phosphate (Gregory PJ, 1994) than nitrate. However, some studies have found that the uptake rate of phosphate, calcium and potassium from solution has little relationship with root length, which may be because root length is significant only when the uptake of these nutrients is limited. The special properties of each nutrient in soil impose different rld requirements on its effective absorption. For example, due to the low mobility of phosphorus (P) in soil, a higher RLD (about 10 cm^3) is required for available phosphorus uptake than for water and / or nitrogen. High plant cycle, coupled with low mobility, leads to the accumulation of phosphorus in topsoil. In order to effectively obtain phosphorus from the soil, shallow roots are needed in the topsoil (Lynch JP, Brown KM, 2001). The RSA response of Arabidopsis to phosphorus deficiency was characterized by increased lateral root and root hair yields (Zhu J and Lynch JP, 2004). The study of a barley mutant without root hair showed that compared with the wild type (Gahoonia TS et al., 2001), the uptake of phosphorus was reduced by 50%. Under the condition of low phosphorus, barley varieties with long root hair can maintain higher yield, while barley varieties with short root hair have much lower yield (Gahoonia TS, Nielsen NE, 2004). Some studies have shown that strigolactones are key regulators of root and shoot responses to available phosphorus levels (Ruyter-Spira C et al., 2011). When phosphate was sufficient, strigolactones inhibited lateral root emergence and elongation, and promoted primary root elongation (Matthys C et al., 2016). When phosphate was depleted, the opposite was observed (Ruyter-Spira C et al., 2011). In addition to the length and number of roots, the angle of roots also determines whether the roots are shallow or deep. Under the condition of low phosphorus, gravitropism may hinder the development of shallow roots, which is an ideal choice for surface soil foraging. In common bean, the development of shallow roots depends on the ability to adjust the gravity drift angle (Bonser AM et al., 1995). With regard to the carbon cost of roots, it seems that there is only limited capacity to reduce the root allocation of cereal crops with high yield potential at flowering stage to about 10% lower than the current level due to the trade-off between water and nitrogen capture required for future biomass growth. However, while maintaining RMR, deeper root relative distribution may be part of the ideal type to maximize yield in future breeding programs.

Hydrophilicity and hydrophilicity are also crucial. Although soil moisture has a strong vertical distribution pattern, the heterogeneity of soil moisture exists, and the sensing of available moisture is very important for the optimal water absorption. Studies have shown that plants can partially inhibit gravitropism and water growth, which is known as the water response (see Eapen D et al., 2005). Arabidopsis thaliana can change its taproot growth from low osmotic potential to low water use (Takahashi N et al., 2002). Similar water driven hydrophilic reactions were observed in maize (Takahashi H et al., 1991), cucumber (Mizuno H et al., 2002) and pea (Takahashi H, Suge H,1991). Auxin distribution, driven by polar auxin transport, plays a central role in regulating the bending of plant organs and the response to gravity (Shkolnik D et al., 2016) Hydrotropism: root bending does not require auxin redistribution. Mol Plant 9:757–759 Hydrotropism: root bending does not require auxin redistribution. Mol Plant 9:757–759 (Shkolnik D, Kreiger G, Nuriel R, Fromm H, 2016). It has been proved that Arabidopsis roots can distinguish between wet and dry surfaces, and selectively facilitate the development of roots in these wet places, rather than in dry places (Bao Y et al., 2014). These moist surfaces determine the location of new lateral root forming cells. Deak and malamy (2005) have shown that the development rate of lateral root primordia under dry conditions is similar to that under control conditions. These primordia can then be rapidly induced in high water use efficiency areas. The combination of the formation and appearance of primordia leads to specific root proliferation in the area with high water use efficiency, which is called waterization. This process seems to have nothing to do with the main drought stress hormone ABA (Bao Y et al., 2014). Further research on this new topic is needed to provide more knowledge about how plant roots perceive water and regulate RSA (Koevoets IT et al., 2016).

Genetic analysis of rooting traits

Root traits are considered to be complex and controlled by multiple genes. The genetic effect of each gene is very small. The genetic loci that regulate these traits are called quantitative trait loci (QTLs) (Sharma S et al., 2011). 29 1BS-1RS recombinants were obtained by crossing Pavon-76 × Pavon-1RS.1BL in bread wheat. A high-resolution chromosome arm specific mapping population was constructed to detect QTLs (Sharma S et al., 2011) for different root traits on short arm of rye chromosome 1. A total of 15 QTL effects were detected for different root length and root weight traits in 1RS wheat, including 6 additive effects and 9 epistatic effects. Bai et al. (2013) studied QTLs for root morphology and seedling traits in 199 lines of a winter wheat double haploid population crossed by Avalon and cadenza. The QTLs of root traits on chromosome 2D and 4D were consistent with the plant height measured in the field. In addition, these authors also reported that near isogenic lines (NILs) of semi dwarf and Dwarf Winter Wheat reduced root length (Rht-B1c, Rht-D1c, Rht-8c and Rht12) and root dry weight (Rht-D1b, rht-B1c, Rht-D1c and Rht12) compared with high control (RHT). Atkinson et al. (2015) identified 29 QTLs for root traits of Winter Wheat Seedlings by investigating 94 lines from a double haploid population crossed by Savannah and Rialto. Two root QTLs were co-located with yield and nitrogen uptake QTLs on chromosome 2B and 7D, respectively. It is also reported that there is a major gene on chromosome 6D that regulates root activity / growth of seedlings. In rice, many QTLs were analyzed for root morphological traits (maximum length, thickness, volume, distribution, etc.) of different mapping populations (see Price et al., 2002; Courtois et al., 2009); Mai et al. (2014) QTL of root penetrating ability was related to QTL of root thickening or lengthening (Ray JD et l., 1996; Price AH et al., 2000). QTL of basal root thickness was related to yield in dry land, but not in wet lowland (Liu H et al., 2005). Using the development process of NILs introduced by different background QTLs, fine mapping of QTLs was carried out in rice with the aim of mapping and cloning (Steele KA et al., 2006). The first QTL cloned for rice is phosphorus uptake 1 (PUP1), which is a QTL for phosphorus uptake in low phosphorus soil. The gene under QTL, later known as phosphorus starvation tolerance 1 (PSTOL1), was cloned and appears to encode a receptor like cytoplasmic kinase (Gamuyao R et al., 2012). Another cloned gene related to root development QTL in rice is deep root 1 (DRO1), which controls root growth angle and enhances deep root development (Uga Y et al., 2011). DRO1 encodes an unknown protein related to the lemma. More generally, the genetic control of grain root traits was reviewed, with emphasis on drought resistance (Coudert Y et al., 2013). In sorghum, maize and rice, the association between root angle and deep rooting system has been confirmed. Recently, many QTLs (Palta J and Watt M, 2009) showing interspecific homology have been reported. Two root hair elongation genes, RTH1 and RTH3, were found in maize, which may be valuable for genetic improvement (Hochholdinger F, Tuberosa R, 2009). In maize, nodal root formation is controlled by a single gene WOX11, an auxin and cytokinin induced transcription factor (Zhao Y et al., 2009).

