INNOVATIVE AGRICULTURAL AND ENVIRONMENTAL SOLUTIONS

EDITORS:
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ECONOMIC COMPARISON OF TURKEY'S LOGISTICS INVESTMENT IN AGRICULTURAL PRODUCTION IN 1923-1948 PERIOD AND 2000-2022 PERIOD

PREFACE

Agriculture is one of the largest and strategic sectors in the world. High yields have been achieved with intensive agriculture practiced since the 1960s. However, as a result of unconscious practices, the sustainability of natural assets has decreased with factors that tire the soil and pollute the environment (greenhouse gas emissions, loss of biodiversity, melting of glaciers, etc.).

The primary advantage of sustainable agriculture is protecting the environment, reducing erosion and natural resource degradation, improving air and water quality, increasing biodiversity as well as reducing carbon emissions. In order to manage this process correctly, environment and agriculture friendly innovative studies and solution-centered holistic approaches are required. Agricultural innovations based on strong scientific foundations have improved both production and production capacity.

Is a growing population of Turkey and the world sufficient for sustainable agriculture and food production? Significant increases have been observed in the inputs needed for agricultural production in all countries of the world, together with the pandemic and energy crises. The goal of the farmers in their production was to produce with less land, less inputs and higher efficiency. Manufacturers have taken hundreds of innovative approaches that contribute to productivity gains, depending on the form and function of the inputs. Some routine habits have changed. These innovations have made manufacturers more productive, more profitable and more resilient to adapt. With the changing environmental and economic conditions, innovations have given farmers even more awareness of conservation through practices and technology processes used for soil health, waste recycling and environmental protection. The recent pandemic process and environmental problems have revealed how strategic and vital agriculture is.

The countries of the world have to work for innovative and holistic alternative approaches for the natural assets that are decreasing and shrinking in the future and day by day. Develop efficient, self-sufficient and economical production systems that provide decent incomes.

To achieve the goals of all stakeholders for innovation in agriculture (a wide range of agricultural groups, consumer groups, scientific groups, non-governmental organizations and individual citizens) their shared agendas need to identify the biggest opportunities and challenges that need to be addressed in the next 10 to 30 years.

Sincerely Yours,

December, 2022

Assoc. Prof. Dr. Ahmet ÇELİK

Assoc. Prof. Dr. Mehmet Fırat BARAN

Assoc. Prof. Dr. Korkmaz BELLİTÜRK

Assoc. Prof. Dr. Ahmet ÇELİK

He completed his undergraduate (Harran University) education in 1995, his master's degree (Harran University) in 1997 and his doctorate (Çukurova University) in 2012. He worked in the private sector for 1 year in 1992. He started to work at the Ministry of National Education in 1997. Between 2000-2007, he worked as an Voluntary Instructor in the Directorate of Kahta Vocational School of Harran University. In 2007, he held various administrative positions at Adıyaman University. In 2013, he was appointed as Assistant Professor Doctor at Adıyaman University Kahta Vocational School, Department of Plant and Animal Production. He is still working as an Associate Professor at Adıyaman University, Faculty of Agriculture. He worked as an executive and assistant researcher in approximately 15 projects supported by the European Union, World Bank, GAP Administration, Çukurova, Adıyaman Universities and Non-Governmental Organizations. Assoc. Dr. Ahmet Çelik took part in 2 second thesis advisory and 24 graduate thesis juries. He is the Adıyaman Provincial Representative of TEMA Foundation and a member of the Turkish Soil Science Association. Assoc. Dr. Ahmet Çelik has been an assistant editor and member of the editorial board, columnist and section writer in various newspapers and scientific journals since 1994, as well as in DÜNYA Newspaper; He prepared research and informational supplements and supplements published alongside the newspaper. He has many national and international articles and papers published on soil quality, soil organic carbon, agriculture and waste management in environmentally friendly practices. He is married and has three children.

Assoc.Prof. Dr. Mehmet Fırat BARAN

He graduated from Trakya University, Faculty of Agriculture, and Department of Agricultural Machinery in 1997 as head of the department. At the same year, he both started to MSc. in institute of natural and applied sciences in Trakya University and started to work as research assistant in Trakya University, Faculty of Agriculture, Department of Agricultural Machinery. He assumed title “MSc Engineer” in 2000 and “PhD” in 2010. He is still working as Associate Professor in Siirt University, Faculty of Agriculture, Department of Biosystems Engineering. He attended many conferences, meetings, courses, seminary, panels, workshops, congress and festivals at home and abroad. He served as project head and researcher in 7 projects supported by Trakya University, Adiyaman University, Siirt University, TAGEM, University of Agriculture- Scientific Research Projects Units. He has 175 articles and 14 Chapters on agricultural energy systems, energy use in agriculture, renewable energy technologies, recycling of agricultural waste, agricultural mechanization. topics as research articles and papers presented in domestic and abroad scientific meetings. Also, 41 of them are the articles published in international periodicals cited by international science indexes (SCI-SCI-Exp.). He studies the subjects about recycling of agricultural waste, biogas, energy use in agriculture and agricultural mechanization which are popular subjects all around the world recently. He still continuing his academic studies, trainings and projects in Siirt University. **Research Interests:** Energy Systems,Energy Use In Agriculture, Renewable Energy Technologies, Recycling of Agricultural Waste, Agricultural Mechanization.

Assoc. Prof. Dr. Korkmaz BELLİTÜRK is Associate Professor of Soil Science and Plant Nutrition Department of Agriculture Faculty at the Tekirdag Namık Kemal University, in Tekirdag, Turkey. He did his undergraduate degree at the Trakya University in Turkey in 1996 as head of the department, followed by a Ph. D project on hydrolysis of urea. He started at the Trakya University in 1996, focusing on plant mineral nutrition, and was a Research Assistant at the Faculty of Agriculture from 1996 till 2007. In 2007, he became Assistant Professor of Soil Science and Plant Nutrition Department, Tekirdag Namık Kemal University, Turkey. He was assigned to lecture for one week each within the context of Erasmus teaching staff mobility at Trakia Democritus University in Greece in 2011 and at University of Technology and Life Sciences in Poland in 2013. He was assigned for 3 months between 11 July and 11 October at the University of Vermont in Burlington/Vermont, USA to take a part in a project called "use of soil earthworms in agriculture" in 2011. From 2014 to 2015, he worked as a postdoc researcher at the University of Vermont in USA, working on soil ecology, earthworms and vermicompost. After the postdoc he became Associate Professor of Soil Science and Plant Nutrition Department of Agriculture Faculty at the Tekirdag Namık Kemal University, in Tekirdag, in 2018, where he focused of phytoremediation, plant nutrition, soil and water pollution, soil ecology, organic farming, composting and vermicomposting. He conducts one of the bilateral cooperation projects signed between the Council of Higher Education-Turkey and Higher Education Commission-Pakistan. The universities involved in the project are Tekirdag Namık Kemal University-Turkey and University of Agriculture Faisalabad-Pakistan in 2019. He served as project head and researcher in 29 projects supported by TUBITAK, Trakya University, Tekirdag Namık Kemal University, Nevsehir Hacı Bektas Veli University, Bilecik Seyh Edebali University, TAGEM, University of Agriculture-Faisalabad and Yozgat Bozok University Scientific Research Projects Units. He has 145 articles (*Totally, 21 of them are the articles published in international periodicals cited by international science indexes [SCI-SCI-Exp.]*), 9 book chapters and 3 books on soil science, ecological management for soil quality, plant nutrition, soil-water pollution, ecologic agriculture, vermicomposting and fertilization topics as research articles and papers presented in domestic and abroad scientific meetings. He has been awarded many projects and scientific publication awards in his field of study. He has been editor-in-chief of the journal Rice Research since 2015. He has one national patent. He features on ISI's list of highly cited authors in the field of soil fauna, soil fertility and plant sciences since 2010.

Research Interests: Soil Fertility, Soil Fauna, Soil Chemistry, Plant Nutrition, Soil Biology, Ecological Management for Soil Quality, Soil Pollution, Composting and Vermicomposting, Sustainable and Organic Agriculture, Fertilizers (Chemical, Organic and Organo-mineral fertilizers).

CHAPTER 1

BIOAUGMENTATION: A NOVEL STRATEGY TO COPE WITH ENVIRONMENTAL IMPACTS OF AGROCHEMICALS

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INTRODUCTION

Organized agricultural activities have been started with the settlement of humans but the due to the rise in population and greater requirement for diet leads to decrease in the nutritional status of soil. Therefore, the use of agrochemicals had been started to manage with ever-growing demand for the food through the rise in the production per unit area Singh et al. (2020). Synthetic fertilizers, plant growth hormones and plant protection chemicals (herbicides, insecticides and pesticides) are usually known as agrochemicals (Koli et al., 2019). The practice of using chemical fertilizers and pesticides has increased several folds after the advent of the Green Revolution which led the farmers to make agrochemicals a crucial part of their farming practices to attain more yield (Sun et al., 2018).

For the economic and efficient production of food, fiber, and feed goods, the application of agrochemicals plays a critical role. Agrochemicals have been utilized in huge quantities over the past few decades, to enhance the production of the crop all over the world (Koli et al., 2019). Globally, the manufacturing of synthetic insecticides and pesticides has touched an approximate extent of six million tons annually (Bernhardt et al., 2017) and global consumption of pesticides and fertilizers is shown in (Figure 1) (IFA, 2021). No doubt during the early time of the Green Revolution, the yield of crop has been increased with the application of chemical pesticides, insecticides, and fertilizers in extensive amounts but the production of crop yields has significantly decreased with time in the last years (Gupta et al., 2014). It is recognized that nonstop application of synthetic fertilizers and pesticides for several years resulted in the pollution of ecosystem and ultimately affect human health (Beketov et al., 2013; Sampath et al., 2014). Similarly, the extreme application of organochlorine pesticides [dieldrin, aldrin and dichlorodiphenyltrichloroethane (DDT)] and cholinesterase-obstructing pesticides [carbamates and organophosphates] pose considerable lethal impression on the living organism (Brain & Anderson, 2019).

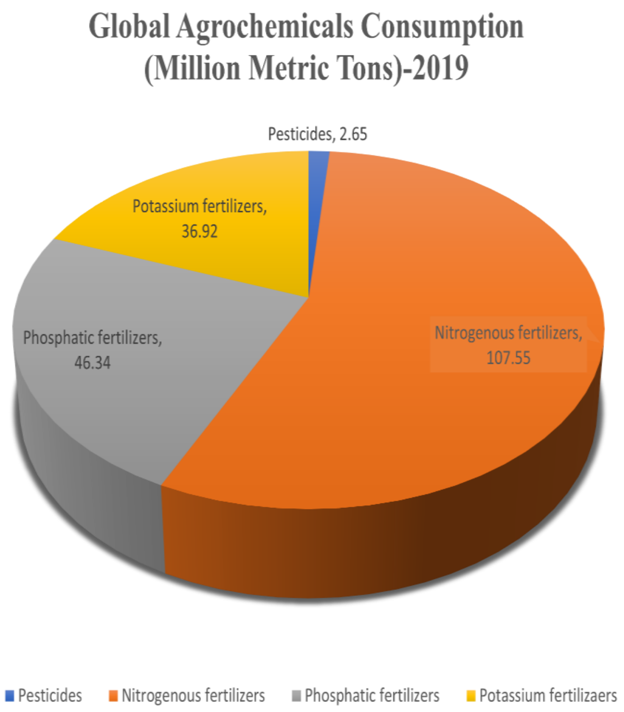

Figure 1. Global consumption of fertilizers and pesticides.

The soil is a main sink for contaminant deposit and intensive use of agrochemicals leads to the leaching of lethal chemicals (cyanide, nitrate, and sulfate) in groundwater and resulted in their accumulation in edible plant parts (Pajević et al., 2018; Saxena et al., 2020). The consumption of nitrate contaminated food or water results in various health ailments such as the generation of reactive oxygen species (ROS) and hemoglobin detention in the blood (Sataieva et al., 2018). Furthermore, the pesticides/fertilizers overflow or seepage into aquatic resources rises the growth of algae, which has an contradictory impact on survival of marine living organisms (Thatai et al., 2019). It is stated that 1% of used agrochemicals, influences the focused pests, and the residual move in the water, air and soil causing contamination and damaging living beings directly or indirectly through contamination of food chain and environment (Lozowicka et al., 2016; Rawtani et al., 2018).

It is a dare need to improve the manner of herbicide degradation for the protection of environment, especially plants, and soil microbial community, and to sustain human health (Fenner et al., 2013). Therefore, organic farming has become famous in which agricultural practices are emphasizing more utilization of natural products e.g. crop manure, compost, farmyard manure, vermicompost, biological-based fertilizers and biopesticides rather than synthetic agrochemicals (Singh et al., 2020). There are several remediation techniques based on chemical, physical and biological mechanisms to cope with the emerging issue of agrochemicals but recently bioremediation of pollutants gain more attention due to its high remediation potential and safety. It has a massive ability to cut the spread of manmade agrochemicals from the environment by living organisms e.g., earthworms and microbes through their metabolic activities. It becomes more popular due to its cost effective, ecofriendly and efficient in nature (Reddy & Antwi, 2016).

The In-situ and ex-situ are deemed as broad categories to eliminate the pollutant from infected soil (Amponsah et al., 2018). Ex-situ bioremediation involves the treatment of excavated infested soil by using bioreactors. Though it's a good technique to remediate polluted soil but the exclusion and transportation of contaminated soil are its major disadvantages and keep the hazard of contaminants dispersal (Tomei & Daugulis, 2013). On the other hand, the in-situ bioremediation method involves the deterioration of the toxin at the infected site and is considered an eco-friendly and non-invasive practice (Perelo, 2010). However, biostimulation is the process that involves the alteration of those factors (increase of electron acceptors and nutrients) that are responsible for biodegradation by native microbiota (Tyagi et al., 2011). Luo et al. (2019) concluded that the biodegradation of pesticides, including 2,4-D, has been increased with the supplement of dispersed organic matter under aerobic conditions in groundwater systems. Addition of dispersed organic carbon as a substrate for growth and oxygen as an electron acceptor completely degrades the pesticide 2,4-D in groundwater (Aldas-Vargas et al., 2021). Whereas adding macronutrients improved the biodegradation of biodiesel in contaminated soil (Meyer et al., 2018). A combine application of straw obtained biochar and a microbial consortia (atrazine deteriorating bacteria (*Acinetobacter lwoffii*) and phosphorus solubilizing bacteria) found significantly effective for atrazine contaminated soil (Tao et al., 2020). Biostimulation through treated organic matter (farmyard manure and biogas slurry) successfully used for exclusion of atrazine from polluted soil (Kadian et al., 2008). Additionally, bioremediation method combine with bioaugmentation to enhance the ability of autochthonous microbes for the biodegradation of contaminants (de Souza Pohren et al., 2016).

Bioaugmentation is the bioremediation technique that involves the usage of living creatures e.g. bacteria, fungi for the degradation of pollutants, especially somewhere the native microbes are not adequate to metabolize or degrade these compounds (Cycoń et al., 2017). The inoculant applied for the bioaugmentation may be "non-specific" for example activated sludge, in which the microbial species and their traits are unidentified; or "Highly specific" in which the chosen organisms are well recognized for their decaying abilities (Semrany et al., 2012). These microbes may be indigenous, with good performance in bioremediation of numerous agrochemicals (carbofuran, atrazine and glyphosate) (Góngora-Echeverría et al., 2020).

Bioaugmentation is one of the best explored approaches to remedy agrochemicals contaminated site which involves the addition of designed microorganisms suitable for the decay of preferred element at contaminated site (Cycoń et al., 2017). Several authors have successfully used this approach to enhance the atrazine elimination from contaminated soils, either as individual species (Q. F. Wang et al., 2013) or as groups of microbial isolates (Kolekar et al., 2019) which includes *Arthrobacter* and *Pseudomonas* (Sagarkar et al., 2013) and *Bacillus* species (Kolekar et al., 2019). The results proved that the application of atrazine degrading bacteria with cheap biowaste could be a viable method for the retrieval of atrazine polluted soils (Aliyu et al., 2022).

Fates and Toxicity of Agrochemicals in Ecosystem

It involves the entry of agrochemicals into the soil, atmosphere, and aquatic environment with a variety of transformations and degradation (Pal et al., 2006). The various mechanisms responsible for the agrochemical's toxicity includes photolysis, volatilization, leaching, surface water runoff, chemicals hydrolysis and microbial degradation. Generally, the degradation of the agrochemicals depends upon the soils and the factors responsible for the various soil processes such as chemical conversion, microbial metabolism, subsurface transport, surface transport, plant uptake, adsorption/desorption and volatilization. Moreover, the origin of application also affects the degradation, immobilization, and removal of agrochemicals (Mandal et al., 2020). Their fates and transfer pathways are complex and require further studies, especially for the new products for their chemical characteristics, physical change and breakdown by biotic and abiotic means. Chemical composition, mode of formulation, structure, solubility, volatility, and application methodology are the general properties of agrochemicals which are the determining factor for their fates in the ecosystem (Zacharia & James, 2011).

The research observed a prolonged pesticides endurance in soils than in living organisms (animals/plants) because the chemical remains rapidly split in aggressively developing living systems than soil (Edwards, 1975). Agrochemicals once distributed into the water or air will ultimately enter in the soil. The persistent agricultural pollutants degrade gradually in the ecosystem and stay for a long period which results in several lethal impacts on the soil (Aktar et al., 2009). Various fertilizers and pesticides are enriched with heavy metals for instance Cd and Cu, which pose negative effects on soil environment (Mandal et al., 2020). Under the agricultural production scenarios, environmental poisonousness may arise due to soil contamination with agrochemicals which may lead to the accretion of heavy metals and organic pollutants. Uninterrupted and over use of persistent agrochemicals may led to cause a high risk to the food security (Aktar et al., 2009).

The continuous use of chemical fertilizers damaged native microbial action in the soil and boosted the threat of pest damage in crop areas. These compounds affect the physiochemical characterization of the soil, pests' population and weeds growth (Ogbodo, 2013). The leaching of chemical fertilizers results in the accumulation of salts in soil, which obstruct plant growth (Khan et al., 2018). In addition, nitrate leaching caused pollution of groundwater and the consumption of nitrate contaminated water produced severe health complications in humans (Wick et al., 2012). Eutrophication and algal bloom are due to the mobility of mineral ions from inorganic fertilizers in water bodies. Application of manmade fertilizers influences soil physical properties, such as porosity, which plays a crucial role to maintain the transport of water through the soil (Sebastian & Prasad, 2015). So, artificial fertilizers that change the chemistry of soil and microbes are also significant environmental concern.

Effect on Soil Microflora and Biota

Soil microflora and biota are major component of soil structure, decomposition, and transformation processes in soil that respond rapidly to agrochemicals or amendments entering the soil. Agricultural inputs (organic matter, microbial culture, mineral fertilizers, and plant-protection chemicals) are practiced with the main objective of raising economic returns in terms of higher crop productivity, while negative effect on soil beneficial microbes is usually ignored. However, extreme agrochemical application diminishes the soil biodiversity (Mandal et al., 2020). The positive or negative influence of pesticide application is shown rapidly by soil microflora in the soil ecosystem. This behavior is usually used in assessments of ecotoxicology to estimate the influence of agrochemicals on soil and indication of the soil intrusion (Chowdhury et al., 2008).

Effect on Soil Enzymatic Activity

With the change in microbial metabolism, the soil enzymatic activity is adversely affected due to presence of agrochemicals especially pesticides and fertilizers (Floch et al., 2011). Generally, the soil comprises different enzymes excreted by microorganisms, restrained extracellular enzymes and free enzymes (Hussain et al., 2009). Enzymes are main markers of fertility and quality of soil, and biological equilibrium. In soil, degradation of natural chemical elements and pesticides residues are catalyze by these enzymes (Kızılkaya et al., 2012). Therefore, determining the variation in enzymes activity categorized as a biological pointer to recognize the influence of chemical elements along with pesticides on microbial activities (Romero et al., 2010). In comparison to the physical and chemical factors, it is believed that assessing the transformation in enzymatic activities is a primary sign of soil degradation (Dick, 1994). Due to the presence of agrochemicals, the increase and decrease in the enzymatic activities such as oxidoreductases, dehydrogenase and hydrolases were evaluated (Riah et al., 2014). Nitrogenase activity was significantly inhibited or decreased with pesticides (Prasad et al., 2011). Pesticide Diazinon did not affect the phosphatase activity while imidacloprid enhanced and lindane reduced the phosphatase enzyme under seed treatment in the field of groundnut (Singh & Singh, 2005). Nowak et al. (2004) stated that under application of various pesticides (Isoproturon, diazinon, captan, profenofos) urease activity was increased while Ingram et al. (2005) reported the reduction of urease enzyme in the soil under the application of pesticide. The impacts of pesticide usually fluctuate on soil enzymatic activities depending upon soil types, pesticide form and widespread environments. Therefore, it is judicious to examine the recently coming commercial pesticides thoroughly before their extensive use by the agricultural communities.