However, the current research on the efficient utilization of crop nutrients still has the following difficulties:

1. Nutrient signal transduction and its regulation. When nutrient deficiency occurs, the morphological configuration, physiological and biochemical reactions and the expression of transporter genes of crop roots will change significantly. The

acceptance, conduction and chain level of nutrient signal are increasingly revealed. For example, it was found that the tendency of Arabidopsis lateral root elongation to nitrate nitrogen was regulated by NO_{-}^{3} signal. Nitrogen deficiency signal in rhizosphere induced lateral root elongation, while high level of nitrogen in vivo inhibited lateral root elongation (Zhang HM et al., 1998). This inhibition may be achieved through ABA signal pathway (Signora L et al., 2009). However, the key problems of crop nutrient signal receptor, transmission pathway and the node and regulatory system of its interaction with hormone signal have not been solved. Revealing these key issues is the basis of exploring the adaptive mechanism of nutrient signal regulating crop nutrient use efficiency, and also the focus of research in this field at home and abroad.

2. Adaptive molecular mechanism of root morphology in response to nutrient stress. Plant has formed a mechanism of root development in the long-term evolution process to adapt to nutrient stress. The adaptability of root system, such as the change of three-dimensional structure of root system, the extension of lateral root and the increase of root hair density, expand the capacity of the inter root nutrient bank. İmprove the ability of activating rhizosphere nutrients, and increase the efficiency of plant to soil nutrient absorption and utilization. However, because of the complexity of root morphology and

difficult to observe and measure in situ, quantitative research on the parameters of root morphology and its molecular mechanism of development has been one of the difficulties in the research of root biology in the world.

3. The molecular mechanism of soil nutrient activation and absorption and transport crops will induce the release of protons, organic acids and hydrolase secretion to the rhizosphere soil to activate insoluble nutrients when the crops are under nutrient stress. At the same time, these activated nutrients are absorbed and transported into the cells through the highly affinity transporter expressed specifically. The results show that there are many different gene families or members in the absorption and transport of a nutrient ion, such as Pht1, Pht2 and Pht3, and 11 genes (Pht1; 1-Pht1; 11) in the Pht1 family of rice, and most of them are in It was induced or enhanced expression under P deficiency stress (Ai PH et al., 2009). The difficulties and key points of the present study are the transcription factors regulating the expression of transporters, the interaction mechanism between different transporters, and the coupling between soil nutrient activation and absorption and transport. It is of great theoretical and practical significance to reveal these molecular mechanisms, clone important functional genes and regulatory factors related to the genetic improvement of crop nutrition.

4. The ultimate goal of nutrient efficiency is that the highest dry matter and grain yield can be formed by the nutrients absorbed by crops. Therefore, the nutrient in the object should play its physiological role in order to achieve the high efficiency and high yield. However, there is a lack of understanding about the molecular mechanism of high-efficiency metabolism of nutrients and how to participate in the formation of crop yield, because it involves not only complex nutrient metabolism network and its interaction with photosynthetic carbon assimilation and energy metabolism (Wu P et al., 2003), but also the redistribution of photosynthetic products to grains. Therefore, it is difficult to reveal the molecular mechanism of the relationship between high efficiency and high yield of nutrients.

The relationship between crop quality and yield is complex. Protein content is one of the most closely related indexes with quality. When the yield level is low, the correlation between yield and grain protein content is not obvious. With the increase of yield, the negative correlation between yield and protein content gradually showed. For example, the critical value of the relationship between protein content and yield of wheat grain is 15% - 16%. When the value is lower than this value, the contradiction between grain yield and protein content is not significant, and higher than this value, the contradiction between grain yield and protein content is obvious. The negative correlation between protein content and yield is related to two factors: one is breeding goal, crop breeding pays more attention to high yield, which leads to the high yield and high quality of the cultivated varieties can not be coordinated; the second is the cultivation target. For a long time, crop cultivation has been high-yield cultivation, cultivation research and technological innovation are closely around the high-yield target. The results show that the negative correlation between yield and protein content is mainly related to three factors.

First, the combination of high-yield varieties and high-yield cultivation technology makes the production accumulation of photosynthetic products and the proportion of distribution to grain increase significantly, which can dilute the egg white content of seeds. The second is that there are two metabolic pathways of carbon and nitrogen in the process of grain development. The relative activity of starch synthesis related enzymes and protein synthesis related enzymes in the process of grain development affects the trend of photosynthetic carbon, thus affecting the synthesis and accumulation of starch and protein in grains and their proportion. Third, the first is high-yield cultivation The common point is that the high photosynthetic rate of the population in the yield formation period lasts for a long time, the plant aging is delayed, and the nitrogen transfer from stem and leaf sheath to the grain is reduced. The quality of crops is not only determined by the protein content of grain, but also directly or indirectly related to the protein components, HMW GS composition, GMP quantity proportion, amylose content, ratio to amylopectin, starch type and particle size distribution. In addition, the quality requirements of different crop products are different, which makes the relationship between crop yield and these factors more complex(Wang Zhenxi, 2011).

Problems needed to be studied in the synergetic improvement of crop yield and quality:

(1) The yield, protein content and quality of crops were improved synergistically. High and super-high yield of crops are often accompanied by the decrease of grain protein content, the accumulation of protein components, HMW, GS and GMP, and the deterioration of quality. It is an important problem to study the mechanism and way of yield, protein content and quality. (2) The high yield of crops is related to the improvement of starch components and starch particle size distribution. The content and proportion of amylopectin and amylopectin in grains and the distribution of starch grains were closely related to the processing quality. The composition of starch components and the morphology of starch grains were different at different stages of grain development. Under the condition of high yield and super high yield, the mechanism of starch composition and starch grain morphology and its cultivation regulation are the important problems to be studied (Wang Zhenxi, 2011).

The difficulties of crop yield and quality improvement are:

1) Physiological mechanism and regulation of the relationship between starch formation and protein formation under the condition of high and super-high yield;
2) Physiological mechanism and regulation of grain protein composition, GMP formation and particle size distribution, starch particle size distribution caused by high yield;
3) Cultivation theory and way of crop yield and quality improvement;
4) The relationship between global climate change and biological disasters (Wang Zhenlin, 2011).

Soil, plant and atmosphere

Soil, plants and atmosphere are connected by energy and matter flows including water and carbon (Baldocchi et al., 2001). Plant photosynthesis and a series of complex supporting physiological processes are the driving forces of these exchange processes, including the absorption of atmospheric carbon and storage in ecosystems, as well as the extraction and release of water from soil to the atmosphere (Lambers et al., 2008). Therefore, vegetation is an important and highly dynamic component of the carbon and water cycle (Reichstein et al., 2013). Driven by soil water availability and atmospheric water demand, water flows continuously in the soil plant atmosphere continuum (SPAC) (Asbjornsen et al., 2011). However, in the growing season, only about 1% of the water extracted from soil is used for plant growth; the rest of the water is released into the atmosphere through plant transpiration, which is an inevitable by-product of carbon exchange through stomata (Green et al., 2017; Nobel, 2009; Reichstein et al., 2013). Evapotranspiration is the general term of water flux from terrestrial ecosystem to atmosphere, which is the sum of plant transpiration and soil and plant surface water evaporation. In Vegetation Ecosystems, transpiration is the largest component of evapotranspiration, with a contribution rate of 90% (Jasechko et al., 2013). In addition to its role in water cycle dynamics, vegetation also responds to changing water availability: water embeds into cells, transports nutrients, provides structural support (expansion), supports plant movement, and stabilizes temperature. Small changes in water use efficiency may lead to functional responses of plants (Nobel, 2009). The dual role of vegetation in driving and responding to water cycle dynamics determines that Vegetation Ecosystems cause a number of interactions and feedback in the earth (Richardson et al., 2013; Seneviratne et al., 2010; Suni et al., 2015). The water potential gradient of the whole spac provides physical forces for roots to absorb soil water, transport water to leaves through plant xylem, and release water to atmosphere through stomata (Norman and Anderson, 2005). Therefore, plant water relationship (i.e. storage and flow of plant water) is highly dependent on soil water content and atmospheric water vapor deficit. Therefore, through a complex feedback mechanism, the relationship between plants and water is expected to change with environmental changes (i.e., changes in temperature and precipitation patterns, increase in aerosol emissions and increase in atmospheric CO_2 concentration). For example, increasing the concentration of carbon dioxide in the atmosphere promotes plant photosynthesis and may change the exchange of carbon and water in Vegetation Ecosystems (Nobel, 2009). With the increase of CO_2 concentration, the decrease of stomatal density of C3 plants may lead to the decrease of transpiration rate (Lammertsma et al., 2011). This development may also affect plant diversity in ecosystems as plants adapt to or migrate to species communities that are more resistant to changing environmental conditions, and the underlying relationship between plant diversity and ecosystem functions determines the strong feedback of biogeochemical cycles (Hooper et al., 2012; Hooper et al., 2005). Although the future trajectory of plant development is still unknown, they may have physiological feedback on Hydrology (Lammertsma et al., 2011).

Soil plant atmosphere system (SPAS) or soil plant atmosphere continuum (SPAC) is an organic whole composed of soil, plant and atmosphere. As early as 1948, Korner et al Soil, plants and atmosphere should be studied as a continuum. In 1965, Cowan, a British scholar, considered that soil, plant and atmosphere should be regarded as a continuous whole when he studied the water transport in soil, and put forward the concept of soil singing plant singing atmosphere system. In 1966, Philip, a famous Australian hydrologist and soil physicist, formally put forward the concept of soil singing, plant singing and atmospheric continuum. At present, it has become a consensus and an important development trend to study the organic relationship of soil, plant and atmosphere as an objective entity (Vitousek, 1997).

In order to reveal the complex feedback and interaction of plant water relationship and environmental change, it is necessary to better understand the impact of vegetation on water cycle and its dependence on the availability of water resources. Nobel (2009) pointed out the wealth of interactive, sometimes compensatory factors. Although our understanding of plants and ecosystems is still limited, all of these factors must be taken into account to promote our understanding of the plant water relationship. Therefore, strategies for assessing plant water relationships across scales ideally include the use of models and observations. However, the model always simplifies the reality and may be biased due to the parameterization calibrated with field observations (Waring and Landsberg, 2011). Useful observations of plant water relationships are always local and expensive; large scale observations are emerging, but not mature enough. Penuelas et al. (1996) pointed out that our assessment of plant water status is still based on the measurement of relative water content, water potential or transpiration, while accurate measurement can only be carried out at the leaf level; their rise to the ecosystem level is still very challenging. Even mature techniques, such as vorticity covariance technique (Baldocchi, 2003), can produce great uncertainty when dividing measured evapotranspiration into evaporation and transpiration components (Villegas et al., 2014). We hypothesize that advanced cross-scale monitoring of the relationship between plants and water can achieve joint observation and modeling methods. This paper reviews remote sensing evaluation methods of plant water relationship from pure observation to joint observation simulation. Based on this view, we used the energy balance and radiative transfer model (Van der tol et al., 2009) to evaluate the explanatory power of purely observational methods focusing on plant parameters for estimating plant water relationships. We outline and discuss a more efficient integration of remote sensing information into the SPAC model. A mechanical model simulating water movement in SPAC reveals the complex relationship among soil, plant and atmosphere parameters to simulate water flow in SPAC, and points out the necessity of combining remote sensing with spac model. Finally, from the perspective of future observation capability, the strategies to promote the evaluation of plant water relationship are discussed.

The transportation and storage of water in the SPAC is shown in (Fig. 21). Liquid water flowing into plants from soil depends on the fact that the water potential of plants is lower than that of soil, so the soil water potential determines the effectiveness of soil water diffusion to plants. Water potential refers to the energy (joule) that can be obtained by moving a large amount of water (kg) into a pure pool under atmospheric pressure and specified altitude; while in soil and plants, the water potential is usually negative, which indicates that energy must be consumed to remove water. As the soil dries, the water potential decreases, making it more difficult for plants to obtain the water needed for growth. Soil water potential is related to soil water content through "water release curve", which varies with soil. The water release curves of many different soil types were measured. Generally speaking, soil can provide water storage equivalent to 5% (sand) to 20% (silt loam) of plant rooting depth. Therefore, for plants with a root depth of 1 m, the soil can provide about 50 – 200 mm of water for the plants. Due to the evapotranspiration rate of 2 – 10 mm day^{-1}, the soil can store enough water to maintain the plant for a month or more without rainfall or irrigation.

Once the water enters the plant through the root system, if the water potential of the leaf is lower than that of the root system, the water will enter the leaf through the vascular system of the plant. According to the principle of conservation, the flow through root and xylem must be equal, and the water potential difference from soil to root xylem is usually greater than that from root xylem to leaf. Water is lost from the plant through stomata on the leaf surface. The cells under the stoma evaporate and absorb water from the leaf cells, which are connected with a continuous water column through water power to the root. When water is transported through the pores, extra water is absorbed through the xylem to replace it, much like suction on straw in soda water. Of course, this evaporation below the surface of the leaf consumes most of the solar energy absorbed by the leaf, because the water vapor molecules take away the potential energy that the liquid water from the root does not contain. The liquid water flow from soil to blade is directly proportional to the water potential difference, while the water vapor flow from inside to surface is directly proportional to the water vapor pressure difference. At the interface, there is an approximate equilibrium between the liquid water and the water vapor in contact with it. Although different processes are used to describe the movement of water in different parts of the system, the flow is continuous at the discontinuities of these processes. As the plant grows, a very small amount of water from the soil to the atmosphere remains in the plant for storage (less than 5%). Hydrogen and oxygen in water absorbed from soil remain in plants in the form of organic molecules synthesized by plants. The water flowing from the stomata must pass through a thin and static air layer, which is called the blade boundary layer, and it is transported through the canopy space along the path of water vapor pressure reduction through turbulent mixing. Finally, the water vapor leaves the plant canopy, passes through the planetary boundary layer thousands of meters below the atmosphere, is lifted into the atmosphere, where it condenses into clouds, and finally falls back to the earth as precipitation, repeating this cycle (Norman and Anderson, 2005).

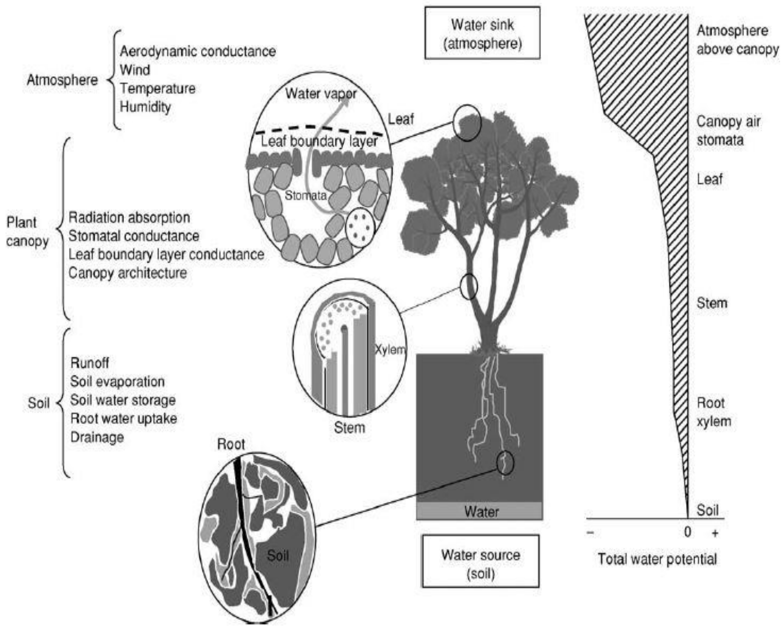


Fig. 21 water movement and storage in soil plant atmosphere continuum. The chart on the right shows the drop in water potential as water flows from the soil to the atmosphere. The left side lists the three components of the soil plant atmosphere system and the main factors for each component that should be considered in the medium complexity model.