Effect on Microbial Communities and Nutrient Cycling

Agrochemicals that influence the soil microbial activities for the nutrient cycling of soil results in the harmful outcomes on soil environment. Pesticides have direct influence on numerous soil microbes and their metabolism (Singh and Walker, 2006) which may change the biochemical and physiological characteristics of soil microbes. Determination of microbial biomass (MB) gives a straight extent of connection between key nutrients cycling and soil microbial activities (Schultz & Urban, 2008). Pampulha and Oliveira (2006) wondered about the adverse effects of agrochemicals on soil respiration and soil MB. Commonly, in pesticide-treated soil, a fall in soil respiration reveals a significant drop in MB Chen et al. (2001). Sometimes, firstly the population of microbe is influenced by pesticides application however, later it becomes normal or even rises due to acclimatization (Niewiadomska, 2004). This shows modifications in catabolic metabolism of microbes which might be the result of stimulated pesticide degradation and modification within the microbes (Ortiz-Hernandez et al., 2013; Yale et al., 2017). Microbial growth have been repressed by disproportionate application of the pesticides, which bounds the accessible nutrients such as nitrogen (N), phosphorus (P), and potassium (K) in soil and results in the degradation of the soil quality (Sardar & Kole, 2006).

Usually, fungicides had additional impacts on soil microbial community than the insecticides and herbicides. When they are used to diminished fungal borne disorders, they will affect advantageous fungi and other microbes of soil participating in the nutrients cycling. The researcher observed that fungicides containing copper have significant harmful effects on population of earthworms (Eijsackers et al., 2005; Van Zwieten et al., 2004). Mostly, the organophosphate (OP) insecticides for instance chlorpyrifos, malathion, dimethoate, quinalphos and diazinon have diverse influence on enzyme activities of soil (Singh &

Singh, 2005), modifications in bacterial and fungal population in soil (Pandey & Singh, 2004), as well as depletion in earthworm reproduction (Panda & Sahu, 1999) and collembolan density (Endlweber et al., 2006).

Effect on Water Resources and Aquatic Life

Excessive application of agrochemicals has turned out to be a risk to the ecosystem and environment. These chemicals persist in the soil and their concentration increases every season. These chemicals enter the water bodies (ponds, rivers, groundwater) and cause water pollution (Gupta et al., 2015). It has been estimated that 25% to >50% of samples are contaminated with pollutants. The residues of agrochemicals such as insecticides and herbicides depend upon the seasons e.g., increased concentration of herbicides and insecticide residues were found more in March and June, respectively (Herrero-Hernández et al., 2017).

Agrochemicals contaminate the surface water as well as the ground water regimes as shown in (Figure 2). Their residues are frequently water soluble and negatively change the quality of surface water. Elevated concentrations of these chemicals in overlaying water can transfer pollute to the ground water (Szekacs et al., 2015). Commonly, pesticides are taken away by soil with water runoff and pollute the aquatic supplies and influence aquatic life (Lewis et al., 2016). The dilemma of water pollution needs massive and serious remedial actions (Chau et al., 2015). WHO has recommended the standards for concentration of pesticides and herbicides remains in the drinking water? The monitoring concentrations for pesticides in µg/L: atrazine-2, aldrin/dieldrin-0.03 chlordane-0.2, 2,4-D-30, cyanazine-0.6, DDT-2, MCPA-2, lindane-2, EDB-0.415, molinate-6, and aldicarb-10. The standard concentrations for herbicides in µg/L: metolachlor-5, pendimethalin-17, bentazone-25, pyridate-60, propanil-175, trifluralin-170 and simazine-17 (Hamilton et al., 2003). Some of the pesticides contain chemicals that are persistent and possess bioaccumulating properties. such as dieldrin, DDT, HCH, toxaphene and aldrin. These persistent chemicals are termed as persistent organic pollutants because their residues are found in soil and water and effect the aquatic and terrestrial ecosystem (Carvalho, 2017). When these chemical pesticides are present in water reservoirs, they are collected in marine biota such as fish. These chemicals accrued in tissues of fish. The extent of accumulated pesticides varies with fish age, biota mobility and their feeding mode. The absorption of pesticides depends upon the lipid content as the lipid content increase, the concentration of pesticides increases (Ogbeide et al., 2015).

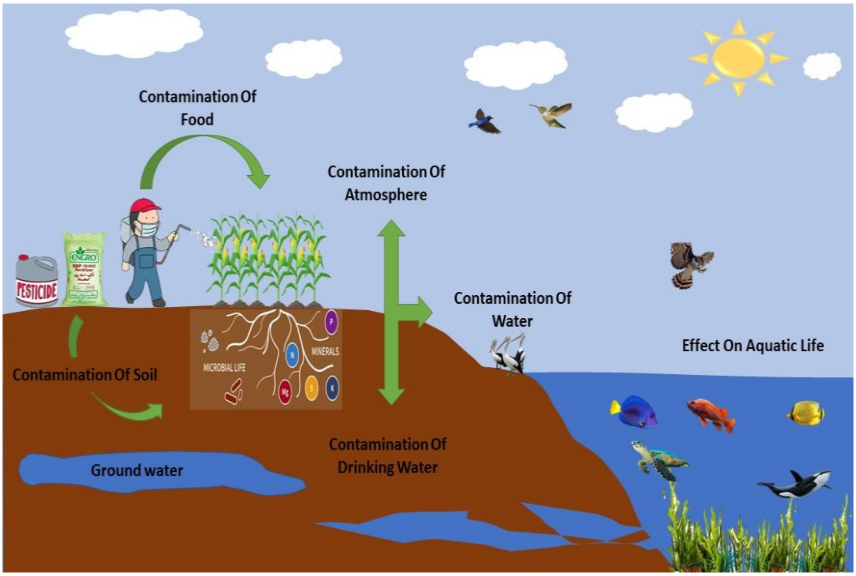

Figure 2. Impact of agrochemicals on soil, atmosphere, aquatic environment and on human health.

Effect on Human Health

Agrochemicals become problematic due to their long-term perseverance in soil. Owing to its possibly damaging effects on human health, gathering of harmful elements as radionuclides, heavy metals and agrochemicals into the environment justify solemn attention. According to the WHO, pesticides contamination affected about 3 million people annually (Nayak et al., 2018). Various pesticides are lipid soluble and capable of persistance in human body which ultimately causes severe health hazards by causing skin and eye diseases and nervous system disturbance (Rawtani et al., 2018) and resulted in “cancer villages” across the globe (Lozowicka et al., 2016).

Globally, the practices of agrochemicals have resulted in acute poisoning with the harmful impacts on the human health, from minor health signs to the death. The exposure of ecological pollutants such as agrochemicals, cleaning agents, heavy metals, detergents, minerals, metals, toxins, pharmaceuticals and organic pollutants may cause prolonged ailments in humans. Frequently their signs are not rapidly apparent and are exposed at a later phase of life. Agrochemical pesticides result in persistent health impacts such as diabetes, depression, cancer, neurological and fertility problems (Prudente et al., 2018). Several health risks are allied with the agrochemicals persuaded oxidative stress such as Parkinson’s disease and interruption of glucose homeostasis (Pandya et al., 2018).

Mechanisms of Bioaugmentation

Microorganisms, especially bacteria survive in toxic and harsh environments using adaption mechanisms (Kapahi & Sachdeva, 2019). Bacteria change their genotype and phenotype to survive in the environment through natural selection (Lenski, 2017). Specifically, they save oneself by developing resistance against toxic pollutants, like heavy continue their populations. Resistant bacteria survive by emerging various mechanisms for instance bioaccumulation, biosorption, biotransformation and bio-oxidation (Fernández et al., 2018). The mechanisms of bioaccumulation and biosorption involve the absorption of pollutants, but it varies according to different processes and pathways. In biosorption process, the pollutants are attached to the external cell wall or are transferred from the medium to the cell. The concentration of pollutants inside the cell is the result of subsequent bioaccumulation and biosorption procedure (Jobby et al., 2018). Biosorption mechanisms can be illustrated extracellularly by the cells of extinct and live microorganisms because of their metabolic independence, while bioaccumulation occurs intracellularly which mainly decides this process on the metabolic basis. In biosorption mechanism, heavy metals can bind to the bacterial cells without using ATP as this process does not need energy to start (Timková et al., 2018). In contrast, bioaccumulation begin rapidly and progress to normal level, permitting physical adsorption or ion exchange for attachment and transportation of metals (Srinath et al., 2002).

Pollutants within cells are normally gathered as complex compounds because of their resistance behavior through multiple enzymatic reactions (Imron et al., 2021). Biotransformation comprises of two processes, bio-reduction and bio-oxidation. These processes take place intracellularly and extracellularly. In bio-oxidation mechanism, the oxidation states of heavy metals change and transform into a harmless oxidation state that usually take place outside the cells (Ahemad, 2019), like oxidizing As(III) into a less poisonous As(V) (Titah et al., 2018). Bio-reduction, such as Cr(VI) to Cr(III), reduces the oxidative state of 6 þ to 3 þ which generally occurs within bacteria cell (Pradhan et al., 2017). Both pathways include enzymes to diminish or convert toxic heavy metals to less form before supplying in the environment (Jobby et al., 2018). The bounds between the functional groups or bacterial cell wall substances may lead to resistant mechanisms of heavy metals (Imron et al., 2021). The functional group and metals form minerals around cell walls, which provide additional safety, known as biomineralization (Dhami et al., 2013; Zahoor et al., 2017). Naturally, bacteria utilize their adaption system to protect their cells from toxic material at the same time decontaminating the environment throughout pollutant removal.

Bioaugmentation using indigenous bacteria

Microorganisms are primarily separated from a target contaminated site and grown under controlled conditions. After that, pre-adjusted pure bacterial strains are reintroduced in the same soil (Nikolopoulou et al., 2013). Bioaugmentation normally uses isolated strains from similar environment which can destroy focused pollutants effectively (Li et al., 2020) as shown in (Figure 3). These isolated strains have wide flexibility to the native environment and play a dominant role in degradation (Jia et al., 2019). This process is known as soil reinoculation with native species. According to (Poorsoleiman et al., 2020) study that used single-strain indigenous bacteria (*Acinetobacter radioresistens* strain KA2) separated from the oil waste water and described that total petroleum hydrocarbons were removed between 67.64 to

89.56% during an eight-week composting incubation period. Earlier studies had identified the potential for bioaugmentation potential for effective degradation of congeners and hydrocarbons.

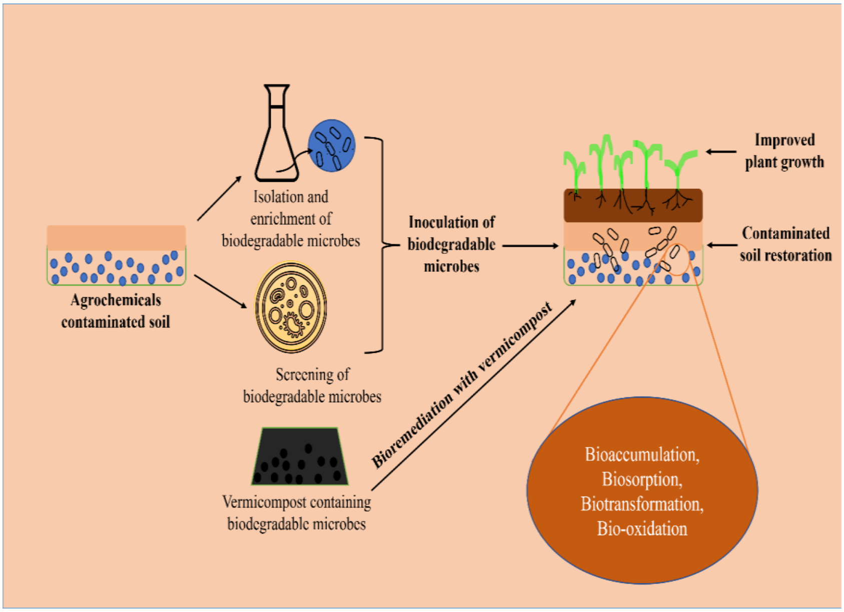

Figure 3. Systematic mechanism of bioaugmentation.

In a comparative description of bioremediation of diesel polluted soil, (Bento et al., 2005) used natural devitalization, bioaugmentation, phytoremediation and biostimulation, and informed that the greatest hydrocarbon degradation occur in the cultured one strain bioaugmentation system. In similar research, the effectiveness of bacterial biostimulation and bioaugmentation was also evaluated (Masy et al., 2016). Remarkably, it was noted that native bacteria endured in system but did not breakdown target contaminants during bioaugmentation. (Jia et al., 2019) reported that the microbial diversity was unaffected by the addition of two native denitrifying strains. However, the bioaugmentation strains boosted the number of bacteria involved in nitrogen elimination. As a result, the metabolism of amino acids and the formation of other secondary metabolites increased which allowed the system to start up more quickly and remove pollutants more effectively. (Bai et al., 2016) isolated Mn-oxidizing bacteria (*Pseudomonas* sp.) and reinoculated in quartz sand filters to remove Mn from groundwater. The population of native bacterial community did not alter. However, the Mn oxidation gene and xenobiotic metallic gene enhance significantly. Although, the bioaugmentation is the alteration of microbial diversity, increased target pollutant degrading bacteria and variation in the whole metabolism of the system. All of these are helpful to get the best pollutant degrading strain and improve system performance. Bioaugmentation of different agrochemicals using biodegradable bacteria is shown in (Table 1).

Table 1. Bioaugmentation of different agrochemicals using biodegradable bacteria.

Bacteria	**Organic pollutants**	**Classification of organic pollutants**	**Bioaugmentation efficiency**	**References**
Kocuria flava, Rhodococcus pyridinivorans	Phenanthrene, fluorene, and anthracene	PAHs	Phenanthrene (55.13%), fluorene (63.46%), and anthracene (59.01%)	(Singh & Haritash, 2021)
Pseudomonas nitroreducens, Ochrobactrum sp.	Atrazine, glyphosate, carbofuran	Organochlorine and organophosphate pesticides	Ochrobactrum sp. degraded glyphosate and atrazine	(Góngora-Echeverría et al., 2020)
Enterobacter sp.	Petroleum hydrocarbons	TPHs	81.63%	(Sun et al., 2019)
Pseudomonas putida CBF10-2, Rhizobium radiobacter GHKF11O, and chrobactrum anthropi FRAF13	Chlorpyrifos	Organophosphate insecticide	Chlorpyrifos degraded (78.55%)	(Islam & Iyer, 2021)
Castellaniella sp.	3,3′,4,4′-tetrachloro biphenyl (PCB 77)	HOPs	Highly efficient in the degradation of PCB 77	(Su et al., 2019)
Pigmentiphaga sp.	Acetamiprid	HOPs	Pigmentiphaga sp. found potential biodegradable	(G. Wang et al., 2013)
Mycobacterium, Methylibium, Rhodococcus, Variovorax, Comamonas, Burkholderia and Pseudomonas	Ametoctradin	Triazolopyrimidine fungicide	81% degradation of the parent compound	(Whittington et al., 2020)
Mycobacterium sp.	Pyrene	PAHs	90% degradation with humic aicd	(Li et al., 2022)
Mycolicibacterium frederiksbergense, Rhodococcus sp. Rhodococcus erythropolis	Total petroleum hydrocarbons and Polychlorinated biphenyls (PCBs)	TPHs	Reduction in TPH (34.6%), PCBs (51.8%) contents	(Steliga et al., 2020)
Bacillus sp.	Cypermethrin	Pyrethroids	Biodegraded cypermethrin 71.0%	(Birolli et al., 2022)

PAH: Polycyclic aromatic hydrocarbons; TPHs: Total petroleum hydrocarbons; HOPs: Halogenated hydrocarbons.

Bioaugmentation using exogenous bacteria

Bioaugmentation through exogenous bacteria leads to bacterial competition with the native bacteria for nutrients and space (Chen et al., 2015) resulting the unstable and unsuccessful bioaugmentation. For a successful bioaugmentation process, it is very important to realize the variations in the system that occur because of the addition of exogenous bacteria. Bioaugmentation through exogenous strains is primarily accomplished by altering the composition of the microbial population, boosting the development of effective pollutant degrading bacteria, enhancing only certain functional species, and realizing the efficient breakdown of target contaminants. In several analyses, it has been observed that bioaugmentation using exogenous strains is unable to survive and sustain its benefits in the system. (H. Wu et al., 2018) isolated two strains of triazole-degrading bacteria and inoculated them to treat fungicidal wastewater. However, these strains were not abundant in the system, but the strains can enhance efficient species for degradation of N- heterocyclic compounds, which further increases the elimination of total organic carbon (TOC) and chemical oxygen demand (COD). (Zhang et al., 2021) conduct various bioaugmentation studies to enhance the nitrogen elimination of wastewater, it was observed that the inoculation of exogenous strains much improved the number of native bacteria with high nitrogen elimination efficiency in the system. In the bioaugmentation of municipal wastewater, (Chen et al., 2015) inoculated nitrogen removal bacteria PCN and discovered that the excellent phosphorus and nitrogen removal occurred under aerobic conditions.

Bioaugmentation using microbial consortia

Naturally, microorganisms are established as different cultures in all kinds of environments. The native habitat of microorganisms is foods, aquatic biomes and xenobiotic polluted sites. Bioaugmentation of pollutants requires different microbial metabolic mechanisms and enzymes from numerous microorganisms for whole degradation of pollutants. Thus, the formation of high-density cell masses called consortia is normally an important tool for effective remedial outcomes. Although, in the microbial consortium, one organism secretes a particular substance that it does not use in enzymatic conversion and metabolism (Nwankwegu et al., 2022). These metabolic byproducts may be beneficial or harmful to the operation of these key microbial producers, but they may be an essential cause of carbon and energy for other microbes in the intricate ecosystem. In the costa rice field, imidacloprid degrading bacterial consortium was isolated. The capability of this consortium was examined in reactor, and it was efficient in degradation of different neonicotinoids. Generally, 95.8% of imidacloprid was degraded by bacterial consortium (Rodríguez-Castillo et al., 2019). Different research demonstrated that the actinobacteria consortium was capable to degrade lindane more efficiently as compared to biostimulation with sugarcane filter cake. The result shows that the bioaugmentation by microbial consortium degrades lindane from contaminated soil (Raimondo et al., 2020).

Bioaugmentation by fungi

Filamentous fungi are chlorophyllous, heterotrophic and eukaryotic microorganisms that can secrete intra and extracellular enzymes and some organic acids (Espinosa-Ortiz et al., 2016). Fungi release a range of enzymes into their surroundings that break down polymeric materials. These enzymes can be employed to break down harmful contaminants like pesticides, cosmetics, and medications (Sankaran et al., 2010). Fungi show distinct metabolic and physiological benefits over bacteria because they do not rely on soluble and rapidly absorbed organic compounds for nutrition. In nature, fungi play a fundamental role in recycling of a broad range of recalcitrant polymeric organic substances made up of cellulose, melanin, keratin, lignin and chitin. Because of this metabolic variety, it is possible for fungi to co-metabolize several xenobiotics that are poorly biodegradable or bioavailable (Prenafeta-Boldú et al., 2019). Under these conditions, the pollutants can be degraded at different degrees, from partial transformation to the complete degradation, but the various organic substrates are needed to support fungal growth. It is curious to evolve the bioremediation by fungi, because of their ability to absorb precipitously into the soil matrix. In addition to, they can grow in conditions with low humidity, an acidic pH, and low nutrient concentrations.

Additionally, fungi utilize biosorption as a way to get rid of dangerous substances (Jiang et al., 2019). The bioaugmentation mechanisms concerned with wastewater treatment using fungi can be separated into three different steps such as biodegradation by intra and extracellular enzymes, sorption onto biomass and mycelium-bound enzymes (Naghdi et al., 2018). Many findings have shown capability of various fungi species to remove and accumulate insecticides and herbicides from the environment. These findings were concentrated on isolating native fungi species growing in the contaminated soils. *Aspergillus tamarii* and *Botryosphaeria laricina* were isolated from agriculture soil, (Silambarasan & Abraham, 2013) and found that these fungal strains were capable to reduce the pollutant and its harmful metabolites such as alpha endosulfan, beta endosulfan, and endosulfan sulfate by using these as a source of energy and carbon. In another work, it was observed that Aspergillus glaucus secrete different ligninolytic enzymes which play significant role in degradation of fipronil and its metabolites (Gajendiran & Abraham, 2017). Moreover, hydrocarbon breakdown inquiries have been conducted by employing white rot fungi like as *Trametes versicolor*, *Pleurotus ostreatus*, and *Phanerochaete chrysosporium* (Mollea et al., 2005). Similarly, white rot fungus *Pleurotus ostreatus* remove the aldrin and its primary metabolites diealdrin. These occur via hydroxylation and epoxidation reactions. In various studies, demethylation, dechlorination, esterification, deoxygenation, and dehydrogenation reactions have been described during the mycoremediation of pesticides (Maqbool et al., 2016). Numerous studies indicated that enzymes are involved in the breakdown of several herbicides and insecticides (Table 2).

Table 2. Enzymes, their sources and bioaugmentation efficiency for agrochemicals.

Agrochemical	Biodegradable enzyme	Source	Degrading efficiency	Reference
Dichlorodiphenyltrichloroethane	Laccase	Polyporus brumalis	47–52 %	(Zhao et al., 2010)
Phenanthrene	Laccase	Aspergillus niger	29.24 %	(Teng et al., 2019)
Chlorpyrifos	Phytase	Aspergillus niger NCIM 563	72.00 %	(Shah et al., 2017)
Dichlorophos, profenovos, chlorpyrifos, monocrotophos	Laccase	Pseudomonas sp.	Dichlorophos (45.99%); profenovos (81.84%); Chlorpyrifos (80.56%); monocrotophos (75.45%)	(Chauhan & Jha, 2018)
Malathion organophosphates	Carboxylesterase	Escherichia coli IES-02	81%	(Sirajuddin et al., 2020)
Anthracene	Yellow laccase	Leucoagaricus gongylophorus	72%	(Ike et al., 2019)
Benz[a]anthracene and phenanthrene	Laccase	Pycnoporus sanguineus 14	benz[a]anthracene (90.1%); Phenanthrene (45.6%)	(Li et al., 2018)

Bioaugmentation by vermicomposting

Vermicomposting is a sustainable way of degradation, oxidation and stabilization of organic material by the combined action of microorganisms and earthworms (Villalobos-Maldonado et al., 2015). This eco-technological method can transform organic residues and pollutants into valuable products for soil restoration (Dendooven et al., 2011). Earthworms can be employed as a substitute for the remediation of different contaminants due to their tolerance against toxic environments (Rajiv K et al., 2010). Earthworms mix the soil in gut transit during burrowing activities. Thus enhancing and facilitating the interaction between microbes and contaminants (Hickman & Reid, 2008). They also secrete extra-cellular enzymes that degrade phenolic compounds and cellulose, enhancing the degradation of consumed material (Aira et al., 2006). Among various kinds of contaminants, heavy metals are considered highly toxic elements. It is well acknowledged that heavy metals accumulation in the earthworms depends on the metals which are bioavailable for the uptake (Dai et al., 2004). Various studies have acknowledged that inoculation of contaminated soil with earthworm (*Eisenia fetida*) directly or with organic matter, increased the degradation of a wide range of environmental pollutants (Lin et al., 2012; Rodriguez-Campos et al., 2014). The bioconversion of industrial sludge by earthworms is effective as it reduces sludge toxicity (Bhat et al., 2017). The chloragocyte cells and gut microbes of earthworms have a potential for the detoxification of heavy metals in industrial wastes (Srivastava et al., 2005). This mutual action of earthworms and microbes approves that vermi-conversion is an efficient method for decreasing industrial wastes genotoxicity. (Hobbelen et al., 2006) studied the significant correlation between the heavy metals' concentration in earthworms and contaminated soil. They concluded that earthworms in the soil accumulated higher concentrations of Cd and Cu despite their low availability. Industrial waste toxicity is primarily detoxified when it is bio-transformed by the earthworms, and the final material is converted into vermicompost. Earthworms accumulate organic contaminants using two pathways i.e., epidermal and dietary uptake (Jager et al., 2003; Zhi-Ming et al., 2014). In epidermal pathway, uptake occurs passively from the site of less chemical potential. Later, organic contaminants dissolved in the pore water and are absorbed by body wall and then translocated into the body of the earthworm. On contrary, dietary uptake is carried out by the feeding of earthworms on organic composites, which can be assimilated in gut and later on translocated to earthworms tissues (Jager, 1998; Zhi-Ming et al., 2014). The vermi-accumulation process is linked with earthworms physiology such as lipid contents in earthworms' tissue and physicochemical properties i.e., concentration and solubility of organic compounds (Rodriguez-Campos et al., 2014). Regardless of the limited information about vermiremediation, the vermicomposting has grown as an effective technology for the elimination of organic pollutants (PAH, pesticides, sewage sludges) and heavy metals in the coal fly ashes (Rorat et al., 2017; Usmani et al., 2017). Vermicomposting has been commonly utilized to stabilize the heavy metals in contaminated areas. Vermicomposting decrease the heavy metals and pesticides mobility (Fernández-Bayo et al., 2015) by the transformation of exchangeable or water soluble fractions of heavy metals into residual elements (Goswami et al., 2016; Lv et al., 2016). Vermicomposting can significantly reduce heavy metals concentration and toxicity along with alteration in bacterial diversity and composition during vermicomposting process (Wang et al., 2017). (D. Wu et al., 2018) investigated to alleviate the heavy metals toxicity in sewage sludge using vermicomposting with urban plant litter as an additive. The urban plant litter increased the macroaggregates in sewage sludge and reduced the bioavailability of heavy metals. Cd contents in the vermicompost (urban plant litter + sewage sludge) declined by 31%. The vermicompost increased the seedling growth of maize. Another effort was made by (Moslehi et al., 2019) to assess the bioaugmentation efficiency of Cd and Pb using vermicompost and ethylenediamine disuccinic acid. Vermicompost reduced the bioavailability of Pb by 43.28% and improved the remediation factor index of Cd. (Zhou et al., 2008) examined the detoxification of methamidophos by earthworms detoxic incubation with illumination. Due to earthworms' action, the half-life of methamidophos with concentration of 15 mg/kg drop from 5.61 days to 5.08 days. (Diaz et al., 2016) investigated the removal of pesticides in bio-bed bioremediation system (BBSs) containing higher concentration of pesticides along with vermicompost, fungal and bacterial strains. Three treatments of BBSs comprised of vermicompost prepared from the greenhouse, winery and olive-mill wastes were contaminated and incubated for one month. In winery wastes, the consortia enhanced the removal of oxyfluorfen, metalaxyl and tebuconazole by 7.7, 3.8, 1.6-fold, respectively. (Delgado-Moreno et al., 2020) also used bio-beds for the remediation of pesticides. Two bio-mixtures, 1) soil:peat:straw (P), and 2) soil:vermicompost (wet olive cake and olive tree pruning) (O), polluted with higher concentration of four pesticides (imidacloprid, tebuconazole, oxyfluorfen and diuron) were used. Vermicomposting process continued for 12 weeks using Eisenia fetida. Earthworms colonized the P biomixture (50%) and O biomixture (70%). The colonization did not affect the tebuconazole and imidacloprid but increased (1.4-fold) the dissipation of diuron and oxyfluorfen in both bio-mixtures. (Luo et al., 2022) explored the potential of vermicompost on degradation performance of atrazine by investigating the alteration in bacterial communities and atrazine metabolites. Their results proved that vermicompost amendment substantially increased the soil organic matter, pH, humic substances and attained higher efficiency for atrazine removal and enriched the soil with atrazine degraders (Streptomycetaceae, Pseudomonadaceae, and Thermomonosporaceae). Thus, above discussion provides a new understanding on significant factors for agrochemicals bioaugmentation using vermicomposting (Table 3).

Table 3. Bioaugmentation with vermicompost improves the bioremediation efficiency of agrochemicals.

Agrochemicals	Substrate	Source	Result	Reference
Oxyfluorfen, tebuconazole and metalaxyl	Vermicompost	Winery wastes	Increased the removal of metalaxyl (3.8), tebuconazole (1.6) and oxyfluorfen (7.7) fold	(Diaz et al., 2016)
TPHs	Vermicompost	Agro-industrial wastes	Bioaugmentation with vermicompost enhances hydrocarbon degradation by up to 34.4%	(Curiel-Alegre et al., 2022)
Petroleum hydrocarbons	Vermi-compost	Organic wastes	Bioaugmentation with vermicomposting boosts 85-91% removal of TPHs	(Koolivand et al., 2020)
Diuron, oxyfluorfen	Vermi-compost	Horse manure	Pesticides bioaugmentation increased 1.4-fold	(Delgado-Moreno et al., 2020)
Methyl carbamate, organophosphorus	Liquid vermi-compost	Grape marc	Chlorpyrifos degraded and inactivated its highly toxic metabolite chlorpyrifos-oxon	(Sanchez-Hernandez et al., 2019)
Organophosphate insecticide	Vermi-compost	Cow manure + coconut husk	Vermicompost was efficient in pesticide degradation and its ecotoxicity reduction	(Dias et al., 2021)
Atrazine	Vermi-compost	Cow dung and straw	Vermicompost increased the soil atrazine degraders and introduced intestinal metabolizers	(Luo et al., 2022)
Diuron	Vermi-compost	Olive waste	Vermicompost addition increased the diuron degraders, hence the soil diuron-depuration capability	(Castillo et al., 2016)
Endosulfan lactone (EL)	Vermi-compost	Rabbit manure	EL removal is higher with the addition of vermicompost	(Vázquez-Villegas et al., 2021)
Diuron	Vermi-compost	Wine and Alcohol Industries wastes	The addition of vermicompost declined the diuron persistence	(Fernandez-Bayo et al., 2009)

CONCLUSION

Agrochemical-contaminated soil imposes several environmental problems, and the existing physical and chemical methods have various difficulties as expensive chemical, soil degradation and consequent pollution. Bioaugmentation is a sustainable and viable technology that effectively removes contaminants from agrochemical-contaminated soils by using microorganisms, their enzymes and other bioremediation additives such as vermicompost. This chapter comprehensively explored the toxic effects of agrochemicals on soil and water environment, microbial structure, nutrient cycling, and human health. Bioaugmentation methods and their degrading mechanism for the contaminated soils are also discussed here.

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CHAPTER 2

ENVIRONMENTAL EFFECTS OF SLOW - CONTROLLED RELEASE FERTILIZERS

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INTRODUCTION

The nutrients that the plant needs and that are not enough in the soil are removed using fertilizers. One of the most significant costs in agricultural production is fertilizers. Fertilization ranks second after mechanization in agricultural costs worldwide (Şahin, 2016). For a more profitable agricultural production, it is necessary to obtain an effective benefit from the fertilizers used. However, the plants cannot benefit enough from all the fertilizers used in agriculture. The plant nutrients contained in the fertilizers used can sometimes turn into forms that the plant cannot benefit from in the soil, sometimes evaporate, and sometimes mix with rain and irrigation into groundwater. Excessive use of conventional fertilizers cause environmental problems related with nutrient loss through evaporation, denitrification, leaching, and surface runoff (Sim et al., 2021). The excessive use of commercial fertilizers for maximum agricultural crop production reduces soil fertility, causes serious environmental pollution, and affects human health directly or indirectly. In addition, it reduces the efficiency of nitrogen use. (Rahman et al., 2021).

One of the plant nutrients that is most lost as a result of fertilization is nitrogen. Nitrogen can leach into groundwater through rain and irrigation. As a result of this event, nitrate pollution can be observed in groundwater. In addition, one of the main causes of nitrogen loss is the volatilization of nitrogen into the atmosphere in the form of gaseous emissions such as N_2O,

NH_3 and N_2 (Özbek and Konak, 2017). The amount of nitrogen taken by plants varies according to production management practices in agricultural production and crop varieties, but it is only half of that applied to the soil (Karaşahin, 2014).

One of the most widely used nitrogen fertilizers in the world is urea. Urea has been the leading form of nitrogen fertilizer worldwide. Currently, 200 million tons of urea are produced worldwide to procurement the need. However, a quarter of the urea produced is lost to the environment due to poor efficiency (Beig et al., 2020). Developing countries consume a large part of the global urea production with a nitrogen utilization efficiency of 20% to 35% (Naz and Sulaiman, 2016). Urea is vulnerable to losses from evaporation and leaching when applied to products (Azeem et al., 2014). Sempeho et al. (2014) reported that the utilization efficiency of urea is below 50%. The release of nitrogen into the atmosphere or leaching is an economic loss. It also creates environmental pollution. The application of urea fertilizer has always been associated with excessive N losses, so it is very important to increase its efficiency in order to reduct the economic and environmental losses related with its application (Khan et al., 2015).

Slow-controlled release fertilizers have been developed to reduce nutrient losses from fertilizers (especially nitrogen fertilizers with high nutrient losses). Lunt (1971), in his article published in 1971, reported that research on the first commercially successful controlled-release fertilizer, which was produced synthetically, was done about 25 years ago. Research on slow-controlled release fertilizers is still ongoing today. Slow-controlled-release fertilizers, in general, aim to prevent the rapid loss of plant nutrient elements contained in the fertilizer by covering the surface of the fertilizer. Controlled-release fertilizers are generally coated or encapsulated with inorganic or organic substances (Liu et al., 2014). The coating material used provides controlled and slow release of fertilizer into the soil and thus it is ensured that the plant benefits from the nutrients contained in the fertilizer for a longer time. In addition, the loss of nutrients is prevented by slow release. Andelkovic et al., (2018) reported that slow-release fertilizers can be more effective than conventional nutrient sources and also decrease the adverse effects of nutrients on the environment. According to Liu et al. (2014), the use of controlled-release or slow-release fertilizers can decrease nutrient losses, protect the environment, and increase nutrient utilization efficiency.

Controlled-release fertilizers can change the release kinetics of fertilizer nutrients through a reduction strategy by providing the fertilizer content in a synchronized manner with the metabolic needs of plants (Irfan et all., 2018).

Slow and controlled release fertilizers can be produced for different plant nutrients. It is observed that the studies conducted on this subject are mostly in nitrogen fertilizers, where plant nutrient element losses are experienced. Among nitrogen fertilizers, a lot of research has been conducted on urea fertilizer, which has a large use area in the world. By slowing the release of nitrogen from urea fertilizer, both low yield and environmental pollution can be prevented. One of the methods for this is encapsulation. (Beig et al., 2020).

In this study, general properties of slow-controlled release fertilizers, coating materials and their properties, comparison of coating materials, use of slow-controlled release fertilizers in agriculture and their environmental effects were investigated. In this context, more information has been given on the controlled-release urea fertilizer, about which there is the most research. If we examine these issues;

1- General characteristics of slow-controlled release fertilizers:

The terms controlled-release fertilizer and slow-release fertilizer are often used interchangeably. Confirmed differences between slow and controlled release fertilizers are not clear. However, these two fertilizers are different from each other. Controlled release fertilizer is used for fertilizers that the factors that dominate the rate, pattern and speed of release are well known. While it is characterized that nutrients are released at a certain time in slow-release fertilizers, the release rate, pattern and speed are not well controlled (Sempeho et al., 2014). In this article, the terms slow and controlled-release fertilizers will be used interchangeably, and in general, they will all be referred to as slow-controlled-release fertilizers.

The main purposes of slow-controlled release fertilizers are: First of all, it is aimed to apply nitrogen fertilizers at one time, which should be applied several times for the needs of the plant. This method will reduce production costs. In addition, it is aimed that plants benefit from plant nutrients in fertilizer with slow release at a higher rate. Thus, the efficiency of the use of nutrient elements will increase and a higher rate of benefits of fertilizer will be provided. Nutrient losses (losses caused by leakage, evaporation, etc.) will be reduced with slow and controlled release, and less damage will be done to the environment. Pack et al. (2006) reported that NO_3-N and NH_4-N concentrations in lysimeter water samples were dramatically higher in ammonium nitrate applications than in controlled release fertilizers.

For this purpose, slow-controlled release fertilizers which prevent the rapid dissolution of the nutrients in the fertilizer were produced by covering the traditional fertilizers with natural or artificial material. According to Vejan et al. (2021) reported that controlled release fertilizers are produced by physically encapsulating or coating the fertilizer granules with hydrophobic inorganic and/or organic materials that act as a diffusion wall or barrier.

The European Standardization Committee (CEN) Task Force has made some proposals on the Controlled Release Fertilizer criteria for reducing the nutrient release rate. "It should be slower than conventional fertilizer, no more than 15% of nutrients should be released within 24 hours, no more than 75% of nutrients should be released within 28 days, and at least 75% of nutrients should be released within the specified release time." Some other desirable factors of a controlled-release fertilizer include cost-effectiveness, environmental friendliness, and sustainability (Lawrencia et al., 2021).

2- Used coating materials and their properties, comparison of coating materials:

One of the most important considerations in the production of slow-controlled release fertilizers is the coating material used. Because the coating material is the most important factor that directly affects the release properties. Many different coating materials have been used from the past to the present. In the early developmental stages of the production of controlled release fertilizers, bioinhibitors were used to help control the release rate for up to several months. In addition, sulfur coating, which is more effective in controlled release, has been developed. The innovation of the polymer coated control release helps to rightly foresee the average release rate and duration under a given humidity and temperature condition. Biocomposite materials are also used for the production of controlled release fertilizers (Soman and Balachadran, 2021). Nooeaid et all. (2021) developed controlled release fertilizers by encapsulating NPK (nitrogen-phosphorus-potassium) nutrients with core/shell fibers in their study. As a result, they reported that NPK loaded polyvinyl alcohol (core)/polylactic acid (shell) fibers can act as controlled release fertilizers by showing the controlled release of fertilizers appropriate for sustainable agriculture. Guan et al. (2014) used attapulgite coated slow release fertilizer for corn cultivation in China and achieved positive results. Abbas et al. (2022) reported that the use of lignin-based controlled-release fertilizers has the potential to greatly increase resource efficiency and environmental protection. Recently, agricultural fertilizer industries and scientists have focused on using bioderived materials such as plant starch, lignin, rice straw, vegetable oil, and other organic polymers to add value to the production of controlled-release fertilizers (Vejan et al., 2021). Ranjith and Sridevi (2021) reported that various materials such as clays, nanoclays, degradable and non-degradable polymers and agricultural wastes are suitable for the development of smart fertilizers (for example, slow-controlled release fertilizers).

Wang et al. (2022), a completely biomass-based controlled release fertilizer was prepared from urea-dispersed starch hydrogel which was coated by natural latex. In the study, starch was premodified with carboxylate groups through a borax-mediated hydrothermal process and blended with calcium nitrate and bentonite. Thus, this study has been reported to open a new avenue towards highly efficient biomass-based composite controlled-release fertilizers. Sim et al. (2021) reported that studies on encapsulated biochar-based sustained-release fertilizers are yet very limited in the literature.

Shaviv (2001) reported that polymer coating based fertilizers were chosen as controlled release fertilizers that offer the best control over the release and they also have the highest growth rate among slow/controlled release fertilizers.

Faqir et al., (2022) emphasized that controlled-release fertilizers can be formulated using ginger oil.

As can be seen, many different coating materials have been used by researchers working on slow-controlled release fertilizers, and it has been emphasized that some studies on this subject are still insufficient. The most important issue in the use of coating material is that the coating material does not pollute the soil. For this reason, covering materials that do not decompose in the soil and contain harmful residues should not be selected. Coatings derived from fossil fuel-derived petro-based chemicals (e.g. acrylics, vinyls, PU, epoxies, polyesters and others) are often costly, toxic, dangerous after use (non-biodegradable), and may require large amounts of hazardous solvents during processing and coating applications. Therefore, it may cause environmental contamination and health hazards upon exposure (Sharmin et al., 2015).

The controlled release coated urea fertilizer based on polymer/superabsorbent materials offers encouraging potential for long term water retention and controlled release. However, the complexity of processing, high costs and environmentally unfriendly adverse impacts of some materials prevent production on an industrial scale (Azeem et al., 2014).

According to the European Parliament's regulations on fertilizer products, by July 2024, all materials used in the coating of fertilizers must be biodegradable (Boberski et al., 2022).

Tian et al. (2022) reported that nutrient release can be regulated and the use of coating material can be reduced by surface modification (polishing technology) to be applied to the fertilizer to be coated in controlled release fertilizer production.

3- The use of slow-controlled release fertilizers in agriculture:

Due to its positive environmental effects, it is recommended to use slow-controlled release fertilizers especially natural and organic coatings used in agriculture. However, slow-release fertilizers are quite expensive compared to conventional fertilizers (Fu et al., 2018). The expense of slow-release fertilizers can make it difficult for producers to choose these fertilizers. However, we know that these fertilizers reduce labor costs by providing long-term nutrient release. Slow-controlled release fertilizers reduce production costs due to the fact that they eliminate the need to apply fertilization several times, which is applied in conventional fertilizers. Vishwakarma et al., (2018) reported that the use of conventional fertilizers is costly due to low nutrient utilization efficiency (Sim et al., 2021). Taking this into account, the cost analysis of these two methods should be carried out by the researchers.