In the vertical direction, the system includes the lower soil root layer, the middle plant layer and the upper troposphere; in the time, the system has obvious dynamic characteristics, and continuously changes in various time scales. The research on the soil plant atmosphere system mainly focuses on the mechanism and law of the flow and transformation of various forms of energy and substances in this continuum.

Water, oxygen, carbon dioxide and other substances flow and transform constantly in the soil and plant atmosphere system. The movement of water in soil and plants is one of the key problems in the study of soil plant atmosphere system.

① Because of the complexity of water movement, the soil water system includes five states of water, namely, water in the atmosphere, surface water, soil water, water in plants and groundwater, which can be called "five water" system. Water in various states can be transformed or exchanged directly or indirectly through a certain interface. For example, water in the atmosphere becomes surface water by precipitation, soil water by infiltration, and groundwater by underground runoff. Soil water is absorbed by plant roots and becomes water in plants. Surface water, soil water and water in plants can be transformed into water in the atmosphere by evaporation and evaporation, and so on. The five ways of water transformation or exchange can be summed up as 10 processes, each of which will be restricted and affected by complex factors.

② The complexity of coupling of water, heat, water and mineral matter, the continuous water flow in soil and plant system is determined by the total water potential gradient of soil, and the water potential gradient is affected by transpiration pull, The total water potential is composed of gravity potential, pressure potential, matrix potential, solute potential and temperature potential. The total water potential of soil is related to soil moisture content, soil texture and structure.

③ Water movement directly or indirectly affects the flow and transformation process of oxygen, carbon dioxide and various minerals. In the flow path of water from soil to plant and then to atmosphere, the total water potential of soil is related to soil moisture content, soil texture and structure, There are two important interfaces: one is the interface between plant root and soil, the other is the interface between plant canopy leaf stem and atmosphere. The process of water entering into roots through the first interface is determined by the water potential difference between plant root sap and soil solution and root surface resistance (Hutjes RWA, 1998) . In plants, driven by water potential gradient, water flows from roots to stems and leaves. The process of air escaping from the stem and leaf canopy through the second interface is driven by the difference between the air vapor pressure inside and outside the leaf stomata. The process of water flowing from soil to various parts of plant body is also accompanied by the process of plant uptake of various nutrients. In addition to water flow, oxygen, carbon dioxide and other gases exchange between plants and atmosphere, soil and atmosphere. In the process of photosynthesis, plants absorb carbon dioxide and release oxygen through stomata; in the process of respiration, plants absorb oxygen and release carbon dioxide through stomata. In the soil, the respiration of plant roots also leads to the continuous exchange of oxygen, carbon dioxide and other gases between the soil and the atmosphere (Chang et al., 1999).

To sum up, in the soil, plant and atmosphere system, all kinds of energy and material transfer, resource, environment and transformation are continuously carried out. The difficulty in studying this system lies in the complexity of these processes, including physical and chemical processes as well as biological processes, which are intertwined, interdependent, and mutually restricted (Kang et al., 1994). The mechanism of some processes remains to be explored and studied, and some processes are difficult to describe accurately and quantitatively. Therefore, there are several difficulties and hot spots in the research of this system. (1) The research on the material and energy cycle of the system has changed from qualitative research to quantitative research with simulation model as the tool. (2) Combined with modern science and technology, we should strengthen the research on the behavior characteristics of logistics and energy flow at the soil atmosphere interface. (3) We should strengthen the research on the feedback mechanism of soil, plant and atmosphere system under global climate change (Cao and Liu, 2011).

The research of SPAC is interdisciplinary (involving research in areas not covered by existing disciplines) and multidisciplinary (requiring cooperation between scientists from many disciplines). For example, to understand the effects of vegetation on weather forecasting, the following activities are needed: meteorologists study the effects of surface energy and water exchange on the lower reaches of the atmosphere, known as the planetary boundary layer. Physiologists describe the dependence of photosynthesis and stomatal processes on atmospheric and soil environmental factors; soil scientists measure soil heat and water retention properties and carbon exchange processes Micrometeorologists relate vegetation canopy characteristics and atmospheric variables to the exchange of heat, mass and momentum with the atmosphere, while hydrologists consider the runoff characteristics of soil surface and the infiltration recharge of groundwater. The study of canopy structure, canopy internal processes and the interaction between remote sensing and vegetation cover is a key interdisciplinary field unrelated to any specific discipline. Most scientific research is funded by government agencies and carried out within the discipline structure of research institutions or universities; therefore, the competition for funds among disciplines and the limited perspective of individual researchers will reduce the comprehensive view of SPAC. Although the value of interdisciplinary and interdisciplinary research is highly praised, there is no obvious sustaining structure in the research institutions for such comprehensive activities, and progress is still dominated by the special efforts of determined and visionary individuals or teams. In recent decades, one of the most valuable strategies is to organize and implement large-scale, international, multidisciplinary and intensive field experiments, which have broad objectives and attract scientists from many disciplines. In recent years, the extensive distribution and open access of these experimental data have brought great gains to people's understanding of SPAC. Two examples of such experiments are the first islscp (International Satellite land surface Climatology Project) field experiment (Fife) in the prairie of Kansas, USA, and the northern ecosystem atmosphere study (Boreas) in the northern forest of Canada. The long-standing reductionist view that "changing a single variable and keeping all other factors unchanged" is impossible in-depth study of SPAC as a whole. Instead, we have to face the challenge of exploring important processes without restrictive paradigms and narrow disciplinary constraints, which is a huge challenge for environmental scientists. In a scientific world dominated by reductionism, it is still a challenge to integrate the knowledge from various components of SPAC into a whole view. The earth is a complex and self-organizing system. With the improvement of our understanding of the relationship between the components of SPAC, this view has been more widely accepted (Norman and Anderson, 2005).

Plant water relationship is an important information source for understanding vegetation function and its impact on water cycle under global environmental change. Remote sensing observation and spac mechanical model are advanced methods to understand water flow and storage of plants. However, our analysis shows that both methods have limitations when applied across space and time. In particular, more in-depth understanding of remote sensing information and its causal relationship with plant water relationship related processes is needed. We conclude that assessing the highly variable flow and storage of water in plants at both spatial and temporal scales requires complex methods based on simple correlated process models and remote sensing observations or using complex data assimilation schemes. These efforts will greatly improve our predictive ability to assess the relationship between plants and water and ultimately the role of vegetation in the water cycle by clarifying and responding to the complex interactions between plants that affect the dynamics of the water cycle (Damm, 2018).

Air temperature

Air temperature is the driving force of many biological and chemical reactions and largely affects the photosynthetic rate of plants, such as Collatz et al. (1991). In addition, air temperature drives the heat exchange (sensible heat flux) in the soil plant atmosphere system, competing with evapotranspiration in the utilization of net radiation flux. Due to the great variation of temperature in space and time, accurate estimation of temperature is very important for understanding and quantifying water movement in ecosystem. The air temperature inside and just above the plant canopy - for any layer of atmosphere - cannot be directly estimated by space remote sensing. This can be explained by weighting functions in the thermal infrared and microwave spectral ranges, which quantify the relative contribution of the atmosphere to the measured signal at a single wavelength on a remote sensor (Rodgers, 1976). However, most of the time, leaf surface temperature (see Li et al. 2013) for a comprehensive overview of leaf temperature remote sensing) is close to air temperature, although significant differences may occur during the day (e.g., Dong et al. (2017)).