Slow-controlled release fertilizers have been used in some plants. There is literature reporting that these fertilizers have positive effects on yield. Sikora et al. (2020) reported that from the use of slow-release fertilizers, a bigger yield of marketable cabbage is obtained than with conventional fertilizers. Yang et al. (2011) determined that the controlled-release urea applied to the wheat plant increased the nitrogen utilization efficiency by 28% compared to urea fertilizer. In addition, it was reported that 6.5% more wheat was obtained from the controlled release urea application at a dose of 150 kg N ha^{-1} compared to the conventional urea application (225 kg N ha^{-1}). Khan et al. (2015) determined in their study on rice that controlled release urea fertilizer increased N uptake, dry matter yield, and grain quality compared to granular urea and control application. Zhao et al. (2009) reported that colophon coated fertilizer and sulfur coated fertilizer increased the grain yield by 13.15% and 14.15%, respectively, compared to common compound fertilizer in their study in which they applied the same rate of N, P and K in the corn plant. Controlled release fertilizer technology has been tested on a large number of crop plants and good quality yields have been obtained compared to conventional fertilizers (Rajan et al., 2021). In addition, Wang et al. (2015) determined that a single basal polymer-coated urea application reduces N loss and improves N utilization efficiency in the rice agroecosystem.

Scientific studies on slow-controlled fertilizers have increased rapidly in the last 20 years. It was observed that 263 publications were made in 2000 and 3034 publications were made in 2020 (Rahman et al., 2021). However, there are still studies to be done about these fertilizers. According to Rahman et al. (2021), currently available slow and controlled release fertilizers are not always size specific, so they cannot be fully absorbed by parts of the plant (leaves or root). In addition, there is no specific nutrient release pattern from these slow and controlled release fertilizers. Therefore, a gap is created between the nutrients taken up by the plants and the release time of nutrients from slow-controlled release fertilizers. There are still no standardized methods to reliably determine the nutrient release rate from controlled-release fertilizers (Lawrencia et al., 2021). In this regard, nanotechnology has been playing a great role in recent years. It is believed that the application of nanotechnology in controlled release has greatly contributed to the development of sustainable agriculture through various methods that synthesize the slow or controlled release of fertilizers (Vejan et al., 2021).

To summarize, the positive effects of slow-controlled release fertilizers, which stand out as being environmentally friendly, on the yield of different plants have been determined. However, some problems may be encountered, such as the fact that these fertilizers are not size specific and there is a gap between the uptake of nutrients by the plant-the release of nutrients from the fertilizer. In this context, nanotechnology applications can be used. In addition, it will be useful to conduct a cost analysis of the economic income and expense to be obtained by the use of these fertilizers will be beneficial in terms of convincing the producers.

4- Environmental effects of slow-controlled release fertilizers:

Plants use 50% of nitrogen fertilizers applied to the soil, 15-25% reacts with organic compounds of clay soil, 2-20% is lost by evaporation, and the remaining 2-10% seeps into groundwater and surface (Savci, 2012). Nitrogen release is fast in conventional fertilizers. Conventional fertilizers used in large-scale cultivation have low nutrient utilization efficiency in most cases. For example, the nutrient utilization efficiency of the three essential micronutrients of crop plants is 30-35% in nitrogen, 18-20% in phosphorus and 35-40% in potassium. These efficiency values are very low (Rahman et al., 2021). Nutrients that cannot be used by the plant are economically lost. In addition, especially a part of nitrogen that is not used by the plant may leak into the soil and mix with groundwater, polluting groundwater and causing environmental problems. Low use efficiency of fertilizers has become a global problem (Tian et al., 2022). As can be seen, only half of the nitrogen used can be taken up by the plant. Nitrogen not taken up by the plant can cause environmental pollution.

A single application of slow-controlled release fertilizers also reduces agricultural emissions. The results of the research made by Sikora et al. (2020) indicate a important potential for the use of slow-release fertilizers in decrease agricultural emissions. When we consider the impact of the use of fossil fuels on global warming, it is understood how important it is to reduce agricultural emissions.

Fu et. al (2018) compared conventional fertilizers with slow-release fertilizers as shown in Table 1.

Table 1. Comparison of conventional fertilizers and slow controlled release fertilizers

Fertilizer Field	Conventional Fertilizers	Slow controlled release fertilizers
Price	Cheaper	More expensive
Technology	Easier	More complicated
Use situation	Popular	Encouraged
Labor force	Bigger	Smaller
Nutrition supply	Worse	Better
Environmental effect	Pollution	Green

As can be seen from Table 1, the environmental impact of slow-controlled release fertilizers compared to conventional fertilizers is quite positive.

One of the environmental problems that can be observed in the use of slow-controlled release fertilizers is the material used to cover these fertilizers. In the production of some slow-controlled release fertilizers, coatings that are insoluble in the soil and pollute the soil are used as coating materials. Commercial controlled release fertilizers using polymer coatings are usually made of a thermoplastic resin such as polyvinylidene chloride, polyolefin, and copolymers that do not readily degrade in soil and can accumulate over time. The major persistent challenge for controlled-slow release fertilizers is the tailing effect, which decreaces the economic benefits in terms of maximum fertilizer use. (Lawrencia et al., 2021). For this reason, materials that do not pollute the soil should be preferred as coating material. Rahman et al. (2021) suggested the development of an innovative nano-fertilizer, which can be called controlled release nano-fertilizers, which will regulate the nutrient release according to the plant's needs with time, increase the efficiency of nitrogen use and decrease environmental pollution. Rakhimol et al. (2021) reported that scientists have adopted many techniques to minimize fertilizer loss, one of which is nanotechnology for the controlled release of fertilizers and pesticides in agricultural fields. However, he noted that nanotoxicity is a major concern in the improvement of nano-based fertilizers. Rudmin et al. (2022), aimed to design controlled release nanocomposites (based on the mechanical activation of a 1:1 ratio of glauconite and nitrogen nutrient mixture) in his study. He reported that nanocomposites are classified as multifunctional controlled release fertilizers that retain 50% of the urea.

Nanotechnological methods can be used to complete the deficiencies of existing slow-controlled release fertilizers, taking into account the issue of nanotoxicity.

CONCLUSION

One of the most significant costs of agriculture is the use of chemical fertilizers. In conventional agricultural practice, chemical fertilizers are used to provide plant nutrients that are not enough in the soil. According to N, P and K based fertilizer data, approximately 199 million tons of total NPK were produced in the world in 2015. According to these production quantity figures, it was seen that there was an increase of 19% in 2015 compared to 2005. When NPK production in the world is examined in 2015, it is seen that nitrogen is produced the most with a ratio of 57% (Anonymous, 2018).

The nutrient utilization efficiency of chemical fertilizers, which are widely used in the world, is low. For example, in nitrogen fertilizers, there is a serious loss of nitrogen through evaporation and leaching. This situation causes both financial losses and environmental pollution. Researchers have been working on slow-controlled release fertilizers since the 1940s to prevent these losses. These studies are mostly concentrated on nitrogen fertilizers that nutrient losses are high. The current fertilizers used were covered with different materials and the release of nutrient elements was trying to be controlled. In this context, the European Standardization Committee (CEN) Task Force, on the controlled-release fertilizer criteria for reducing the nutrient release rate, said, "It should be slower than conventional fertilizer, no more than 15% of nutrients should be released within 24 hours, no more than 75% of nutrients should be released within 28 days, and at least 75% of nutrients should be released within the specified release time" has suggested (Lawrencia et al., 2021). For this purpose, many different natural and artificial materials have been used as coating materials. Different results were obtained on the release from these coating materials used. It has been determined that some synthetic coating materials are used to pollute the environment and soil, and it has been stated that it is not suitable for use in terms of the environment. Since one of the most significant purposes of slow-controlled release fertilizers is to prevent nutrient losses and environmental pollution, coating materials that pollute the environment completely contradict this purpose. In this regard, the European Parliament has made a regulation that all materials used in the coating of fertilizers must be biodegradable until July 2024. Therefore, from an environmental point of view, natural, environmentally friendly coating materials should be used and scientific studies should proceed in this direction.

In addition to obtaining slow-controlled release fertilizers, several studies have been conducted on the effect of these fertilizers on yield and nutrient utilization efficiency in different plants.

Slow-controlled release fertilizers have come to the fore with their positive environmental effects. Controlled-release fertilizers have proven to be more advantageous than conventional fertilizers (Vejan et al., 2021). However, the most important problem that may be experienced in the widespread use of slow-controlled release fertilizers in the future is that they are expensive. The high material cost is a important impediment to the widespread use of controlled-release fertilizers in agriculture, and its price is still much higher compared to chemical fertilizers (Lawrencia et al., 2021). The production technique of these fertilizers also has some difficulties. The high efficiency and simplified preparation process of coated manure are still seen as a major challenge (Sun et al., 2020).

Sempeho et al. (2014) stated that researchers should design nano-controlled-release fertilizers using natural excipients to create effective, reliable, efficient and cost-effective controlled-release fertilizer formulations based on prevailing resource limitations. Another point to be emphasized is the use of nanotechnology in the production of slow-controlled release fertilizers. Nanotoxicity is a major concern if nanotechnological methods are used (Rakhimol et al., 2021). To obtain the desired controlled release and to develop the release model suitable for the plant, nanotoxicity should be considered in the case of using nanotechnological methods.

As a result; It is important to use slow-controlled release fertilizers in terms of preventing environmental pollution and increasing the efficiency of the use of nutrients in fertilizers. However, in order to achieve the desired environmental goal, synthetic coatings that pollute the soil and do not degrade should not be used in the production of these fertilizers. It is important to conduct research to decreace the production cost of slow-controlled release fertilizers for their widespread use in the future. In addition, nanotechnological methods should be used to improve the deficiencies of existing slow-controlled release fertilizers, but attention should be paid to nanotoxicity.

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CHAPTER 3

THE EFFECT OF SOIL ORGANIC CARBON FRACTIONS ON SOIL PROPERTIES AND CROP YIELD

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INTRODUCTION

Soil and its health are a significant part of the natural ecosystem of this world and played a robust role in all organisms' life (M. A. Ashraf & Hanafiah, 2019; Brevik et al., 2020; Krzywoszynska, 2019; G. Li, Sun, Ren, Luo, & Zhu, 2018). The soil organic matter (SOM) and soil organic carbon (SOC) concepts affect all soil physical, chemical, and biological properties and soil quality (Coleman & Elliot, 1988; Tiessen, Cuevas, & Chacon, 1994). SOC shows 25% of the ability of natural climate solutions (Bossio et al., 2020). Therefore, the studies which mentioned the exchanges between SOC restoration and crop yield (Oldfield, Bradford, & Wood, 2019) is important in land management (Beillouin et al., 2022). For this reason, the identification of the components that affect and improve SOC and thereby, all soil properties and crop yield are necessary for soil management in sustainable agriculture. The most sensitive part of soil labile OC is permanganate oxidizable carbon (POXC or AC) which is rapidly variable against management practices in the soil (Tatzber et al., 2015; Weil, Islam, Stine, Gruver, & Samson-Liebig, 2003). Bongiorno et al. (2019); Fine, van Es, and Schindelbeck (2017) introduced AC as the main indicator of soil quality (SQ) by using a Comprehensive Assessment of Soil Health scores. Furthermore, according to Haynes (2005), the changes in total SOC are hard due to SOC stability. As a result, Awale, Emeson, and Machado (2017); Q. Wang, Wang, Wang, and Liu (2014) have attempted to explain that the labile carbon portion of total SOC with its rapidly changing could be more effective to determine SQ. Labile carbon fractions of the soil, have mostly the responsibility for changes in the soil properties through soil management functions (Ćirić et al., 2016). There is a considerable amount of literature on SOC fractions (Matias E Duval et al., 2013; Q. Liang et al., 2012). As mentioned above, Bongiorno et al. (2019) and Q. Wang et al. (2014) demonstrated that AC (labile carbon fraction), which is sensitive to soil management was strongly correlated with soil chemical, physical and biological properties. Overall, they came to the conclusion that AC can be utilized as a complete indicator of soil properties and soil health.

Although, plenty of studies in the field of soil have focused on SOC effect on soil fertility (Awale et al., 2017; S. W. Culman et al., 2012; Geraei, Hojati, Landi, & Cano, 2016), but too little attention has been paid to SOC fractions impact on all soil properties and therefore crop yield in-detail. This paper will review the research conducted on SOC, and labile fractions to prove our hypothesis that labile fractions of OC as the critical indicator of soil health by improving soil properties and therefore increasing crop yield. This chapter will explain the significance of SOC, and SOC fractions and their key role in improving all soil properties, and plant production based on several previous and recent studies. In this chapter, we first identified the SOC and its fractions and SOM amendments and then indicated their relations with soil biological, physical, and chemical properties and therefore, crop yield in detail.

1. SOIL ORGANIC CARBON (SOC):

The SOC content is the main representative of the soil's physical, chemical, and biological properties (Matias E Duval et al., 2013; Matias E Duval, Galantini, Martínez, & Limbozzi, 2018) (Table 1).

As mentioned above, SOC storage as the main part of SOM is highly dependent on climatic conditions like temperature (Conant et al., 2011). Koven, Hugelius, Lawrence, and Wieder (2017); H. Li et al. (2021); Tan, Han, Li, and Wang (2020) emphasized the significant negative effect of increasing temperatures on SOC stocks. In terms of climate impact on SOC storage, Pekkan et al. (2021) also reported a total reduction of 18,330.57 tons of SOC on the wind farms in the Karaburun Peninsula from years 2000 to 2019.

C. Wang et al. (2021) also indicated a strong relationship between climate, MB, and SOC content on a large scale. This result is consistent with Y. Li, Li, Cui, Liang, and Zhang (2021); Somayyeh Razzaghi, Islam, and Ahmed (2022), who mentioned a significant and positive correlation of SOC and NT content with MBC and particulate organic C(POC). Surveys such as those conducted by Jonathan M Gray, Bishop, and Wilson (2015); Viscarra Rossel, Webster, Bui, and Baldock (2014) have shown that the highest content of SOC is commonly determined under cool, humid climates and decreases under drier and warmer conditions.

Furthermore, although water availability or precipitation could be the other limiting factor of net primary productivity (NPP) and thus the SOC input and storage in arid or semi-arid environments (E. U. Hobley, Baldock, & Wilson, 2016), SOC contents of topsoil are more sensitive to precipitation changes (H. Li et al., 2021). Moreover, Fanin et al. (2021) mentioned the importance of soil depth and water availability on SOC storage in temperate forests. They discovered that 15 to 30 cm deep, there is a positive relationship between the stock of SOC and the mixing of tree species and irrigation. Soil moisture can also control microbial activity and SOC input and output (Mayes et al., 2014; Vasques, Grunwald, Comerford, & Sickman, 2010). The elevation and topography are probably the other important factors, which have a great impact on the SOC storage at the regional scale (Che et al., 2021; Wiesmeier et al., 2019). Microbial residues associated with SOC decreased at higher altitudes (L. Yang et al., 2020). Guo et al. (2021) also highlighted difficulties in SOC mapping of low relief areas and suggested using of the time series characteristics of multispectral images in the mapping of SOC in flat areas. Furthermore, Oxygen and soil aeration are limiting factors of SOC mineralization. According to Yuhong Li et al. (2021) under oxygen-limited conditions in paddy soils, soil Fe^{2+} content as an electron acceptor play important role in SOC mineralization rate. It has been demonstrated that humid conditions also cause increased weathering of the parent material and this event lead to soil acidification, which reduced the decomposition of SOM and helps the formation of mineral surfaces that cause SOC stabilizing (Chaplot, Bouahom, & Valentin, 2010; Doetterl et al., 2015; Meier & Leuschner, 2010; Wiesmeier et al., 2019). There is a large volume of published studies describing the role of parent material in controlling the soil texture (Si concentrations), mineralogy, and fertility which influence NPP and SOC stabilization and storage (Badgery et al., 2014; Barre et al., 2017; Jonathan M Gray et al., 2015; Herold, Schöning, Michalzik, Trumbore, & Schrumpf, 2014; Pichler et al., 2021; Wiesmeier et al., 2014; Xiong et al., 2014). Additionally, Mao, Qiu, Zhang, Shen, and Zhang (2020) showed that carbon accumulation in limestone and basalts treated with organic inputs leads to the formation of large and more stable aggregates which can help to improve the physical protection of SOC. Compared with acidic igneous rock soils, limestone soils have significantly higher SOC, which may be due to the stability of OM related to Ca^{2+} bridges and the stability related to Fe and Al (oxides) in this type of soil (S. Yang et al., 2020).

Soil biota (Lavelle et al., 1997; C. Liang, Schimel, & Jastrow, 2017; Tang et al., 2021; Xu et al., 2021), Soil physical properties (Feng, Plante, & Six, 2013; Hengl et al., 2017; Ito & Wagai, 2017; McNally et al., 2017; Somayyeh Razzaghi, Vignozzi, & Kapur, 2017; Johan Six, Conant, Paul, & Paustian, 2002; Toosi, Kravchenko, Mao, Quigley, & Rivers, 2017; Totsche et al., 2018) and soil chemical properties (Beare et al., 2014; Curtin, Beare, & Qiu, 2015; Kaiser et al., 2012; O'Brien, Jastrow, Grimley, & Gonzalez-Meler, 2015; Schneider et al., 2010) are considered as be core important factors for SOC stabilization. In addition, the incorporation of roots and shoots of green manure can increase SOC stabilization (Almagro, Ruiz-Navarro, Díaz-Pereira, Albaladejo, & Martínez-Mena, 2021). Long-term manure input can enhance the Ca-OC storage in Fluvic Cambisol which can be vital in the SOC stabilization in arable soils (Wan et al., 2021). Consequently, Guidi et al. (2021) by optical microscopy and SEM-EDS technique provide a new view of SOM stabilization. They reported that in order to lower porosity and smaller pore size and highest values Al: C, Fe: C, and Ca: C ratios, SOM stabilization was observed in the fine macroaggregates (0.25–1mm). Similarly, by measuring soil porosity and according to SEM images and soil physicochemical property analysis the high and stable SOC content was determined under a canopy of natural Red pine in the 0.25 to 0.05 mm aggregates (Somayyeh Razzaghi et al., 2021; Somayyeh Razzaghi et al., 2017).

Land use and soil management are observed to be the most dynamic factor which influences SOC stock changes (Demir & Mirici, 2020; Martin et al., 2011; Viscarra Rossel et al., 2014). Numerous studies have attempted to explain the vegetation cover types like shrubland, grassland (Jobbágy & Jackson, 2000; Lange et al., 2015; S.-l. Liu et al., 2016; Poeplau, 2021; S Razzaghi, Oskouei, & KR, 2016; Soussana et al., 2004) and forest (Frank, Pontes, & McFarlane, 2012; Somayyeh Razzaghi et al., 2022; Somayyeh Razzaghi et al., 2017), which significantly affects SOC storage due to differences in plant litter chemistry, higher root biomass production.

Previous evidence has been reported that when forests or grasslands were converted to agricultural land, the SOC content 30-80% decreased (Poeplau et al., 2011; Wei, Shao, Gale, & Li, 2014). The reduction of SOC content in the conversion of forest to agricultural land was also reported by G. Han et al. (2020). Moreover, SOC stock in forests is five times more than the vacant regions (Zaher, Sabir, Benjelloun, & Paul-Igor, 2020). In contrast to the above finding conversion of natural grassland to cropland, enhanced C and the SQ (Acir & Gunal, 2020).

According to Hamza and Anderson (2005), the reason for lower stable SOM and SOC losses in croplands could be contributed to decomposed aggregates during tillage and increased soil aeration which promotes mineralization and therefore erosion. In the same vein, Sanderman et al. (2021) reported significantly higher SOC content in the grassland when compared to cultivated soils. Meersmans, De Ridder, Canters, De Baets, and Van Molle (2008) noted that the SOC storage in grassland was higher than in forest and cropland. Despite the fact that Lettens, Van

Orshoven, van Wesemael, De Vos, and Muys (2005) found that SOC storage in forestland can be higher than in grassland. As a consequence, Canedoli et al. (2020) indicated that grassland and broad-leaved mixed forests have a higher content of SOC compared to the conifers, spruce, and larch forests.

According to Leifeld et al. (2015) approximately, 68% of the total global agricultural land is covered by grasslands. The soil management of grasslands such as decreased grazing intense, proper fertilization, irrigation, and attention to climate change leads to increasing SOC in grasslands (Conant, Cerri, Osborne, & Paustian, 2017; McSherry & Ritchie, 2013; Poeplau, 2021; Wiesmeier et al., 2019). Consequently, Crème et al. (2020) reported that the continuous grassland can enhance the SOC content at 0-30 depth. In contrast, grassland degradation causes a reduction in the fine intra-aggregate particulate organic C and an increase in CO2 emissions from the soil (Dong et al., 2020).