Steam pressure difference

VPD is the difference between the actual vapor pressure and the saturated vapor pressure at a given temperature (Choudhury, 1998). It constitutes the atmospheric water demand and therefore has a significant impact on leaf water potential and water movement from plants to the atmosphere (Asbjornsen et al., 2011; Waring and Landsberg, 2011).

Wind speed

Wind speed is another important environmental forcing, which not only contributes to the observed changes in atmospheric evaporation demand (McVicar et al., 2012), but also affects the leaf boundary layer conductance (Haghighi and Kirchner, 2017; Schymanski and Or, 2017), which limits the water vapor, heat and CO_2 exchange rates at the leaf atmosphere interface Considering the non-linear relationship between transpiration and wind speed under different environmental conditions, it is very important to quantify the effect of wind speed on plant transpiration rate. The results show that under cloudy sky conditions, transpiration rate increases with the increase of wind speed due to the increase of water vapor concentration gradient in the leaf boundary layer (Haghighi and Kirchner, 2017; schymanski and or, 2016; Schymanski and Or, 2017).

Soil volume water content

Only when there is no vegetation or the vegetation is sparse, can we obtain the soil parameters on the relevant spatiotemporal scale through remote sensing technology (Mulder et al., 2011; Owe et al., 2008; Srivastava, 2017). One of the key parameters is soil volume water content, which is the supply side of water transport in SPAC. Various methods for estimating soil volumetric water content from remote sensing data have developed over time. Early attempts focused on the use of spectral data and the use of soil moisture induced water absorption characteristics (Liu et al., 2002; Lobell and Asner, 2002). Other methods use thermal and optical data and empirically correlate soil volumetric water content with derived surface temperature and an index describing green biomass (i.e., NDVI) (Sandholt et al., 2002). Other confounding factors affecting radiative transfer in the optical domain, as well as the empirical nature of thermooptic methods, hinder their wide acceptance in global soil volumetric moisture mapping.

Soil type

Soil type is a volume parameter that characterizes soil water holding capacity, soil water movement and soil water potential. Distinguishing soil types greatly affects the success of estimating water content, because various inherent and dynamic soil properties (i.e. texture, structure, composition) affect the water holding capacity and water flow of the soil. Methods for distinguishing soil types (Digital Soil Mapping) are usually based on combinations of soil properties derived from spectral measurements and used as primary or secondary data sources in Geostatistical Methods (Mulder et al., 2011). These soil properties include soil organic carbon content, soil salinity, soil iron content, clay / sand components or their mineralogy (Ben dor et al., 2009; Mulder et al., 2013; Stevens et al., 2010).

Soil tilled layer structure

Under the effect of long-term cultivation, cultivation and fertilization, the solid particles and pores with different sizes and shapes in the soil plough layer form a certain spatial arrangement, that is, the soil plough layer structure. Some scholars believe that soil plough layer structure not only refers to the size, shape and spatial distribution of solids and pores in the plough layer, but also includes the continuity of pores, the ability to maintain and transport substances (liquid, inorganic and organic), and the ability to support the growth and development of crop roots (Lal R.,1991). Soil plough layer structure determines the porosity, distribution and proportion of large and small pores in plough layer, thus regulating the maintenance and transmission of water and nutrients in soil, soil heat and ventilation, microbial activity and organic matter transformation, and further affecting farmland CO_2 fixation and crop growth and development (Kladivko EJ, 1994; Bronick et al., 2005). Although people have long recognized the decisive role of plough layer structure in soil quality, there is still a lack of comprehensive indicators that can accurately and quantitatively describe plough layer structure and its dynamics. Soil bulk density (and relative porosity, etc.) is the most commonly used parameter to reflect the structure of soil plough layer, while soil compaction is used to express the degree of soil compaction (Logsdon SD, 2004). Unfortunately, it is difficult to accurately reflect the compaction process of soil only depending on the changes of bulk density and compactness (Whalley WR, 2007). Some scholars believe that water content and aeration are better indicators of soil physical structure. Recently, it has been proposed to quantitatively describe soil structure using soil water characteristic curve (Dexter AR., 2004; Schjonning P. et al., 2007).

From the perspective of Agronomy, good soil plough layer structure can effectively regulate the soil water, fertilizer, gas and heat status, buffer the impact of adverse environmental conditions on the soil, so as to create conditions for high and stable yield of crops. From the point of view of soil science, the soil with good plough layer structure is often characterized by high content of organic matter, obvious aggregate structure and suitable ratio of large and small pores (Keller et al., 2007). Among them, the quantity, size distribution and stability of soil aggregates are important indicators to measure the structure and function of plough layer. Aggregates are formed by the interaction of soil mineral particles, organic matter and ions in various physical, chemical and biological processes (Kladivko EJ, 1994). A large number of studies have shown that soil physical and chemical processes dominate the formation of micro aggregates, while soil biological processes earthworm activity, fungi and plant root growth greatly affect the formation and stability of large aggregates. Soil plough layer structure is the product of certain soil, climate and planting system, so it has significant temporal and spatial variation characteristics. For example, although they are all major corn producing areas, there are great differences between the fluvo aquic soil in North China and the black soil in Northeast China in plough layer thickness, aggregate distribution and content, water retention and permeability. After ploughing, the plough layer gradually changes from loose to compact. Under field conditions, alternation of drying and wetting and freezing and thawing have a great impact on soil plough layer structure. In addition, the requirements of plough layer structure are different in different growth stages of crops. How to quantitatively determine the optimal plough layer structure of crops at a certain growth stage according to the climate, soil and water conditions, and provide a good soil environment for crop growth and development, is still a scientific problem that has not been solved by the academic circles (Rentu Sheng, 2011).

İt is necessary to use agricultural technology to cultivate soil layer structure. Human beings mainly regulate the structure of soil plough layer through crop cultivation, rotation, soil plough layer structure, intercropping, etc., soil tillage and water and fertilizer management.

Recent studies have shown that traditional tillage can only improve the relationship between soil moisture and air moisture in a short period of time, providing a more favorable plough layer structure for crop growth (Bronick CJ, 2005). However, long-term ploughing not only produces plough layer and leads to water loss, but also destroys soil structure and promotes decomposition of organic matter, thus forming poor soil plough layer structure and aggravating soil erosion risk. On the contrary, conservation tillage, covering crops, less tillage, no tillage, etc. have been greatly developed in the world in the past 50 years due to creating good hydrothermal conditions, reducing mechanical disturbance to soil, increasing organic matter accumulation, and promoting the formation of stable aggregates in soil It's more than 50% (Six J, 2002). In recent years, conservation tillage technology has attracted more and more attention. How to build conservation tillage system according to local conditions. It is an inevitable choice to establish crop rotation and organic fertilizer application system suitable for conservation tillage technology to improve soil layer structure, promote crop high yield and resource efficient utilization.

Agronomists and breeders often believe that grain quality and yield are equally important. Quality characteristics are why only a few plant species are used to meet human needs for food and fiber (Slafer GA and Satorre EH, 1999). Traditionally, grain quality consists of a set of characteristics that together determine the utility of harvested grain for a specific end use. Therefore, it is very important to cultivate and manage food crops to achieve specific quality standards and to be able to predict the quality of specific crops in a specific growth environment. To achieve this goal depends on the understanding of the factors that change the grain composition.

As food markets become more specialized, food quality now includes other characteristics. Consumers are increasingly interested in the sustainability of production systems that produce grains, and concepts such as organic and non genetically modified organisms (GMOs) also affect product quality. At present, one of the biggest challenges facing the world is how to ensure that the growing global population has enough food to meet its nutritional needs in a sustainable way. Food security is a complex condition that requires an integrated approach to various forms of malnutrition, productivity and income of small-scale food producers, resilience of food production systems, and sustainable use of biodiversity and genetic resources (FAO, 2017). Farmers are facing more and more pressure, they need to produce more unified and more characteristic food under specific sustainable management (Wrigley CW, 1994). Appropriate animal husbandry to obtain high quality and stable food may be more and more important to achieve economic benefits. Food quality is changed by the environment and crop management methods used by farmers. However, the strategies and tools needed to produce grains with certain quality characteristics are not as good as those needed to achieve high yield.

Structure and function of farmland biodiversity

Natural and improved ecosystems provide a variety of functions and services to support human well-being (Díaz et al., 2018 and 2019). It has long been recognized that biodiversity plays an important role in the operation of ecosystems (Naeem et al., 2012; Tilman et al., 2014), but the dependence of ecosystem services on biodiversity is still under debate. Early comprehensive results showed inconsistent results (Cardinale et al., 2012), while subsequent studies showed that a few dominant species may provide most of the ecosystem services (Winfree et al., 2015; Kleijn et al., 2015). Therefore, it is not clear whether a few dominant species or many complementary species are needed to provide ecosystem services. The explanation of early studies has always been controversial, because the multiple mechanisms of ecosystem service changes in response to biodiversity can be combined (Loreau et al., 2000; Hooper et al., 2005). On the one hand, communities with many species may include species that have a significant impact on the whole community due to statistical selection. On the other hand, such different communities may contain specific combinations of species that complement each other in service delivery. Although these mechanisms imply that species richness has a positive impact on ecosystem services supply, the total biological richness or dominance of some species may also promote the number of interactions conducive to ecosystem services supply. According to species complementarity, community richness and relative importance of dominant species, different relationships between species richness and ecosystem services can be expected (Schleuning et al., 2015). In real world ecosystems, natural communities are composed of some highly abundant (dominant species) and many rare species. The importance of richness, richness, and dominance may be influenced by the extent to which relative richness varies with species richness (Larsen ert al., 2005) and differences in the effectiveness and specialization of communities providing services. However, these three aspects of diversity are usually tested in isolated environments, mainly in small-scale experimental environments (Reiss et al., 2009; Bannar-Martin et al., 2018). However, comprehensive studies on their relative importance in real world ecosystems are still lacking. One of the major constraints in addressing these relationships is the lack of evidence from human driven biodiversity change in the real world (Balvanera etr al., 2014; Isbell et al., 2017), especially for ecosystem services in agricultural ecosystems. For example, the impact of agricultural land clearance (Chaplin-Kramer et al., 2011; Kennedy et al., 2013) on the biological richness and total or relative richness of services provided may change the flow of human interests in different ways than the experimental random loss of biodiversity. Over the past half century, the need to feed a growing world population has led to a significant expansion and intensification of agricultural production, turning many areas into simple landscapes (Foley et al., 2005). This transformation not only promotes the improvement of agricultural production, but also leads to the deterioration of the global environment. The loss of biodiversity will destroy the key intermediate services of agriculture, such as crop pollination (Ricketts et al., 2008) and biological pest control (Bianchi et al., 2006), which are the basis of the final supply services of crop production (Garibaldi et., 2013). Recently, crop yields have stagnated or even continued to decline (Ray et al., 2012), indicating that alternative approaches are necessary to maintain stable and sustainable crop production in the future (Foley et al., 2013; Bommarco et al., 2013; Pretty et al., 2018). There is an urgent need for a better understanding of ecosystem services driven by global biodiversity in agroecosystems and their knock on effects on crop production in order to predict the future supply of ecosystem services and implement sustainable management strategies (Isbell et al., 2017). We developed an extensive database of 89 studies measuring the richness and abundance of pollinators, natural enemies of pests, and related ecosystem services at 1475 sampling sites around the world (Fig. 22).

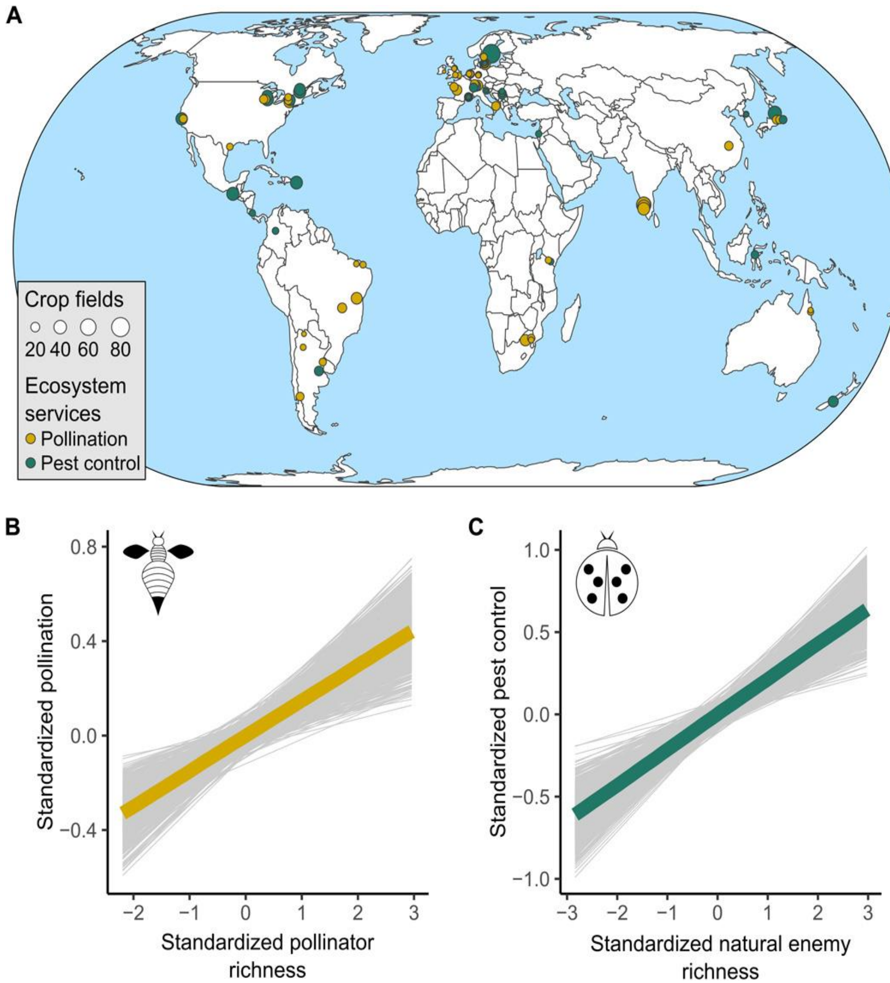


Fig. 22 analyzes the impact of the distribution and richness of the study on the provision of ecosystem services. (A) The map shows the size (number of crop fields sampled) and location of the 89 studies (further details of the studies are shown in table S1). (B) The global impact of pollinator richness on pollination (821 areas of 52 Studies). (C) Global impact of natural enemy abundance on pest control (n = 654 fields, 37 studies). The thick line in each graph represents the median of the posterior distribution of the model. The light gray line indicates that 1000 are randomly selected from the back. These lines are used to describe the uncertainty of model relationships (Matteo et al., 2019).