In order to forest soil management, the age of trees, environmental factors like storms, fertilization as well as the plant type and residues should be considered which can directly affect the SOC stock (Carroll, Milakovsky, Finkral, Evans, & Ashton, 2012; López-Vicente, Calvo-Seas, Álvarez, & Cerdà, 2020; Lorenz & Lal, 2014). Furthermore, the SOC model also is a better measurement tool of SOC content and forest soil management functions (Gholizadeh et al., 2021). Additionally, forest moderates thinning as one of the forest management practices significantly enhanced SOC storage by 7.2% in planted forests of china (Gong, Tan, Liu, & Xu, 2021). It is widely known that soil management can be the best strategy to modify a system to increase SOC stock (Wiesmeier et al., 2019). Notwithstanding management practices, according to Baldassini and Paruelo (2020) changes in land use like deforestation have negative impacts on SOC storage.

The soil management in cropland like increasing crop rotational diversity (Jarecki & Lal, 2003; Tiemann, Grandy, Atkinson, Marin-Spiotta, & McDaniel, 2015), using perennial/forage crops and cover crops (Bolinder et al., 2020; Poeplau & Don, 2015; Somayyeh Razzaghi, 2021) could play the main role in increasing SOC stock. Recent cases reported by Bell, Terrer, Barriocanal, Jackson, and Rosell-Melé (2021) also indicated a SOC accumulation rate of +2.3% yr^{-1} in the agricultural land post-abandonment as one of the cropland management practices in peninsular Spain.

SOC sequestration is an important factor due to its impress in soil fertility and mitigating climate change in recent years (Bell, Barriocanal, Terrer, & Rosell-Melé, 2020; Lal, 2004; Lehmann & Kleber, 2015; C. Liang, Amelung, Lehmann, & Kästner, 2019). Lehmann et al. (2020) suggested that soil management should be based on continuous care, not one-time management to lock C in the soil. As well, SOC management and sustainable agriculture can have a strong influence on reducing atmospheric

CO_2 and the rate of SOC sequestration and increasing the soil carbon pool (Lal 2004). As suggested by Gross and Glaser (2021) the SOC stocks will increase when the applied manure was mixed with mineral fertilizer. It has been determined the soil C sequestration rate of 0.4% yr^{-1} with conservation agriculture in Almalybak (Kazakhstan) and Jokioinenin (Finland) (Valkama et al., 2020). Even so, regional climate conditions are an important factor to assess the benefits of conservation agriculture in soil C sequestration. Conservation agriculture in arid regions leads to higher C sequestration and crop yields compared to humid and colder regions (W. Sun et al., 2020). In spite of this, abandoned farmland has the potential for high C sequestration and therefore, mitigating climate change (Bell et al., 2020). By drawing on the concept of C sequestration, Tong et al. (2020) reported that during 2002-2017, various land use changes in southern China enhanced surface SOC storage by 0.11 ± 0.05 Pg C y -1 by satellite observations. They also indicated that newly established forests, existing forests, and forest growth in harvested forest and non-forest areas contribute 32%, 24%, 16%, and 28% to this carbon sink, respectively. Karlen and Cambardella (2020) assert that croplands can be both a sink and a source of in the atmosphere. They also claimed that Mollisols covered with grass and the C pool in tropical forests have the highest potential for C sequestration.

As mentioned above, since SOC can return back to the atmosphere due to heterotrophic mineralization of photosynthesis product of plants can have the main role in global carbon cycling in the Earth ecosystem and small changes in global soil carbon storage will have considerable effects on the CO2 concentration in the atmosphere (Chabbi et al., 2017; Davidson & Janssens, 2006). In addition to the above findings on vegetation cover effect on C sequestration, due to complex actions of roots in both SOC stabilization (Henneron, Cros, Picon-Cochard, Rahimian, & Fontaine, 2020; Jackson et al., 2017; Novák, Jankowski, Sosnowski, Malinowska, & Wiśniewska-Kadżajan, 2020; Poirier, Roumet, & Munson, 2018) and destabilization (W. Cheng et al., 2014; Finzi et al., 2015; Hartley et al., 2012) (Fig. 1), Dijkstra, Zhu, and Cheng (2021) by their Rhizo-Engine framework provide a better understanding of how the root functions may help the reactions for soil C sequestration.

The bulk SOC is not sensitive to the short-term variation in C dynamics. The labile portion of the SOC by short turnovers, which source from the decomposition of MB and the plant and faunal biomass, is considered the most sensitive indicator of early SOC changes that is useful for SOC management (Bayer, Mielniczuk, Martin-Neto, & Ernani, 2002; Bu et al., 2020; X. Jin et al., 2020; Somayyeh Razzaghi et al., 2022; Zhao et al., 2016). Cotrufo, Wallenstein, Boot, Denef, and Paul (2013) demonstrated that Labile C is so essential for SOM stability. Decomposed plants and microorganisms mixed with root exudates lead to the formation of labile C in soil (Bolan et al., 2011). Due to shrub encroachment in the eastern Tibetan Plateau grasslands of soil labile C pools increased (W. Liu et al., 2021). The SOC fraction determination is the core factor to represent SOC dynamics in biogeochemical models (Rossel et al., 2019; Sanderman et al., 2021).

According to Bongiorno et al. (2019), the labile carbon fractions include the dissolved organic carbon (DOC) (Bolan et al., 2011; Leinemann et al., 2018) which originated from root and microbial exudates, hot water extractable carbon (HWEC) (Ghani, Dexter, & Perrott, 2003; Yousefi, Hajabbasi, & Shariatmadari, 2008), Permanganate oxidizable carbon (POXC or AC)(Song Chen et al., 2016), particulate organic carbon (POC) (Benbi, Brar, Toor, & Singh, 2015; Haynes, 2005; Salas, Elliott, Westfall, Cole, & Six, 2003; Sequeira & Alley, 2011; Skjemstad, Swift, & McGowan, 2006) which is composed of semi-decomposed organic residues and microbial biomass carbon (MBC) (Vance, Brookes, & Jenkinson, 1987) which determine by microbial respiration incubation conditions. A recent study by H. Wang, Wu, Li, and Yan (2020) reported that the content of SOC and POC significantly affect the activities of urease and sucrose enzymes, and MBC affects the activity of catalase under different vegetation types. Furthermore, to explain the importance of soil

C fractions in SOC sequestration, Shah et al. (2021) reported that, after 23 years of fertilization applications, the highest C content (60.9% and 61.5%) was observed in the unprotected cPOC fraction in the topsoils (0–20 and 20–40 cm) of Eumorthic Anthrosols in Northwest China.

According to Ghani et al. (2003) soluble carbohydrates and microorganisms contain, HWC portion, which is the indicator of the active part of the global C cycle. It has been suggested that both POC and mineral-associated organic carbon (MAOC) are basically different SOC pools (Lavallee, Soong, & Cotrufo, 2020). By increasing the AC content, straw return leads to higher SOC content, than inorganic potassium (Yuan et al., 2021). S. W. Culman et al. (2012) also define AC measurement as the rapid and precise method to assess SOC content. Due to the major role of AC in soil management and increasing SOM, Hurisso et al. (2016) emphasized that AC could be the best indicator of C sequestration in the soil. Therefore, analyzing AC rather than total C is better to understand how management changes affect nutrient concentration and the possible accumulation or loss of SOC (Wander, 2004).

In light of all these studies, the AC or easily metabolizable C (Haynes, 2005) occupies a small part of the soil (5%-20%) which is composed of the compounds such as lignin and complex polysaccharide (Haynes & Beare, 1997) is one of the portion of labile C and the source of food, energy for soil microbial activities, nutrient availability, structure stability, soil aggregation has a significant role to increase soil quality (Bongiorno et al., 2019; Cotrufo et al., 2015; K. Islam, 2006; K. R. Islam & Weil, 2000; R. Islam & Sundermeier, 2008; Kallenbach, Frey, & Grandy, 2016; Schmidt et al., 2011; S. Singh et al., 2020). Overall, SOC fractions affect directly all physicochemical properties of the soil (Blair, Lefroy, & Lisle, 1995).

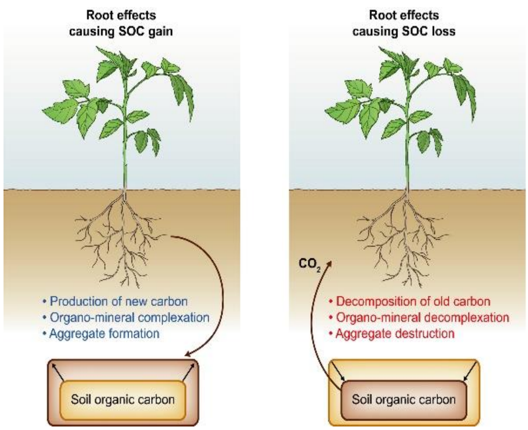

Figure 1. The Root– (SOC) Paradox. Roots Can Cause SOC Stabilization (Resulting in SOC Gain) and de-Stabilization (Resulting in SOC Loss) (source=(Dijkstra et al., 2021).

Table 1. Summary of The Literature About the Effect of Different Types of Soil Properties on SOC Content

Cover crop type	**SOC**	**References**
Climate (Soil Moisture)	SOC↑	(Doetterl et al., 2015; Meier & Leuschner, 2010)
Climate (Temperature)	SOC↓	(Davidson & Janssens, 2006; E. U. Hobley et al., 2016; Koven et al., 2017; Yuhong Li et al., 2021; Smith et al., 2005; Tan et al., 2020)
Climate (Cool Humid Conditions)	SOC ↑	(Baritz, Seufert, Montanarella, & Van Ranst, 2010; Jonathan M Gray et al., 2015)
Soil depth	SOC↓	(Badgery et al., 2014; Jonathan M Gray et al., 2015; Johnson, Xing, & Scatena, 2015; Shah et al., 2021)
Topographical Features	SOC LE	(Viscarra Rossel et al., 2014; Xiong et al., 2014)
Parent Material	SOC LE	(Jonathon M Gray, Humphreys, & Deckers, 2009; Herold et al., 2014; Wiesmeier et al., 2014)
Parent Material	SOC ME	(Badgery et al., 2014; Barre et al., 2017; E. Hobley, Wilson, Wilkie, Gray, & Koen, 2015; Mayes et al., 2014; Vasques et al., 2010)

Vegetation (Grassland)	SOC ↑	(W. F. Cong et al., 2014; Lange et al., 2015; Poeplau, 2021)
Vegetation (Forestland)	SOC ↑	(Leifeld, Bassin, & Fuhrer, 2005; Oostra, Majdi, & Olsson, 2006; Schulp, Nabuurs, Verburg, & de Waal, 2008)
Vegetation (Forestland)	SOC NE	(Vesterdal, Schmidt, Callesen, Nilsson, & Gundersen, 2008)
Vegetation (Cropland)	SOC↓	(Balesdent, Chenu, & Balabane, 2000; Martin et al., 2011; Wei et al., 2014)
Vegetation (Cropland)	SOC ↑	(Post & Kwon, 2000; Schulp & Veldkamp, 2008)
Soil Management (Crop Rotations)	SOC ↑	(Jarecki & Lal, 2003; Kätterer, Bolinder, Andrén, Kirchmann, & Menichetti, 2011; Tiemann et al., 2015)
Soil Management (Cover Crop)	SOC ↑	(Karlen & Cambardella, 2020; Lal, 2016; Paustian et al., 1997; Poeplau & Don, 2015; Somayyeh Razzaghi, 2021)
Soil Management (No-Tillage Systems)	SOC NE	(Z. Luo, Wang, & Sun, 2010; Powlson et al., 2014)
Soil Management (No-Tillage Systems)	SOC ↑	(Valkama et al., 2020)

Soil Biota (Microorganisms)	SOC↑	(K. Islam, Weil, Mulchi, & Glenn, 1997; C. Liang & Balser, 2011)
Soil Fauna	SOC↑	(Fujimaki, Sato, Okai, & Kaneko, 2010; Lubbers et al., 2013; Maaß, Caruso, & Rillig, 2015)
Physical Properties (Clay Content↑)	SOC↑	(Arrouays, Saby, Walter, Lemercier, & Schvartz, 2006; Feng et al., 2013; Hengl et al., 2017; Ito & Wagai, 2017; Zinn, Lal, Bigham, & Resck, 2007)
Chemical Properties (Exchangeable Cations Fe^{3+}, Al^{2+}, Ca^{2+} And Mg^{2+})	SOC↑	(Baldock & Nelson, 2000; Duckworth, Bargar, & Sposito, 2008; Kaiser et al., 2012; Kleber, Mikutta, Torn, & Jahn, 2005; McNally et al., 2017; O'Brien et al., 2015; Wiesmeier et al., 2019)

2. SOIL BIOLOGICAL PROPERTIES

2.1. Soil Biological Properties and SOC Fractions

As mentioned above, according to Chantigny (2003); Haynes (2005) labile carbon as the easily available and energy source of soil microorganisms, could be the main and comprehensive indicator of SQ by promoting the biological activity in the soil (Bongiorno et al., 2019). In this case, Y. Zhang et al. (2020)

mentioned that litter entry in the forest soils has a strong positive impact on soil respiration, labile C amount, and thereby, the soil biota community abundance. This finding is supported by X. Zhang, Chen, Liu, Xu, and Wei (2020) who come to the conclusion that the lower content of SOC fractions in urban forests compared to those in suburban forests is due to changes in soil microbial community structure, which occur during urbanization.

Melero et al. (2011) in their study pointed out the reduced tillage effect on increasing microbial activity and production of enzymes which have a great impact on increasing the content of labile carbon fractions and SQ. The climate condition is also a key factor in soil labile C content and microbial community. This is inconsistent with Q. Chen, Niu, Hu, Luo, and Zhang (2020) who reported a remarkable increase in soil microbial activity under warming conditions which has a reliable effect on the degradation of labile-fraction of SOM only under increased precipitation.

Bastida, Zsolnay, Hernández, and García (2008) also highlighted the direct impact of OM input instead of chemical input by adding an external microbial community and increasing labile carbon content in the soil. But the type of OM input is an important factor in microbial distribution. This is confirmed by the recent literature, which demonstrated that MBC and DOC are more sensitive to different forms of straw that return to the field.

The SOC fraction changes lead to changes in the soil physical and chemical properties that strongly influence microbial distribution (P. Cong et al., 2020). On the contrary, the addition of hydrochar caused the increase of decomposers of labile SOC such as *Flavobacterium*, *Anaerolinea*, *Penicillium*, and *Acremonium* and thereby, reduced the labile SOC content by 15.6-33.6% (K. Sun et al., 2020). These findings further support the idea of S. Culman et al. (2010); Weil et al. (2003) who concluded that the oxidation of AC as the sensitive labile carbon portion has a positive relation with soil organism respiration and microbial biomass. Some authors have also suggested that using specialized microorganisms due to using complex compounds can be a better way to indicate the relationship between AC and microbial activity (Lehmann & Kleber, 2015; Romero et al., 2018). Additionally, Ramírez, Fuentes-Alburquenque, Díez, Vargas, and Bonilla (2020) indicated that among all of the factors determined in 28 sites with different land use and climate condition, the pH, POXC/SOC (AC/SOC) ratio and light fraction organic matter (LFOM) have been identified as major contributing factors for changing the microbial community structure which contributes to the prediction of ecosystem models and early warning factors of land degradation (Fig. 2). For instance, Bacteroidetes, Proteobacteria, and Archaea were be the most dominant groups in high POXC/SOC rate and low LFOM content (Ramírez et al., 2020).

Thies, Rillig, and Graber (2015) revealed that the presence of labile C in OM amendments can enhance the amount of AMF colonization. AMF can modify soil aggregation, water hydraulic conductivity, and nutrient availability in the soil (Ortaş, Razzaghi, & Rafique, 2016; Q. Shen, Hedley, Camps Arbestain, & Kirschbaum, 2016; Vasconcellos, Bonfim, Baretta, & Cardoso, 2016). Further studies carried out on SOC fraction and soil biological properties confirmed that vegetation cover type also has a great impact on the microorganism community and SOC fraction. In this line, Prommer et al. (2020) reported using higher plant species richness has a positive impact on root biomass and therefore on microbial population growth and MBC content. Additionally, the temporal changes in the structure of the soil microbial community reflect well the process of conversion and distribution of straw C into SOC fraction. After the first 180 days of straw decomposition by the soil microbial community, about 3.93%, 19.82%, 0.02%, and 2.25% of straw C were converted into soil MOC, POC, DOC, and MBC, respectively (Su et al., 2020). In the same way, Yan et al. (2020) indicated that returning rice straw to the field led to increased SOC fractions such as DOC and MBC and thereby, help to enhance soil microbial richness. Collectively, these studies outline a critical role of SOM via biological properties on soil quality.

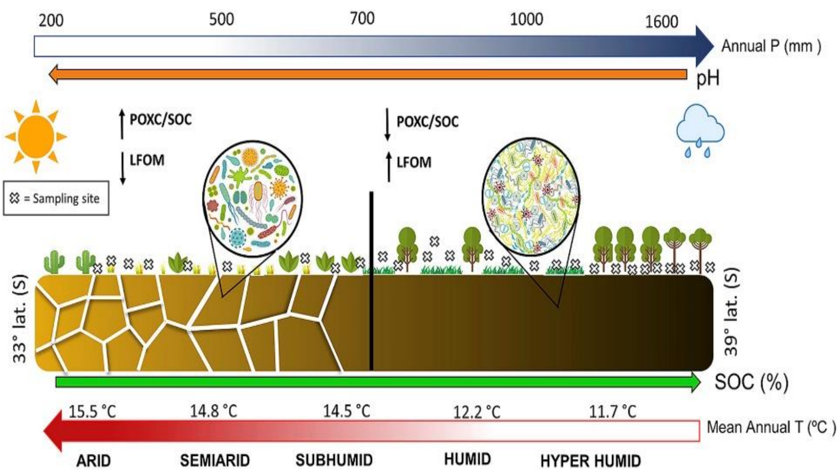

Figure 2. The effect of labile SOC fractions on the bacteria-archaea community in the topsoil under different land use, soil types, and climate conditions (source= (Ramírez et al., 2020))

2.2. Soil Biological Properties and OM Amendments

Apart from the important role of microorganisms in SOM decomposition and soil productivity, SOM amendment can also change the size, activity, and population of soil microorganism communities (M. N. Ashraf et al., 2020; Caione et al., 2021; Shu Chen, Qi, Ma, & Zhao, 2020; Elbl et al., 2019; Huang et al., 2020). Beyond that, compost input has a positive effect on the number of endogeic earthworms, by providing food to them (Tresch et al., 2018). Additionally, Compost contains humus, essential nutrients, and endogenous microorganisms, and acts as a biological control agent against plant pathogens which can improve SQ (De Corato, 2020).

In addition, waste organic materials input into the soil can affect the soil microbial activity, and nutrient availability (Y. Cheng, Wang, Wang, Chang, & Wang, 2017). The amendment of the soil by dark color biochar as an OC reservoir leads to increased temperature, thereby improving biological processes such as mineralization of nutrients and helped plant growth (Grunwald et al., 2017; Maroušek, Kolář, Vochozka, Stehel, & Maroušková, 2018). Despite this, the organic amendments have a great effect on soil enzyme activities but this impact is changeable according to the interactions between soil and enzymes (Foster, Hansen, Wallenstein, & Cotrufo, 2016; Paz-Ferreiro, Gascó, Gutiérrez, & Méndez, 2012). Nevertheless, these phenomena indicated the importance of biological activity and hence, SOM as the main indicator of soil quality (Bonilla, Gutiérrez-Barranquero, Vicente, & Cazorla, 2012). As a consequence, biochar with *T. aureoviride* inoculation (Biological material to control diseases) the application plays a positive crucial role in sustainable agriculture to improve soil quality (Medeiros et al., 2020). The integrated residual sulfur-enhanced biochar + effective microorganism treatment has significantly positive effects on increasing soil essential nutrient content for plant growth and plant productivity under salinity stress (Abd El-Mageed et al., 2020). Additionally, It has been reported that rice straw as OM amendment can reduce the negative effect of saline-alkaline conditions on soil microbial activity and in the paddy rice soils (Wichern, Islam, Hemkemeyer, Watson, & Joergensen, 2020).

Furthermore, vermicompost input with deep tillage can help aline-sodic soil reclamation and enhance wheat yield (Ding, Kheir, Ali, Hafez, ElShamey, Zhou, Wang, Ge, et al., 2021). J. Wang et al. (2019) reported the increase in Arbuscular Mycorrhizal Fungi (AMF) community by biochar amendments to the soil. AMF also plays an active role in SOM stability and formation (Frey, 2019). In addition, OM input can change the earthworm community as the mesofaunas of the soil depend on their species and the type of OM (Sanchez-Hernandez, Ríos, Attademo, Malcevschi, & Cares, 2019; M. Zhang, Riaz, Zhang, El-Desouki, & Jiang, 2019). In addition, Jin, Wood, Franks, Armstrong, and Tang (2020) found that long-term (8 years) soil CO_2 enrichment enhanced the presence of oligotrophs in bacterial communities and SOC mineralization in the topsoil with a high content of OC. These changes in microbial function caused improving soil quality and crop production.