In 1992, 168 countries signed the convention on biological diversity (CBD) to protect biological diversity. In 2002, in what is known as the most important conservation agreement at the beginning of the 21st century (Balmford et al. 2005). World leaders set the specific goal of achieving a substantial reduction in biodiversity loss rate by 2010. The important tools to achieve this goal include a series of international treaties such as cites, CMOS and Ramsar) and various policy instruments, such as European Union (EU) nitrate directive, natura 2000 (EU bird and habitat directive) and agricultural environment plan. However, as 2010 goes by, these treaties and instruments are obviously not enough to achieve this goal (Butchart et al., 2010). Between 1970 and 2009, conservation work increased rapidly and significantly, but biodiversity threats also increased. To understand why biodiversity is still declining, it is crucial to know how conservation actions and threats interact and to what extent conservation can offset the loss of biodiversity.

In Europe, more than 45% of the rural areas are used as farmland (EEA, 2006). Many threatened species are closely related to farmland habitats. The decline of this group of species is well documented and particularly steep (Gregory, et al., 2014). The drivers of this decline have been extensively examined and relatively well understood (Benton et al., 2002). Species from other parts of the world and more natural habitats are only now beginning to receive a similar level of attention (Craigie, et al., 2010); in contrast, the impact of conservation policy instruments on farmland in Europe has been widely reviewed for more than a decade.

In recent decades, driven by population growth, food shortage and economic development, excessive attention to the output of agricultural products and one-sided pursuit of agricultural economic benefits have become the leading goals of agricultural development, making modern agricultural production increasingly single, large-scale, intensive and humanized. In today's oil agricultural production process, it is usually to plant some specialized varieties or species of crops in a large area, artificially exclude the competition of other crops (plants) to improve the yield of target crops, which results in the decline of biodiversity and the decline of crops in the farmland ecosystem Varieties tend to be monotonous, biological community structure tends to be simplified, and many excellent local varieties are eliminated and gradually disappear. Compared with the natural ecosystem, the species type and density (including many important natural enemies of pests) of farmland biological community are greatly reduced, and the biodiversity of farmland is reduced. At the same time, a large number of agricultural chemicals, especially the excessive use of chemical pesticides, have killed many non-target natural enemies (such as frogs, spiders, etc.), and the original food chain (WEB) in the farmland ecosystem is broken and appears to be "fragmented", thus weakening or replacing the harm to pests (diseases, insects, grass, etc.) under natural conditions The ecological control function of the plant (You Shimin et al., 2004; Zhang Jiaen et al.,

2005) Due to the perennial use of chemical pesticides, the resistance of crop diseases and insect pests is also rising, and some new or occasional diseases and insect pests continue to be rampant or frequent. Modern oil agriculture has fallen into a "never ending and never winning" war with crop pests. In this context, only by respecting the laws of nature and ecology, reconstructing and optimizing the structure and function of farmland ecosystem. And restoring, protecting and effectively utilizing the biodiversity of farmland, can we gradually get out of the current predicament and achieve twice the result with half the effort. In farmland, the utilization of biodiversity is mainly carried out from two levels of genetic diversity and species diversity. In recent years, many researchers have carried out active and beneficial scientific research and practical exploration on the utilization of farmland biodiversity from these two levels. In the aspect of genetic diversity utilization, it is usually to use the varieties of the same crop with different genetic characteristics to control the occurrence of some diseases, pests and weeds by means of appropriate space-time configuration such as rotation, intercropping or mixed planting. In the past decade, China has made great progress in using genetic diversity to continuously control rice diseases and insect pests, and there have been many successful cases. For example, when a new rice variety is replaced by a new one, it can control the disease and insect resistance by planting different varieties. That is to say, multiple varieties should be reasonably distributed in the same area to increase the diversity of crop disease resistance genes in farmland. Reduce the selective pressure of pathogens and pests, and then reduce the possibility of epidemic of rice pests; or multi line rice varieties and varieties carrying different disease resistance genes should be mixed, and the resistance difference and density of genetic diversity should be analyzed. The results showed that the effect of degree dilution, physical barrier, nutrient complementarity, allelopathy and microclimate had a good continuous control effect on rice diseases, insect pests and weeds (Zhu YY et al., 2000; Tang J et el., 2009, 49: 47-54; Zhu Youyong et al., 2004).

In terms of species diversity utilization, there are many excellent patterns of species diversity utilization in traditional Chinese agriculture (Li WH, 2001). For example, using the differences of light, temperature, nutrient, water, disease resistance, insect resistance and grass resistance among different crops, through the reasonable variety matching between crops and the optimization of space-time planting structure, that is, through intercropping, mixed cropping, intercropping, rotation and adjacent cropping and other diversified planting patterns, farmland space can be fully utilized niche, time niche and resource niche, and then realize the complementary utilization of aboveground light and heat resources and underground nutrient and water resources (Li L et al., 2007), effective control of diseases and pests and other ecological functions. There are also many successful practices in the utilization of farmland biodiversity in the breeding of compound species between crops and animals (Zhang JE et al., 2009), such as duck raising, fish raising, shrimp raising and turtle raising in paddy fields. In addition, the relationship between crop pests and insects, between crops and soil microorganisms, and between crops and soil animals can also be used to restore and reconstruct the biodiversity community structure of farmland, such as releasing or cultivating natural enemy organisms of pests in farmland, inoculating beneficial microorganisms such as mycorrhizal fungi in soil, and so on; In order to prevent and control the harm of pests, we should introduce or breed soil animals (such as earthworm) in the farmland, or plant some plants with the function of avoiding or trapping ("biological fence" or "ecological patch") on the ridge of farmland to prevent and control the harm of pests, which are commonly used in the utilization of farmland species diversity (Luo Shiming, 2008).

Although a lot of scientific research and related production practice have been carried out in the field of farmland biodiversity utilization at home and abroad, there are not many farmland biodiversity utilization modes which have obvious effect and can completely replace the use of pesticides and chemical fertilizers. There are many scientific problems to be solved. These problems mainly include:

1) Most of the existing farmland biodiversity utilization models are often empirical and arbitrary, and lack of strict, scientific and reasonable proportion structure and corresponding technical parameters and standards, so it is difficult to play its optimal ecological function.

2) At present, there is a lack of in-depth research and understanding on the process of farmland biodiversity and its internal ecological mechanism and function. Therefore, it is difficult to effectively regulate and utilize farmland biodiversity according to local and temporal conditions.

3) When different levels of farmland biodiversity (such as genetic diversity, species diversity and even ecosystem diversity) are superimposed and integrated at the same time, how will the interaction process and its ecological function effect change? How to make a systematic and effective space-time configuration for them to play a greater role in the overall superposition and integration? They are important scientific propositions that need to be studied.

4) How to make a scientific, objective and operable comprehensive evaluation of the ecological service function of various farmland biodiversity utilization patterns and their impact on global change from the perspective of ecological, economic and social benefits is also a major problem.

5) Due to the influence of technology, capital, human resources, education level of producers, production standards, and the differences of independent production goals and value orientation of thousands of households, some scientific and reasonable farmland biodiversity utilization modes are difficult to operate and implement in production and application, which

are different between regions and production It is difficult to coordinate with each other and make overall plans, so it is difficult to popularize and apply. The research and solution of the above scientific and practical problems will be the key to the successful popularization and application of farmland biodiversity (Zhang Jiaen, 2011).