3. SOIL CHEMICAL PROPERTIES

3.1. Soil Chemical Properties and SOC Fractions

Several studies have revealed that organic matter input like green manure and compost instead of chemical fertilizer can offset soil constraints that limit nutrient availability and thus, can increase soil labile carbon content (Bongiorno et al., 2019; J. Li et al., 2018; Pezzolla et al., 2015; Tatzber et al., 2015; Vieira et al., 2007) which have a major impact on chemical properties of the soil such as nutrient availability (Y. Chen, Camps-Arbestain, Shen, Singh, & Cayuela, 2018; Conz, Abbruzzini, ANDRADE, Milori, & Cerri, 2017; Diacono & Montemurro, 2011; Hong et al., 2019; Martínez, Duval, López, Iglesias, & Galantini, 2017; Meena et al., 2018; Wright, Provin, Hons, Zuberer, & White, 2007) therefore, increase SQ. Higher content of labile OM and nutrients was reported in biochar that were produced by low-temperature pyrolysis (<550 °C) which are more useful for adding to poor soil nutrients (Y. Luo et al., 2018). Wander (2004) also mentioned to the positive correlation of AC with soil CEC. Somayyeh Razzaghi et al. (2022) reported that the SOC lability, AC, and TN contents were higher under forests when

compared to their shrubby soils. Haibo Wang et al. (2020) found that when broad-leaved forests were converted to tea and Moso bamboo plantations, the chemical structure of SOC and labile C pools such as water-soluble organic carbon (WSOC), LFOC, and humus carbon (HC) changed. They also reported that these practices have a negative impact on SOC content. Due to N Fertilization soil pH, MBC, MAC, and exchangeable Ca^{2+} decreased, whereas POC increased in a subtropical forest in southern China (J. Chen, Xiao, Zheng, & Zhu, 2020). Moreover, MBC assimilation and re-formation of SOM are influenced by soil nutrient storage such as C to N, P, and sulfur (S) (Coonan et al., 2020). Soil C/N was the crucial driver of the labile fraction of SOM after 2 years of N addition in the Tibetan alpine steppe (Q. Chen et al., 2021). There is also a positive relationship between heavy metal content and SOC fractions (LFC and MAC) in the soil, which would explain the remarkable role of these fractions in heavy metal binding (Błońska, 2015; Lasota, Błońska, Łyszczarz, & Tibbett, 2020). Unlike, Enya, Heaney, Iniama, and Lin (2020) reported the more essential role of pH, Eh and EC compare with soil heavy metals on SOC dynamics.

In view of all that has been mentioned so far, there are strong relations between soil chemical properties, SOM, and thereby, SQ.

3.2. Soil Chemical Properties and OM Amendments

The most important factors for determining soil chemical properties are the clay, CEC, OM, pH, and soil colloids, which can change according to soil management functions such as OM amendments (Costantini et al., 2016; D. Liu et al., 2021; M. Singh et al., 2017). Scherer, Metker, and Welp (2011) also reported high content of SOC, soil N, and microbial activity after long-term compost input. It has been conclusively shown that compost input increased soil P, K, and some micro-elements in a bell pepper-cropping system, but did not affect bell pepper growth and yield (Tubeileh & Stephenson, 2020). Likewise, the pH and buffering capacity of biochar are high. Therefore, the addition of biochar is a common way to the amendment of acidic soils (Cornelissen et al., 2018; Malik et al., 2018). According to M. Ahmad et al. (2017); F. Jing et al. (2020); Lwin, Seo, Kim, Owens, and Kim (2018); Nzediegwu et al. (2019); Ogbonnaya and Semple (2013); Z. Shen et al. (2019) biochar by its high-sorption capacity can also help decrease soil pollution by immobilizing heavy metals that are extremely important in SQI. It was proved that biochar by adsorbing Al^{3+} on its surface leads to decreased available Al in the soil. Besides that, the application of biochar + N fertilizer can enhance the N use efficiency of maize and improve SQ (Xia et al., 2020). Similarly, Ali et al. (2020) reported that using biochar application (60 t ha^{-1}+270 kg N ha^{-1}) has a positive effect on soil chemical properties, SQ, photosynthesis, and rice yield. There is also a significant positive relation between biochar application and SOC (Dubey, Dubey, Chaurasia, Singh, & Abhilash, 2020; L. Han et al., 2020; Joseph et al., 2020a; Joseph et al., 2020b), TN, and P content (Y. Jing et al., 2020). Mensah and Frimpong (2018) investigated the different impacts of OM application to the soil on the soil chemical properties and found that biochar and compost alone or mixed together significantly increased soil pH, SOC, available P, mineral N, and CEC which all have high potential to improve SQ and increase maize yield. Biochar and compost can enhance SQ, by increasing soil nutrient content as well as promoting plant growth in the early stages of apple tree growth (Safaei Khorram et al., 2019). Furthermore, it was demonstrated that substitution of 50% inorganic N with sewage sludge as a fertilizer will be useful for increasing micronutrient availability and enhancing SQ (Sharma & Dhaliwal, 2019). Furthermore, according to Kwiatkowska-Malina (2016) application of OM to the soil can increase the value of the C: N ratio in sandy soils in Poland. C.-A. Liu and Zhou (2017) recommended the application of manure + chemical fertilizers for obtaining a higher yield in semi-arid conditions in China. The application of chemical fertilizers increased wheat grain yield and cultivate beneficial whereas natural manure upgraded grain quality and SOC content (Hammad et al., 2020). The highest soil P content was determined in cattle slurry treatment, but the highest soil K content was obtained in the digestate + straw application to the soil. In contrast, these fertilizer treatments did not change SOC content (Barłóg, Hlisnikovský, & Kunzová, 2020). Besides increasing SOC the composting rice straw+ farmyard manure could enhance soil nutrient supply (Pauline Chivenge et al., 2020). In addition, manure + inorganic P fertilizer improved soil P balance C sequestration rate in acidic paddy soil (Qaswar et al., 2020).

4. PHYSICAL PROPERTIES

4.1. Soil Physical Properties and SOC Fractions

The labile fraction of SOC has the potential to be the main indicator of soil physical functions and improve SQ (Bongiorno et al., 2019). In the same vein, Matias E Duval et al. (2018) measured the effect of fractions of labile C on SQ. They found a stronger relationship between AC and SOC (R_2 = 0.76–0.92) and identified fine POC and HWC as the most sensitive indicators of soil quality due to their high relationship with the soil physical properties. Plaza-Bonilla, Álvaro-Fuentes, and Cantero-Martínez (2014); Yang et al. (2009) indicated that the ratio among labile C and SOC declines with depth. Moreover, soil cultivation can decrease AC content (Mandal, Yadav, Sharma, Ramesh, & Venkanna, 2011). Alvarez and Alvarez (2016) demonstrated that no-till and crop rotation lead to higher changes in POC content compared to OC in the Pampas Region. The same result was obtained by Garcia, Li, and Rosolem (2013) who observed a close relationship of POC content changes and improved soil physical properties. Ferreira et al. (2020) also indicated that no-till farming can increase crop residue input to the topsoil, which can be accompanied by an increase in POC and MAOM content. Furthermore, No-tillage and subsoiling as well as, rotation tillage are improved SOC fractions including AC, POC, and MBC. Therefore, according to the above results and Reynolds et al. (2007), POC can be the best indicator of the physical properties of the soil, and due to Vieira et al. (2007) can be used as the indicator (r = 0.88) of the soil quality. The results of the study of the conventional tillage effect on soil structure and SOM which was carried out by Bongiorno et al. (2019); J Six, Elliott, and Paustian (1999), indicated that the aggregates which disrupts due to tillage lead to an increase soil temperature and aeration and cause to decreasing the labile fractions of SOC contents which were protected in the soil and transfer organic and mineral fertilizer to deeper soil layers. Jastrow, Amonette, and Bailey (2007) underline the effect of no-tillage on improving soil physical properties and indicated that labile carbon contents were higher in reduced tillage. This concurs well with Kumar et al. (2018) who indicated that zero tillage seems to be the most useful function for increasing soil labile carbon fractions content in the Typic Ustochrept soil. Cooper et al. (2016) have identified that SOC management practices such as reduced tillage have the potential to enhance labile organic carbon content. Using crop rotations for a long time (>24 years) can increase SOC fractions content such as POC and LFC and soil aggregation (Maiga et al., 2019). The reduction of the SOC and structural stability, as well as SQ, is more in high-temperature biochar application compare to low-temperature biochar application (Saffari, Hajabbasi, Shirani, Mosaddeghi, & Mamedov, 2020). By contrast, Ladoni, Basir, and Kravchenko (2015); Margenot et al. (2017); Sequeira and Alley (2011) reported no influence of tillage on the labile C content. This result may be contributed to the time of soil sampling, environmental conditions, and soil types (Bongiorno et al., 2019; PP Chivenge, Murwira, Giller, Mapfumo, & Six, 2007). Kiani et al. (2017) identified MBC and aggregation as powerful SQ indicators under long-term land management. Long-term (28 Years) organic and inorganic fertilization improved the proportions of coarse POC and physical protection of SOC and C sequestration in northeast China(Mustafa et al., 2021).

4.2. Soil Physical Properties and OM Amendments

Some physical properties of soil which are important in SQIs measurements are the depth of the soil for root penetration and water infiltration, soil structure stability, and soil porosity can be easily changeable through soil management interventions such as adding OM (Blanco-Canqui, 2017; Lei & Zhang, 2013; Oliver, Bramley, Riches, Porter, & Edwards, 2013; Omondi et al., 2016; Pandey, Gautam, & Singh, 2018). On the other hand, according to Are, Adelana, Fademi, and Aina (2017) although, the texture is the inherent property of the soil and changes very slow and difficult during soil management practices, decreasing the bulk density of the soil is the best indicator of soil texture and soil porosity by OM adding (Blanco-Canqui, 2017; Omondi et al., 2016; Pranagal, Oleszczuk, Tomaszewska-Krojańska, Kraska, & Różyło, 2017; Xiao et al., 2016) can be effective on changing the soil texture by pore size and volumes. Notably, the OM amendment to the soil cause to decrease in average pore sizes and thus leads to decrease drainage, enhanced water retention, and plant-available water in the soil, even in sandy soils with a high percentage of macrospores (Amoah-Antwi et al., 2020; Devereux, Sturrock, & Mooney, 2012; Mollinedo, Schumacher, & Chintala, 2015). In converse, J. Li et al. (2012) showed increases in macroporosity and water infiltration in heavy clay soils by OM addition to the soil. Indeed, increasing water retention by adding humic substances cause to reduces soil loss due to erosion (Piccolo, Pietramellara, & Mbagwu, 1997). Beniston and Lal (2012) reported soil physical properties can be improved by OM inputs like mulch and compost. Compost input generally enhances soil physical properties (Kranz, McLaughlin, Johnson, Miller, & Heitman, 2020). Compost and manure application for a long time (15 years) enhanced water retention and the Atterberg limits, and gas diffusion in the soil (Paradelo, Eden, Martínez, Keller, & Houot, 2019). Woody biomass and plant residues also can increase C stocks and thus, improve soil structure stability and enhance SQ (Amoah-Antwi et al., 2020; Mahmood et al., 2017; Meena et al., 2018). Better SQ through the high quality of physicochemical properties was reported under the application of animal-derived organic fertilizer compare with plant-derived in the red soil farmland of China (Kranz et al., 2020). There is a significant positive variation between soil physical properties and biochar application (Blanco-Canqui, 2017). Besides that, the increase in soil aggregation due to the large pore volumes of biochar was reported by Munoz, Gongora, and Zagal (2016).

In Planosol and Cambisol soils, biochar also resulted in soil aggregate stability enhancement (Burrell, Zehetner, Rampazzo, Wimmer, & Soja, 2016). Lower soil bulk density was observed in the soil with a high rate of biochar application (Horák, Šimanský, & Igaz, 2019).

5. CROP YIELD

5.1. Crop Yield and SOC Fractions

Other observations showed that the number of studies that indicated the direct effect of SOC fraction on crop yield is insufficient. As has been noted above, SOC fraction through affecting soil properties can affect crop yield. In this context Lee et al. (2009) claimed that compost application can improve effective SOC fraction, thus enhancing soil physical properties and crop production. Although, the seaweed addition increased AC and SQ compare to other organic fertilizers but sweet corn yield is similar to when organic fertilizers are applied (Possinger & Amador, 2016). In addition, Azolla compost application by increasing non-labile fractions of SOC helped long-term carbon sequestration and enhanced grain yield of winter wheat (by 27%) (Bharali, Baruah, Bhattacharyya, & Gorh, 2017). Furthermore, NPK and wheat straw application (high rate) to the soil resulted in higher total SOC, WSOC, HWC, MBC, POC, and LFC contents and thereby, higher rice yield compared with the soil without any amendment treatment (Dai et al., 2021). As indicated in the above section, the quality and amount of biomass of crops are effective on total SOC content and its fraction. In this vein, Matias E. Duval, Galantini, Capurro, and Martinez (2016) reported that Gramineous after 6 years can improve SOC and POC content in 0–20 cm soil layers. The crop rotations and biomass of crops after harvest can reduce the loss of SOC and its fraction which will be useful in promoting production systems in Sub-Saharan Africa (Soler et al., 2011). As noted earlier, due to the low cost and protection of natural conditions, a very labile C fraction was introduced as a comprehensive indicator for SQ and its crop productivity (Majumder, Mandal, Bandyopadhyay, & Chaudhury, 2007). Likewise, it was demonstrated that very labile C, MBC, POC, and mineralizable C were affected more by the different management strategies and showed high sensitivity in the crop yield in India (Majumder et al., 2007).

5.2. Crop Yield and OM Amendments

Numerous studies have attempted to explain the positive correlation between OM amendments and crop yield (Agegnehu, Bird, Nelson, & Bass, 2015; Arif, Ilyas, Riaz, Ali, Shah, Haq, et al., 2017; Ding, Kheir, Ali, Hafez, ElShamey, Zhou, Wang, Lin, et al., 2021; Golabi, Denney, & Iyekar, 2007; Hussain et al., 2020; Imran, Amanullah, & M. Al-Tawaha, 2021; Olmo, Lozano, Barrón, & Villar, 2016; Xu Zhang et al., 2020). Turgay, Karaca, Unver, and Tamer (2011) highlighted that the applications of humic substances to the soil with high pH, in the first cropping season in Adana/Turkey, can have a great impact on increasing SOM, available P, and bread wheat yield. Straw application at 25 cm had a major role in increasing crop (wheat and maize) yield in the North China Plain (N. Liu et al., 2021). Organic amendments lead to an increase in maize grain yield by 10%–29% (Agegnehu, Bass, Nelson, & Bird, 2016). Long-term manure application improved soil productivity and remarkably increased crop yield by 7.6% in china (Du et al., 2020). The application of organic fertilizers can increase broccoli crop yield for a long time (Sánchez-Navarro, Zornoza, Faz, & Fernández, 2019). The straw application could significantly increase SOC, soil N, and P content, and crop production in the semiarid regions of China (P. Zhang et al., 2016). Moreover, the application of wheat straw mulch can increase SOM contents and maize yield (Asif et al., 2020). Straw application at 25 cm can increase SOC at 20-40 cm soil depth and thereby, crop yield (N. Liu et al., 2021).

Viger, Hancock, Miglietta, and Taylor (2015) reported that OM input can increase lettuce yield by improving root length. Co-composted biochar can enhance SQ and crop productivity (Antonangelo, Sun, & Zhang, 2021). Biochar by improving soil chemical properties and SQ can increase the grain yield of barley, wheat, and corn but this increase can reduce two years after the application of biochar (Horák, Šimanský, & Aydin, 2020). Moreover, in contrast to synthetic fertilizer application, the highest crop production and quality were obtained by biochar + alfalfa straw application (Bonanomi et al., 2020). It was reported that the application of the biochar with particle size <3 mm significantly more useful for the enhancement of soil fertility and tomato yield (Zeeshan et al., 2020). Consequently, the highest grain yield (4402 kg ha^{-1}) would be obtained by vermicompost application (5t ha^{-1})+ recommended content of NPK (75%) (H. A.-u.-R. Ahmad & Anjum, 2020). According to the results of many articles, biochar application (about 10 t ha^{-1}) can increase crop yields by 20% (Agegnehu, Srivastava, & Bird, 2017). The increase of maize-wheat yield and SQ by biochar + organic and inorganic fertilizer application was also reported by Arif, Ilyas, Riaz, Ali, Shah, Ul Haq, et al. (2017) in poor alkaline soil. The increase in wheat grain yield in the biochar-rich soils was also found by Olmo et al. (2016).

Similarly, converting to biochar application which resulted in rice residue conversion could increase rice yield in Sierra Leone (Kamara, Kamara, & Kamara, 2015). The yield of potatoes increased under biochar + compost with proper mixing ratio and wastewater irrigation (Mawof, Prasher, Bayen, & Nzediegwu, 2021). Similarly, the increase in rice productivity by biochar amendment (especially 10, 20, and 40 t ha^{-1}) was reported by A. Zhang et al. (2012).

CONCLUSIONS

This chapter is a considerable collection of numerous findings of about the significant role of SOC on soil properties. First of all, the definition of SOC, SOC fractions, and SOM amendments and then their effect on soil biological, physical, and chemical properties were indicated based on a large number of studies.

To prove our hypothesis in this review chapter about labile fractions of the SOC as the key indicators of soil health and soil properties and therefore crop yields, in the next steps, the effect of OM amendment and then the SOC fractions' effect on crop yield was explained by referring to multiple studies. Returning to the question posed at the beginning of this study, it is now possible to state that the net key effect of OM amendments like biochar on increasing labile fraction of OC and its positive influence (especially AC) on soil biological properties such as soil biota community abundance and soil organism respiration, and also a significant positive relation between AC with soil CEC, soil pH, soil nutrient storage and heavy metal binding and also structure stability/ We also explained the positive impact of zero tillage on increasing soil labile carbon fractions for physical protection of SOC and C sequestration. The most obvious finding to emerge from this study is that returning C inputs to the soil beside the increasing labile OC content and therefore crop yield, can accelerate increasing C sequestration and help to mitigate global warming and climate change.

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CHAPTER 4

THE IMPORTANCE OF SALT STRESSES IN PLANTS

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INTRODUCTION

Despite efforts to increase the yield and quality of agricultural areas to nourish the world's population of 8 billion, non-arable areas are on the rise due to salinity. In recent years, climate change-driven arid and semi-arid climate regimes have been observed in many regions of the world. Fertile farmlands will shortly turn into barren saline soils because of factors such as low-quality irrigation water, using irrigation systems, soil cultivation area, and insufficient drainage. Problems arise when the amounts of soluble salts in the soil exceed the levels necessary for plant growth and development, limiting plant water use. Cl^-, SO_4^{2-}, HCO_3^-, and CO_3^{2-} anions, and Na^+, Ca^{2+}, Mg^{2+}, and K^+ cations cause salinity in the soil. The pH rarely rises above 8.0 in soils with a good physical structure. Sodium chloride (NaCl) is the most abundant salt with the highest toxicity due to its high solubility (Saatçı and Tuncay,1973; Wahome, 2003; Bahçıvan,2011).

If the NaCl content in the soil solution is more than 0.5%, these are saline soils. Salinity is one of the major soil problems worldwide, where 10 million hectares of land are lost annually due to salinity. In the world, salt-affected soils are distributed in the USA, East Asia (especially in India, Pakistan, and China), Africa (Sudan, Egypt, Libya, Tunisia, Algeria, and Morocco), and Australia. While there are more than 1.5 million hectares of land with salinity and alkalinity problems in our country, the largest area belongs to the area of Konya in Central Anadolu (Saatçi and Tuncay, 1973; Bahçıvan, 2011).

Unknowledgeable irrigation, poor drainage, and high groundwater greatly affect soil salinization. Salinity and alkalinity of ordinary soils, especially with irrigation, are the most important economic aspect of salinity. Insufficient drainage and rising groundwater in irrigated farmlands are the main causes of salinity. Moreover, lack of knowledge about irrigation water quality and lack of soil survey leads to the formation and expansion of saline soils (Saatçi and Tuncay, 1973; Mechlia, 2000).

The type of salt accumulated in the soil is affected by geological configurations and formations that mediate the passage of surface and drainage water. Climate also plays an important role in the formation of saline soils. The arid and semi-arid nature of a region or low precipitation, soil washing, and high evaporation are some of these factors (Mechlia, 2000).

The plant is stressed when the salt concentration is sufficiently high (0.5-0.1 bar) to reduce the water potential, called salt stress (Lewitt, 1980). Salinity results from the accumulation of soluble solutes in the soil surface due to the evaporation of soluble salts mixed with groundwater by washing with water and capillary, especially in arid and semi-arid climates (Aydemir and İnce, 1988; Marschner, 1993). These soluble salts, which are present at high concentrations in the soil, adversely affect the cultivation of crops and are both toxic to plants and disrupt the physical, chemical, and biological structures of the soil.

Soil salinity criteria include a low pH of saturated soil extract at 8.4, an exchangeable Na (sodium) percentage of < 15%, and electrical conductivity (EC) of 4 dsm^{-1} for saturated soil extract (Saatçi and Tuncay, 1973; Aydemir and İnce, 1988).

In salt-sensitive plants under salinity stress, the yield decreases when the EC value exceeds 4 dsm^{-1}. Thus, this value should not exceed 2 dsm^{-1} in irrigation waters (; Tuncay, 1994; Çelik, 2015). In addition ıt is stated salinity classes and plant response to salinity according to electrical conductivitiy in Table 1. Therefore plants such as cotton and sugar beet are very resistant to salt, and grapes, wheat, and sunflower are moderately resistant, while legumes, citrus fruits, paddy, and maize are plants with low resistance (Bernstein, 1970; Çelik, 2015).

Table 1. Salinity classes and plant response to salinity according to electrical conductivity (Bernstein, 1970)

EC dsm^{-1} at 25 °C	Classification	Planr response
0-2	Non-saline soils	Not affected
2-4	Slightly saline soils	Sensitive plants are affected along with reduced yield
4-8	Saline soils	Yield is affected in many plants
8-16	Strongly saline soils	Only salt-tolerant plants produce yield and grow
>16	Extremely saline soils	Only a few salt-tolerant plants produce yield and grow

The reasons for soil salinization include the quality of water used for irrigation is given as follow: over-irrigation, land with flat or hollow topography, movement of salt-containing groundwater to the soil surface, soil formation in the old beds of lakes, salinization of irrigation water in areas close to the sea, lack of drainage systems, insufficient precipitation and high evaporation in arid and semi-arid climates, one-way fertilization of soils, and impermeable strata and high groundwater that is prevented groundwater flow (Mengel and Kirkby, 1982; Bahçıvan, 2011).

Therefore, this research aims to explain the importance of salt stress limiting agricultural production and plant growth, the physical, chemical, and biological effects of salinity on soil, and comprehensive practicable measures (such as plant selection, cultivar and rootstock selection, use of regulators for amendment, using K fertilizers, and phytoremediation) that can be obtained against salt stress.

1. EFFECTS OF SALINITY ON SOIL

1.1. Physical Effects

These include physical, chemical, and biological effects. The most important physical and alkalinity effects of salinity are on soil permeability, which depends on cation exchange and flocculation. In alkaline soils, dispersion occurs instead of flocculation with increasing exchangeable Na in the soil, which degrades the soil structure and reduces hydraulic permeability.

The soil structure undergoes changes depending on the nature of the exchangeable cations in the soil. In general, divalent cations (Mg^{2+}, Ca^{2+}) provide the formation of good soil structures. On the other hand, monovalent cations destroy the soil structure and reduce soil hydraulic permeability (Bahçıvan, 2011; Yağmur et al., 2021).

1.2. Chemical Effects

The chemical effects of salinity target soil cation exchange, leading to salt interactions with each other, which is an important chemical effect. The most important of these are the reactions that dissolve the lime ($CaCO_3$). When lime dissolves in the soil, or when it begins to dissolve, the soil is considered good for agriculture. The dissolution of $CaCO_3$ is facilitated by CO_2, atmospheric pressure, and neutral Na salts (Bahçıvan, 2011).

1.3. Microbiological Effects

The type of salt in the soil differently affects soil-inhabiting living organisms, and microorganisms also differently react to different salts. Therefore, the microbiological activities of microorganisms in the soil are different in the presence of various salts. For example, NaCl negatively affects the decomposition of organic matter because salts negatively influence microbiological activity. The Na_2CO_3 salt causes more negative effects than NaCl and Na_2SO_4 salts. Therefore, saline alkaline soils contain Na_2CO_3 in barren soils. Compared to a decrease in the number of ammonification bacteria, the number of nitrifying bacteria increases at non-toxic concentrations of salts. A total salt concentration of 1.5% reduces the number of fungi. Nitrification is more affected by soil salinity than ammonification (Altınbaş, et al., 2004; Bahçıvan, 2011; Yağmur et al., 2021).

2. EFFECTS OF SALINITY ON PLANTS

In general, salinity stress in plants occurs for two reasons. **1-** An increase in density caused by increasing soluble salts in the root zone leads to the plant difficulty in water uptake (physiological dryness). **2-**An increase in the amount of some ions causes toxic effects (Mengel and Kirkby, 1982; Aydemir and İnce, 1988; Çelik, 2015).

When exposed to high salinity, plants are divided into two large groups. Halophytes are plants that adapt to soil salinity and continue their life cycle in this environment. Glycophytes (sweet plants) are known as non-halophytes and are not as resistant as halophytes in saline environments. Stunted growth, leaf discoloration, and a decrease in plant dry weight occur when the salt concentration in the soil exceeds the threshold for glycophytes. Maize, onions, lemons, oranges, lettuces, and beans are very sensitive plants to salt, cotton and barley are moderately resistant plants, and sugar beets and dates are very resistant to salinity (Bernstein, 1970; Greenway and Munns, 1980; Çelik, 2015).

The Na/K content is quite adequate in salt-resistant plants. In saline soils, however, it is better to use K_2SO_4 instead of KCI, which has a low salt index. The negative effects of high concentrations of K^+ and Na^+ in the plant are also amended by the external application of Ca^{2+} (Mengel and Kirkby, 1982; Niab, 1982; Helal et al., 1984; Ağme and Anaç, 1994; Kacar and Katkat, 1998; Çelik, 2015). Salinity-stressed plants possess small, opaque leaves with a bluish-green color and show very rare symptoms of paleness, which are quite the opposite of those in plants affected by water stress. It also affects enzyme activity, membrane permeability, protein synthesis, mitochondria, chloroplast activity, and plant hormonal behavior (such as cytokinin deficiency and abscisic acid accumulation) (Mix, 1973; Prisco and Oleary, 1973; Aydemir and İnce 1988; Çelik, 2015).

Most plant species are very sensitive to salinity during germination and seedling stages. In seed plants, grain products are less affected by salinity than vegetative products. Salinity also affects the quality of plant production (Mengel and Kirkby, 1982; Marschner, 1993). While some plants develop mechanisms against salt stress, others show adaptation and change their nutrient intake according to their resistance to salt stress. Excessive salt stress in plants puts pressure on root growth, reduces bud formation, adversely affects growth at the ground surface, and leaves remain small, resulting in yellow spots on the roots, buds, leaf margins, and growth tips due to cell death. The disturbed balance between ions creates competition between the salt-forming ions and the macro- and micro elements needed for the plant, and plants cannot consume adequately the necessary elements for themselves (Lewitt, 1980; Lauchli and Epshein, 1990; Mengel and Kirkby, 1992; Marschner, 1993; Olympius et al., 2003; Çelik, 2015). For example, salt reduces P, Ca, Na, and K. Cl has been shown to reduce NO_3 uptake. High concentrations of Na and Cl in the soil solution suppress ionic activity and show severe ratios of Na^+/ Ca^{2+}, Na^+/K^+, Ca^{2+}/Mg^{2+}, and Cl^-/NO_3^- Salinity also affects plant physiology in the cell. Excessive accumulation of Na^+ and Cl^- due to a reduction in the absorption of other minerals, such as K^+, Ca^{2+}, and Mn^{2+}, causes ion imbalance in cells. On the other hand, the uptake of Fe, Mn, and Cu increases by plants under salinity stress (Lewitt, 1980; Mengel and Kirkby, 1992; Marschner, 1993; Kacar and Katkat, 1998; Yakıt and Tuna, 2006; Çelik, 2015).

These effects are divided into two groups: physical and chemical effects.

2.1. Physical Effects

An increase in the soil salt concentration elevates the osmotic pressure and reduces water uptake in the soil, which decreases and stops plant nutrition, an effect called osmotic pressure. The total osmotic pressure in fertile soil is between 1.3 and 1.8 atm. Plant growth is limited when the osmotic pressure of the soil solution reaches 10 atm, and it stops completely at 40 atm.

Depending on the chemical composition of the soil solution, the osmotic pressure can increase up to 200 atm in some saline soils. However, the electrical permittivity (EP) of the soil solution is related to the osmotic pressure; in practice, therefore, EP is calculated instead of osmotic pressure with the following equation (Lagerwerf and Eagle, 1961; Bernstein, 1961; Tuncay, 1994; Bahçıvan, 2011).

$$OP = 0.36 \, X \, (EC \, X10^3)$$

where $ECX10^3$ is the EP of saturated soil extract in mmhos cm^{-1} at 25 °C, and OP is soil osmotic pressure at a given humidity (atm)

2.2. Chemical Effects

Some salts in the soil make it difficult to absorb nutrients and damage plant growth by impairing metabolism. These special effects are called ionic effects. Since some ions have a toxic effect on the plant, they negatively affect plant growth and yield. The nutritional needs of plants and the negative effects of some special ions on plant development are different according to plant species. For example, high levels of Ca in the soil cause the uptake of K in plants, high levels of Ma and Na in the soil lead to a lack of Ca and K in plants, and high levels of HCO_3^- (bicarbonate) result in a lack of Fe and chlorosis in fruit trees (Mengel and Kirkby, 1982; Kacar and Katkat, 1998; Kaya et al., 2002; Bahçıvan, 2011).

3. NECESSARY ACTIONS AGAINST SALT STRESS

To amend saline soils, the high concentrations of soluble salts in the root zone of plants should be diluted with irrigation water (washing) to remove them from the root zone. The point worthy of note in soil amendment is to maintain the groundwater level below the depth of the plant roots and to remove the groundwater containing soluble salts. This can also be achieved with proper soil measurement and drainage systems. In the amendment procedure, it is absolutely necessary to use drainage, drainage systems, and chemical amendments along with washing (Saatçı and Tuncay, 1973; Tuncay, 1994). There is a risk of salinization in irrigated lands while a vast irrigated area may become unproductive, therefore, the quality of irrigation water is very important (Ayıldız, 1983; Tuncay 1994). Studies on the amendment of saline soils mainly aim to determine the required levels of chemical amendments and the amount of irrigation water, which is possible with field experiments and model studies in laboratories (Saatçı and Tuncay, 1973; Mechlia, 2000; Bahçıvan, 2011).

The selected method for water transfer to the field is also affected by many factors such as land topography, the type of cultivated plants, soil properties, irrigation water quality, and soil salinity (Saatçı and Tuncay, 1973; Aydemir, 1983).

3.1. Selection of Plants for Cultivation

One of the essential measures against salt stress is to grow salinity-resistant plants that can be of economic value. Based on salt tolerance, plants are divided into two groups of halophytes and glycophytes (Bernstein, 1970; Bahçıvan, 2011). The mechanisms used by halophytes cause their salt tolerance (Mengel and Kirkby, 1982; Bahçıvan, 2011), as described below;

- **Na pumps (extrusion):** When plants are exposed to salinity at stressful levels, they can extrude back excess Na to the environment with Na pumps in their stem cells (Tozlu et al.2000).
- **Accumulation in vacuoles:** An important mechanism against salt toxicity is the accumulation of Na in vacuoles to prevent damage to the plant (Mengel and Kirkby, 1982).
- **Rapid growth**: In this mechanism, the plant shows rapid growth and dilutes the absorbed salt per unit volume.
- **Cell membrane permeability**: Some plants can protect themselves against salt stress by preventing the passage of K and Na ions through the cell membrane (Kacar and Katkat, 1998).

3.2. Selection of A Resistant Cultivar and Rootstock

The stress caused by salinity does not affect a single feature in the plant but affects many physiological and metabolic processes. For this reason, many physiological, biochemical and molecular effects should be considered in salt tolerance studies. It is important to determine the genetic characteristics that provide salt tolerance and to understand the working mechanisms in the creation of breeding programs aimed at developing salt-tolerant plants. Abiotic stress factors such as high or low temperatures, drought or salinity threaten crop production in the world and cause production losses. Due to increasing environmental problems such as rapid population growth, climate changes and pollution in the world, the stress factors faced by plants are increasing and many of soils in the world are affected by salinity (Gupta and Huang, 2014).

The selection of a cultivar and rootstock is important in garden construction because the construction must have a long and economical lifespan. The genotypes of the same species are also different in salt tolerance. Therefore, cultivars with high salinity should be preferred in soils with salt stress (Tozlu et al., 2000).

It has been determined that the expressions of different genes, such as rice, arabidopsis, tomato, barley, are upregulated or downregulated in many plants treated with different NaCl doses. Among these genes with varying expression profiles, there are genes associated with cell wall protection, proline and soluble sugar, signal transduction pathways, ethylene signal transduction pathway, heat shock proteins, stress-related proteins. Therefore, the identification and classification of genes responsible for the expression of desired traits in plants are particularly important for the identification, characterization, and interrelationships of salt stress-related genes, and for the development of salt-tolerant plant (Jamil et al., 2011; Shavrukov, 2013).

3.3. Application of Regulators for Amendment (Using Chemical)

In the use of gypsum ($CaSO_4.7H_2O$), compounds containing sulfate groups are used as an amendment agent as given Table 2. Ca is replaced by Na by using fertilizers containing ammonium and Ca.

Table 2. Equivalents of 1 ton of sulfur (S) In amendment agents (Saatçı and Tuncay, 1973)

Amendment agent	The equivalent of 1 ton of S
S	1.00
S-lime (%245)	4.17
H_2SO_4	3.06
$CaSO_4.7H_2O$	3.38
$FeSO_4.7H_2O$	3.69
Aluminum sulfate ($A1_2SO_4.8H_2O$)	6.94

3.4. The Use of Potash (K) Fertilizer

The widespread K deficiency and Na toxicity in the world limit plant production. While salinity more negatively affects plants in areas with K deficiency, it has a less negative effect on plants in areas with sufficient and high levels of K. In particular, K protects the plant from salt and water stress and increases its tolerance (Kacar and Katkat, 1975; Mengel and Kirkby, 1982; Marschner and Possingham, 1993).

3.5. Phytoremediation

Phytoremediation is an environmentally friendly and economical method tailored to restoring lands damaged by salinity. Special crop rotations are applied to the plants of desalinated soils with those that grow in saline soils. Sunflower, livestock fodder, winter barley, sorghum, Sudanese maize, clover, and other flowering plants are generally used for this purpose. These improving plants prevent the extrusion of solutes to the soil surface with capillary by affecting the water order of the soil (Kaya et al., 2002; Bahçıvan, 2011).

CONCLUSION

The application of good-quality irrigation water, washing water, drainage systems, and chemical amendments are very important in saline soil amendment or restoration implementation. Major actions to deal with salt stress, which limits the quality of agricultural products per unit area, include the selection of a plant, a stable rootstock, and a cultivar the application of chemical amendments, K fertilizers, and phytoremediation. It is also possible to benefit from the oceans with salt elimination and costly industrial treatment processes by improving and genetically obtaining salt-resistant plant species with the ability to counteract salinity. The need for plant breeding programs and genetic studies is also extremely important nowadays taking account of the area occupied by low-yield and saline soils and the rising world population

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CHAPTER 5

CITRUS PROCESSING WASTE AS A SUSTAINABLE AND RENEWABLE RESOURCE: A REVIEW

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1.INTRODUCTION

By 2050, the world population will be 9.5-10.0 billion is expected. In order to meet the food needs of this growing population, it becomes mandatory to increase plant production by 60 -70% come. Waste is defined as "the part of the substances we use to meet our needs that is not used at the moment or is discarded after use". These include household, commercial, industrial and agricultural waste. The FAO defines food waste as “food losses in quality and quantity during the supply chain process that take place during the production, post-harvest and processing phases” (Tsang et al., 2019). With the acceleration of population growth, urbanization and industrialization, the amount and type of waste left in the environment is increasing day by day. Because of this, especially solid wastes have become one of the most important environmental problems of today. Since a plant grown with intensive labor and high costs means that only the consumed part is taken and the rest is discarded, labor and inputs are also thrown into the trash (Alkaya et al., 2010), waste assessment is one of the important issues of today. Although it has no significant economic value, some of the agricultural industry waste can be used as animal feed or fertilizer, while fruit and vegetable waste such as kernel, fruit and vegetable peels, root, plant peel and leaves are mostly discarded, which constitutes a serious waste problem in the food and agriculture sector (Ashoush and Gadallah, 2011).

Food waste begins to form from the fields, which are the beginning of production. In order to reduce the negative effects of greenhouse wastes on the environment and to ensure their recycling, various studies have been conducted on their composting. Due to food production, which has increased quite rapidly in recent years, there is a similar increase in the amount of waste in food enterprises. The most basic action that needs to be implemented in order to protect valuable natural resources and ensure sustainability is to prevent food losses and waste in all components of the supply chain, from production to consumption, such as processing, storage, transportation and reaching consumers. However, some food fractions, such as some agricultural residues, food production residues or inedible parts of plants and animals, are inevitably wasted. On the other hand, this recycling of organic waste, plant biomass and animal by-products from various chemicals and fuel, it is possible to obtain; thus, non-renewable resources to prevent the depletion greatly illustrates the contribution as well as the provision of environmental integrity (Santagata et al., 2021).

2. CITRUS FRUITS

Citrus fruits are a group of fruits belonging to the subfamily *Aurantoideae* of the *Rutaceae* family. Although there are many species, according to the data of the World Agricultural Organization, the most cultivated citrus fruits in our country are, respectively, Citrus sinensis (orange), Citrus reticulata (mandarin), Citrus limon (lemon), and Citrus paradisi (grapefruit). According to TUIK data, the amount of lemons produced in Turkey in 2021 is 1.550.000 tons, the amount of mandarins is 1.819.000 tons, the amount of oranges is 1.742.000 tons, and the amount of grapefruit is 249.000 tons. Turkey is 4th in the world in lemon production., while in the production of grapefruit 5th is ranked (TUIK, 2022). As shown in Figure 1, except for the edible part of citrus fruits, their peels, which are 30-60% of the fruit weight (Turhan et al., 2006), are used in the production of various alcoholic beverages (limocello) in the production of marmalade, although they are not consumed raw because they have a bitter taste (Crupi et al., 2007).

Figure 1. The Ratio of Juice and Waste Of Citrus Fruits.

In the Far East, it is also used in various Chinese dishes, as a spice in food, beverages and confectionery, in dried form in pastry and milk desserts, in the production of essential oils and in the production of medicines (Başer, 1997). Also, it is popularly used in the treatment of various diseases such as diabetes, high blood pressure (Oboh and Ademosun 2012).

Since citrus wastes are very rich in pectin, which is a colloidal carbohydrate and benefits from its gel-forming property, its most common use is considered to be pectin production (Marin et al., 2007; Turhan et al., 2006).

3. NUTRITIONAL CONTENT OF CITRUS FRUITS PEELS

When we look at the peel structure of citrus fruits, the thin layer that varies from yellow to orange on the outside is called flavedo. It makes up 8-10% of the fruit. Its content, on the other hand, consisted of pigments consisting of carotenoids, oil droplets and D-Limonene (Figure 2).

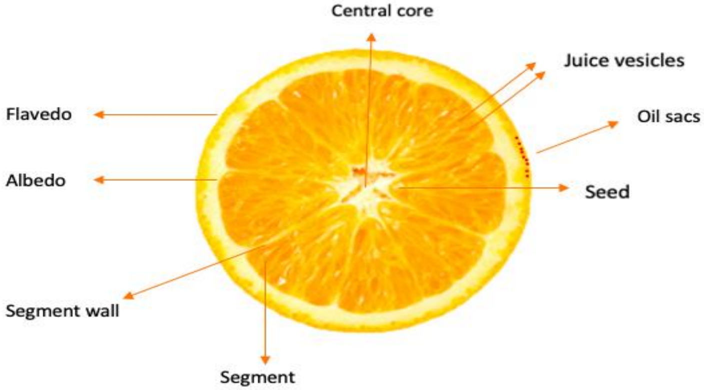

Figure 2. The General Structure of Citrus Fruits

The citrus peel contains essential oils, which are well known antimicrobial substances. Essential oils are contained in oil sacs ranging from 0.4 to 0.6 mm in diameter (Şekil 3). The sacs are located at irregular depths in the flavedo, which is located on the outer peel of the fruit. Orange peel typically contains 5.436 kg of fat per 1000 kg of oranges, of which about 90% is D -Limonene (Plessas et al., 2007).