Human land use threatens the global biodiversity and damages many ecosystem functions that are crucial to food production. It is unclear whether crop yield related ecosystem services can be maintained by a few dominant species or depend on high abundance. Using the global database of 89 studies (1475 sites), the relative importance of species richness, richness and dominance to pollination, biological pest control, and final yield in the context of sustainable land use change were classified. The richness of pollinators and enemies directly supports ecosystem services, and is independent of richness and dominance. Up to 50% of the negative impact of landscape simplification on ecosystem services is due to the loss of the richness of the organisms providing services, which has a negative impact on crop yield. Therefore, maintaining the biodiversity of ecosystem service providers is essential to maintain the flow of the main benefits of agroecosystems to the society (Matteo et al., 2019).

Biodiversity and ecosystem function are inseparable. The reasons for biodiversity conservation can be demonstrated from the perspectives of economy, social culture and aesthetics (Balmford e et al., 2002).

Although biodiversity loss occurs in all terrestrial ecosystems, many of its driving factors are related to agricultural intensification (Hails et al., 2002). Agricultural production will double again by 2050 (Tilman, 1999). Unless the agricultural footprint is carefully managed through sustainable development, both the agricultural system and the remaining natural ecosystems will be further degraded, increasing the proportion of endangered species in the world and further limiting the ecosystem services they can provide (Tilman, 2001). Managing the environmental impact of agriculture requires assessing the biodiversity risks and benefits of all new agricultural practices (ACRE, 2006). Understanding the ecological mechanisms that affect the risk of extinction is the basis of risk assessment. A key factor seems to be the degree of specialization shown by a species (Owens et al., 2000). Experts have narrow niche requirements and are disproportionately affected by reduced niche availability; their inference is that generalist species may be more resilient to environmental disturbances (Siriwardena er al., 1998).

Agricultural land accounts for one third of the earth's land area. In recent decades, the expansion and intensification of agricultural land has become one of the direct driving forces of biodiversity loss in the Anthropocene due to the continuous increase of population and the change of diet structure. However, the expansion of agricultural production is not always or everywhere at the expense of biodiversity. On the contrary, a considerable number of wild species have adapted to or even depended on farmland habitats in the course of centuries of agricultural practice and development. Therefore, the exact characteristics of agricultural development are related to the fate of global biodiversity, and wildlife friendly farmland should be regarded as a valuable ecosystem (Li, L et al., 2020).

Biodiversity - the diversity and variability of animals, plants, and microorganisms at the genetic, species, and ecosystem levels - is necessary to maintain the key functions, structures, and processes of ecosystems. Food and agricultural biodiversity can be managed to maintain or strengthen ecosystem functions, provide options for optimizing agricultural production, and help improve the disaster resistance of ecosystems and reduce risks. In fact, biodiversity enhances ecosystem services because, at some point in time, seemingly redundant components become very important when they change.

Crop genetic diversity plays a key role in improving and maintaining production level and nutritional diversity under various agro ecological conditions. A variety of organisms that contribute to soil biodiversity play many important roles in regulating soil ecosystem, including: decomposition of litter and nutrient cycling; conversion of atmospheric nitrogen into organic form and then into gaseous nitrogen; and change of soil structure. Through crop rotation, crop species mixing, permanent soil cover crops used in conservation agriculture or agroforestry, the diversity of intentional planting on farms is a common technology to improve yield stability and soil fertility.

Grassland and forage / crop systems that diversify and integrate ruminants and crops tend to be more sustainable, as they offer opportunities for rotational diversity, perennial farming and higher energy efficiency. The introduction of grazing animals at some stages of the agricultural cycle may help to decompose plant matter and increase nutrient supply. Predators and parasites attack pests or pathogens on crops, or plants feed on insects to attack weeds, which is helpful for pest control. In addition to these direct nutritional relationships, a network of interactions between different life forms on the farm can bring additional benefits. For example, crop production may benefit from benign microorganisms that reside in crops and their habitats, preventing pathogens from forming, or from non crop plants that are attractive to pests, thereby reducing their number on crops. In conclusion, the direct and indirect effects of biodiversity may create "pest control" conditions. Greater farm plant diversity, closer distance between crops, bare land coverage and more perennial cultivation may be measures to enhance resistance to invasive agricultural systems and contribute to weed management. Pollinators are essential for orchards, horticulture and feed production, helping to improve the quality of fruits and fiber crops. The best guarantee of healthy pollination service is the richness and diversity of pollinators, which is largely provided by wildlife diversity.

Ecosystem services are defined as "the benefits that ecosystems provide for human beings". Biodiversity provides many key ecosystem services, such as nutrient cycling, carbon sequestration, pest control and pollination, which maintain agricultural productivity. Promoting the healthy functioning of ecosystems ensures the resilience of agriculture, which is being strengthened to meet the growing demand for food production. Climate change and other pressures are likely to have a significant impact on key functions, such as pollination and pest control services. Learning to strengthen linkages between ecosystems to promote resilience and mitigate barriers to the ability of agro ecosystems to deliver goods and services remains an important challenge.

Ecosystem services can be:

Support (e.g. soil formation, nutrient cycling, primary production)

Supply (e.g. food, fresh water, fuelwood, fiber, biochemical products, genetic resources).

Regulation (such as climate regulation, disease regulation, water regulation, water purification, pollination)

Culture (e.g. spirit and religion, recreation and ecotourism, aesthetics, motivation, education, sense of place, cultural heritage).

Biodiversity is an important regulator of agricultural ecosystem function, which not only affects production in a strict sense, but also meets the needs of farmers and the whole society. Agro ecosystem managers, including farmers, can establish, strengthen and manage the basic ecosystem services provided by biodiversity in order to achieve sustainable agricultural production. This can be achieved through good agricultural practices that follow an ecosystem based approach aimed at improving the sustainability of production systems. They are designed to meet consumer demand for products of high quality, safety and produced in an environmentally and socially responsible manner.

Biodiversity conservation and enhancement in aboveground and underground cropping systems, such as soil biodiversity, is the basis for sustainable farming practices. These measures can also improve biodiversity in other parts of the environment adjacent but not directly connected to farmland, such as water bodies and broader agricultural landscapes. The composition and diversity of planned biodiversity (e.g. selected crops) strongly affect the nature of the associated Biodiversity - plants, animals and microorganisms. One challenge is to combine planned biodiversity with associated diversity (e.g., wild pollinators) through an ecosystem approach strategy.

By 2030, food production will have to increase by 50% to feed nine billion people. This brings great pressure to agricultural production. In addition to the demand for increased production in the agricultural sector, there is an increasing expectation and demand for sustainable farming practices. The increased demand for crop production of food, fiber and non food agricultural products (especially bioenergy crops), coupled with the impact of climate change and climate change, makes it necessary to rethink agricultural systems to adapt to new needs.

Traditionally, increased yields have involved increased dependence on pesticides and fertilizers, as well as excessive water use, which can degrade soil and water resources. However, planting practices are undergoing a shift from relying on traditional inputs and chemical based intensification to bioaugmentation that utilizes rich biodiversity and natural resources to provide ecosystem services. Promoting the healthy operation of ecosystem services through ecosystem based approaches can increase the choice of sustainable and optimized agricultural production (Case Studies Database: CSD-16).

FAO stressed that the protection of food and agricultural biodiversity and its sustainable use, oriented towards increased crop production and quality, is necessary for food provision, improvement of people's economic, social and environmental conditions, and meeting the needs of future generations, especially the rural poor. In this regard, the partnership assists member countries in developing their capacity to manage biodiversity and in providing ecosystem services to increase options for optimizing agricultural production.

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