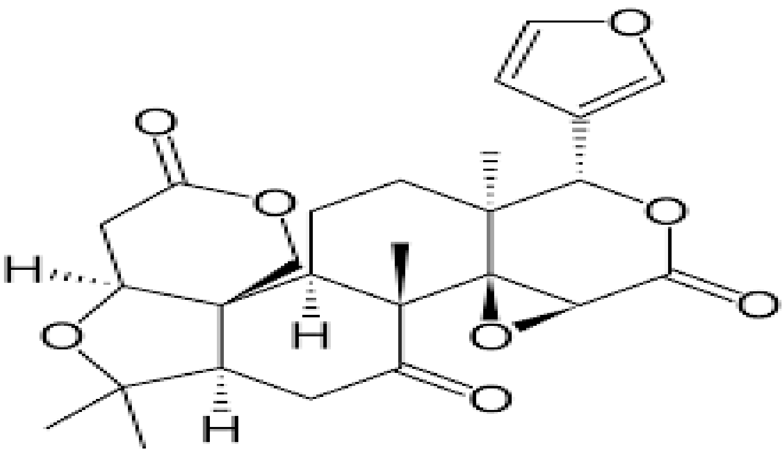

Figure 3. Chemical Structure of D – Limonene

Essential oil has an active role in the food industry. It can be used as a flavoring/perfuming agent in alcohol and tobacco products, beverages, condiments, confectionery and pastries. The resulting essential oil also has a calming effect on the human central nervous system, which can relieve stress and relieve fatigue. It has expectorant, antitussive, analgesic, relieves gallbladder inflammation, and also dissolves stones, has gastrointestinal effects (Figure 4). It is believed that the coumarin contained in it has an anticancer effect by decomposing toxic functional groups in carcinogenic substances and inhibiting the metabolism of cancer cells (Yang Shan, 2017).

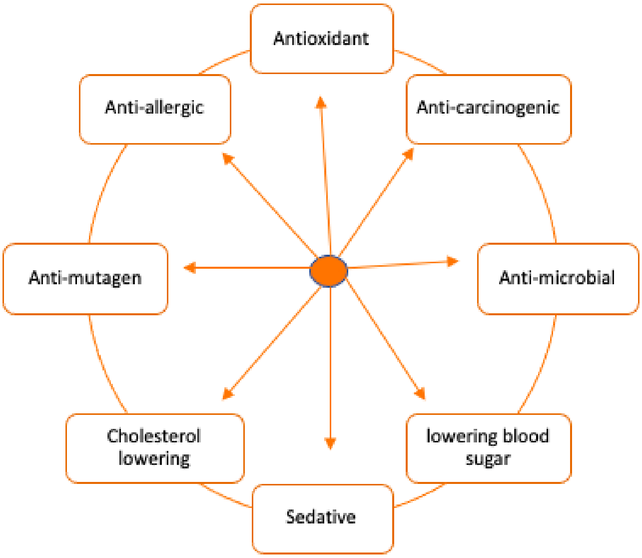

Figure 4. Functional Properties of Citrus Waste

Citrus peel is also rich not only in glucose, fructose, sucrose and amino acids, but also in a certain amount of thiamine, riboflavin, vitamins, bioflavonoids, carotenoids, cellulose, hemicellulose and lignin, etc. contains items. Essential oil is an aromatic, concentrated and hydrophobic liquid that tends to evaporate at room temperature, accounting for about 0.5-2% of the fresh weight of the citrus peel. Pectin, accounts for 20-30% of the dry weight of fresh citrus peel. It is a polysaccharide containing 1,4-galacturonic acid. Pectin is a thickener and stabilizer that is widely used in the food industry. The addition of pectin to jam and juice stabilizes the jam during transportation and improves its taste. Pectin also shows acid resistant properties when added to juice and syrup, which stabilizes fatty lactic acid in suspension. The addition of pectin to dairy products prevents the coagulation of casein protein and prolongs the shelf life of acidic dairy products. Pectin dietary fiber has preventive and therapeutic effects on high blood pressure, cancer, diabetes, obesity and other diseases. Due to its fiber content, it has a satisfying effect, increases gastric motility and nutrient absorption. In a study conducted on citrus peels, the pectin content was determined to be 19.3% of the total dry weight of the citrus peel (Yang Shan, 2016).

4. STUDIES ON CITRUS WASTES

Citrus wastes cover 30-60% of the fruit. Güzel and Akpınar, in their study in 2017, determined the amount of dry matter and oil content in lemon, mandarin, orange and grapefruit fruits as %90.97, 88.64, 89.04, 90.13 and % 2.48, 1.63, 1.74 and 2.21, respectively. Carotenoids are the most commonly found color pigments in nature after chlorophyll and too much physiological functions. By effectively neutralizing free radicals, it strengthens the immune system. In the same study, it was determined that the total carotenoid contents of citrus peels varied between 8.65-18.22 ppm, mandarin peels contained more carotenoids compared to other peels, followed by grapefruit, orange and lemon peels, respectively. Ascorbic acid, on the other hand, is important because of its strong antioxidant properties, as well as being an important nutrient with its vitamin activity. It was determined that the total ascorbic acid content of the peels was in the range of 251.70-1374.15 ppm, the ascorbic acid content of the lemon peel was higher than the other peels, followed by mandarin, orange and grapefruit peels.

In another study, the total phenolic substance contents obtained as a result of extraction application to lemon, sweet orange and mandarin peels were found to be 74.80 mg GAE/g, 66.36 mg GAE/g and 58.68 mg GAE/g, respectively (Londono et al., 2010). Again, studies have shown that flavonoids in citrus fruits are mostly found in the peel (Guardia et al., 2001). In the literature, in the extraction of orange and grapefruit peels with 80% acetone, total flavonoid contents were reported as 1.3 mg/g and 0.93 mg/g, respectively (Oboh and Ademosin, 2012). The total flavonoid content of sweet orange peels attempted more studies with different solvents (hexane, ethyl acetate and ethanol) between the maximum flavonoid compound ethyl acetate for the extraction of

(3.37-9.94 g QE/100 G) has been reached, than that achieved with ethanol (0.93-1.5 g QE/100 g), it was found that the higher (Fidrianny vd., 2014). Anthocyanins are phenolic pigments that form the colors of most plants ranging from red to blue and are soluble in water (Gao et al., 1997). In another study, it was determined that the total monomeric anthocyanin content of citrus peels was the highest in mandarin peel (479.24), followed by orange peel (451.40), lemon peel (22.87) and grapefruit peel (14.62) (Güzel and Akpınar 2017). The antioxidant capacities (DPPH) of grapefruit, orange and lemon peels were compared by Immanuel (2014) and it was reported that grapefruit, lemon and orange peels have the highest antioxidant activity.

Nowadays, people have realized how badly the consequences of excessive consumption and unsustainable attitudes will affect our near future and have begun to take conscious approaches. People therefore had to take into account the later life of an object before it was produced. Based on the need to rely on sustainable raw materials, be less dependent on fossil sources and reduce carbon emissions, biomaterials and bioplastics that replace traditional petroleum-based plastics have become the focus of many materials scientists (Özdamar and Ateş, 2018).

Orange peel, which is an agricultural waste, contains 42.5% pectin. Thanks to the high content of pectin in orange peel waste, it can be used as a matrix to increase gelling, biodegradability and physical properties based on starch biocomposite. For this purpose, the effect of the addition of nanocrystalline cellulose (NCC) and glycerin based on pectin-starch biocomposite was studied (Fath et al., 2019).

Recent research, especially resulting from the processing of fruits and vegetables by-products, including many of the waste food, natural food additives, nutraceuticals and functional foods and the food chain can be found in re-that should be taught, that they may be good sources of bioactive component reveals. Food wastes is a rich source of different bioactive components such as carotenoids, betalains, chlorophyll, especially polyphenols (Kyriakoudi and Mourtzinos, 2022). Safe, inexpensive and sustainable technologies should be applied for the recovery of bioactive components, avoiding the use of toxic organic solvents or expensive equipment (Carrillo et al., 2022).

Due to the high cellulose content of food waste and its easy availability, it is intended to produce bioplastic films from orange peel using simple laboratory techniques. The developed film was mixed with glycerin as a plasticizer, resulting in consistent and promising results. It has been observed that the production of bioplastics from orange waste increases the prospects for producing new materials, and they have the potential to replace traditional plastics and are environmentally friendly biomaterials (Yaradoddi et al., 2021). In another study investigating the extraction of pectin from orange peels using different methods, hot water extraction for high methylated pectin and microwave assisted extraction for low methylated pectin were found to be the most sustainable methods in terms of yield, esterification degree and energy consumption (Benassi et al., 2021).

In another study, research was conducted to control the stability of ultrasound-treated lemon peel and lemon peel to prepare biopolymer film, and also to improve the active biopolymer film and its effect on film quality (Borah et al., 2017).

In another study related to the production of bioactive components, citrus peels were subjected to liquid (20 MPa, 20°C) and supercritical carbon dioxide (30 MPa, 60 °C) extraction with 20% ethanol, and 19.86- 44.05 mg/g naringin was obtained (Romano et al., 2022).

In a doctoral dissertation, powdered orange waste and apple pulp were evaluated as raw materials and it was aimed to develop 3-dimensional structures. Pectin was used as matrix and cellulosic fibers were used as reinforcement. It has been demonstrated that biofilms can be produced from these wastes by solution casting and compression molding methods. It has also been proven that a binder-free chipboard can be created from orange waste powder and apple pulp using low pressure molding (Bátori, 2018).

5. CONCLUSION

Food waste, which is a global problem, is increasing rapidly due to the increase in the rate of food production. In order to enable sustainable food production, as well as to increase awareness of food safety, environment and cost issues, it is necessary to carry out the necessary corrective and preventive actions at each stage of the food supply chain. In particular, the necessary studies should be carried out on the transformation of citrus fruits from agricultural waste into products with high added value and increasing the areas of use of recovered products. It is supported by the literature that pectin obtained from citrus wastes can be used as a thickening and emulsifying agent in the food industry. In recent years, obtained from citrus waste polyphenols, carotenoids, and chlorophyll betalain bioactive components such as cosmetics, pharmaceutical, chemical and food industries-are available in different fields of use, although the use as animal feed is a common practice. It can be said that the potential of using citrus wastes in a creative and innovative way in the production of original products of plant-derived bioplastics is high. Thanks to the efficient use of citrus waste materials in bioplastics, it is thought that the cost of bioplastic production can be reduced and this will be an environmentally friendly sustainable cyclical method.

In addition to these studies, sustainable food production will become more possible with new studies to be carried out on topics such as performing the recovery process with higher efficiency and higher purity, researching and testing alternative methods for recovery, and increasing the possibilities of using the recovered components. The research results show that citrus waste is much more valuable than what is eaten.

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CHAPTER 6

FLORICULTURE SECTOR POTTED FLOWERS MARKET: A REVIEW

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1.INTRODUCTION

The increasingly hypercompetitive floricultural markets and decreasing profit margins of nurseries forces for continual analysis of production and marketing systems. Data for the ornamental industry is inadequate and very distributed. Data statistical offices, government organisations, ornamentals industry organisations, market analysis companies, wholesalers, academics are needed to be used to learn current leading countries and players for production and consumption; where are global established and emerging hot spots of ornamentals demand; where are the products grown and how does it get to the markets; how can we increase consumption of ornamentals?

From a product category point-of-view, floriculture is divided into four groups: cut flowers, cut foliage, pot plants (including pot flower and pot greens) and bedding/garden plants. Begonias, Marigolds, Geraniums, Pansies/Violas, Impatiens, Petunias, Hardy/Garden Chrysanthemums, Ferns (Hardy/Garden), Daylily, Hostas, Peony, Florist Chrysanthemums, Poinsettias, Easter Lilies, Orchids, Spring Flowering, Bulbs Florist Roses are frequently sold in pots.

The proportion of different floriculture products varies greatly between countries. The main floriculture products are cut flowers in Germany; cut flowers and potted flowers in Netherlands; bedding and garden plants and cut flowers in the USA; potted flowers and cut flowers in China.

Here in this review, some important data from dominant and emerging countries and dominant and emerging pot plant species are reviewed with addition of different types of related information from floriculture sector.

The field of floriculture has enormous potential and is now a key component of contemporary living. The floriculture sector has changed, becoming a profit - making enterprise with a significant market value and promising prospects (Anumala & Kumar, 2021). Main demand markets, which are typically located in high-income nations, have the added benefit of networked logistic hubs to import or trade huge volumes of perishable ornamentals. Examples of these locations include Japan, the Netherlands, the United States, the European Union, and China. The demand for ornamentals is rising in major worldwide cities like Tokyo, London, New York, Paris, Shanghai, Hongkong, Sydney, and Singapore. Total aggregated category of cut-flowers, indoor plants, outdoor plants, garden and lawncare services and even public green space is primarily dependant of an economy's purchasing power followed by a changing consumer demand and changing buying behaviour. In order to wait for the best market price, ornamental plants and flowers cannot be maintained in stock for an extended period of time. They must be moved fast, and efficient production planning to satisfy (seasonal) demand peaks is a crucial factor in profit or loss. We can see that demand is the primary factor at work by looking at the seasonality of the demand for outdoor plants in the spring and for cut flowers the peak days of special consumer events like Valentine's Day, Mother's Day, and the Chinese Singles Day, where retailers report to make the same turnover in just a few weeks or even days as in the rest of the year. The ornamental services sector must also be mentioned. The service that is offered along with the commodity (the flower or plant) sometimes has a higher monetary value in transactions than the actual thing itself. The product has only become an ingredient. Because ornamentals are perishable, a strong logistics system is needed. Markets like North East Asia (China and Japan), North America, and Europe, which have strong production bases and ornamentals are at the core of their societies' cultures, are mature domestic manufacturers. Brazil may have coined the phrase, but emerging domestic producers are those nations where it is generally expected that future demand will be satisfied as locally as feasible. The Holambra production hub has become highly networked, with quick information flows and trustworthy financial transactions. The forthcoming need of the sizable urban clusters in Sao Paolo and Rio de Janeiro is supplied by growers and industry organizations. Despite its potential, that region's economy is performing worse than other regions', delaying expansion (AIHP, 2019c).

The globalization of the floricultural industry and the dominance of the Dutch floriculture system increase competitiveness and put the floricultural industry's innovation and restructuring under pressure. Continuous evaluation of production and marketing strategies is necessary due to the markets' rising levels of competition and declining profit margins for nurseries (Falla et al., 2020).

With 31.0% of the global value of sales of cut flowers and ornamental pot plants, the EU leads the field, followed by China and the USA with 18.6% and 12.5%, respectively. In the EU, sales of cut flowers and ornamental pot plants peaked in 2016, with the Netherlands leading, followed by France and Italy (Eurostat, 2017).

2.THE GLOBAL FLORICULTURE MARKET

The global floriculture market is projected to reach a valuation of almost US$ 80 Bn by 2029, expanding at a CAGR of about 6.7% from 2022 to 2029. The market is predicted to be close to US$ 50 Bn in 2022. Top 5 Suppliers of Floriculture Products account for 45% of the market. The historical period from 2014 to 2021 had a growth rate of 5.9% for the global floriculture market (FMI, 2022).

Key Countries are U.S., Canada, Brazil, Mexico, Germany, Argentina, France, Italy, U.K, Spain, Nordic, Japan, India, China, Malaysia, Australia, Thailand, South Africa, Turkey. Key Companies are Selecta Cut Flowers S.A.U., Forest Produce Ltd., Native Floral Group, Oserian Group, Tropical Foliage Plants Inc., Esmeralda Farms, DOS GRrINGOS LLC, Flamingo Horticulture

Ltd., Marginpar BV, Danziger Group, Florensis Flower Seeds UK Ltd., Florance Flora and Verbeek Export B.V. (FMI, 2022). Also Kariki, Karen Roses, Multiflora, Harvest Flower, Queens Group, Afriflora, Ball Horticultural, Karuturi Global Ltd., Selecta One, Oserian, Washington Bulb, Carzan Flowers, Arcangeli Giovani & Figlio, Rosebud, Danziger, Sakata, Benary, Oserian and Selecta One are also key companies. Additionally, advancements in cold storage technology, better supply management, and the use of biotechnology to create distinctive and disease-resistant flower types are anticipated to fuel floriculture market expansion (MMR, 2022).

With a vast range of floral varietals, the global market for commercial flowers is quite dynamic, and trade volume contributes 6-9% of the yearly growth rate. Due to globalization, ongoing advancements in plant biotechnology, protected cultivation technologies, transit and marketing conditions, and its impact on income generation in various regions of the world, floriculture has been recognized as a historically maximum hub of activity with competitiveness. When production outpaces demand for floricultural goods, prices are constantly in competition. More than 145 countries throughout the world engage in commercial floriculture. Both in the traditional production nations (the United States, Japan, Italy, Netherlands, and Columbia) as well as in the newest growing economies in Latin America, Africa, and Asia, flower crop production has expanded dramatically (India, China, Vietnam, etc.). The intense rise of the worldwide flower trade is a direct outcome of the fierce competition among the various nations. The overall area under production in the traditional producing nations is either steady or slightly rising. In these nations, floriculture crop productivity has increased. The transformation of the marketing system has increased competitiveness for floriculture products. Historically, flower shops were the principal sellers of these products. Retailers now play a bigger part in society. This has a significant effect on the commercial floriculture industry since it puts pressure on established markets like auctions and retail markets. This progress will be accelerated by the effects of contemporary communication systems (Anumala & Kumar, 2021).

Roughly 145 nations are participating in this industry globally, with western nations including the Netherlands, the United States, Columbia, and Italy serving as the top growers and traders. Netherlands continued to lead the globe in floriculture commerce in 2018, accounting for 43.7% of all exports. Demand and manufacturing have also steadily increased in Asian nations including India, China, Thailand, Japan, Sri Lanka, etc. India ranks 14th in the world for exporting floriculture products and is the second-largest flower-growing nation after China. India, however, only contributed 0.40% of the world's floriculture exports in 2018, which may be because to shortcomings in upholding international quality standards, a lack of integrated cold chain management, and an unorganized market and distribution system (Anumala & Kumar, 2021). East Asia's flower trade and production have grown rapidly since 2000. While Japan has seen a decline in production, China has significantly boosted flower production, exports, and imports. South Korea has recently started importing (Niisato et al., 2020).

From the perspective of product categories, floriculture is classified into four groups: bedding/garden plants, pot plants (including pot flowers and pot greens), cut flowers, and cut foliage. The distribution of various floriculture products differs significantly between nations. In Germany, cut flowers and potted flowers are the most popular floriculture products. Cut flowers and potted flowers are also popular in the Netherlands, the United States, and China (Xia et al., 2006).

Currently, 90% of global floriculture trade is duty-free everywhere: The majority of trade is conducted through preferential trading agreements or free trade agreements with developing nations in Africa and South America (Union Fleurs, 2022a).

Table 1. Export/Import values of major countries in 2020 according to records of Union Fleurs (International Flower Trade Association)

	Export Value (million EUR)	**Import Value (million EUR)**
EU	4.200 (Cut Flowers)	4.100
	4.900 (Pot Flowers)	4.000
US	14	1.052
Japan	-	309
Colombia	1.235	-
Kenya	487	-
Ecuador	721	-
Ethiopia	180	-

China has replaced the Netherlands as the largest producer of floriculture crops and their products, accounting for 19% of global production. The USA (12%), the Netherlands (10%), Japan (8%), and Brazil (5%) are next in line (Adebayo et al., 2020).

Table 2. Flowers and ornamental plants (area, production value and number of enterprises) data of major countries

	Area (ha)				**Production Value**		**Number of Enterprises**	
	In protection	**Open field**	**Total**	**Year**	**Million EUR**	**Year**	**Number**	**Year**
China			184.586	2018	7.739		70.758	2018
US	20.078	8.078	28.155	2017	3.297	2017	39.300	2017
Netherlands	3.920	3.540	7.460	2020	2.379	2019	3.320	2020
Germany	1.703	4.885	6.588	2017	1.391	2019	3.668	2017
Italy	5.443	7.282	12.724	2010	1.269	2019	14.093	2010
Colombia			7.665	2018	1.236	2020		
Japan			17.800					
Spain	2.325	3.896	6.221	2018	961	2019	-	-
France	-	-	6.390	2020	957	2019	3.308	2017
India			313.000					
Ecuador	5.526	931	6.457	2020	741	2020		
Poland	1.525	3.844	5.369	2020	531	2020	-	-
Kenya			4.039		501	2020		

UK	450	6.300	6.750	2020	474	2020	-	-
Ethiopia	-	-	1.695	2017	245	2019		
Portugal	610	1.090	1.700	2010	225	2019	-	-
Costa Rica			3.600	2018	105	2020		
South Africa			11.461		83	2019		
Brazil			15.600	2020			8.300	2020
Thailand			12.324					
World			734.000		34.000		300.000	

Begonias, Geraniums, Impatiens, Pansies/Violas, Marigolds, Petunias, Hardy/Garden Chrysanthemums, Ferns (Hardy/Garden), Daylily, Hostas, Peony, Easter Lilies, Florist Chrysanthemums, Orchids, Poinsettias, Florist Roses, Spring Flowering Bulbs are sold in pots (USDA, 2021).

3. MAJOR POT FLOWER MARKETS

Major pot flower markets are USA, Germany, UK, France, Japan, Italy and Switzerland.

3.1. USA

According to the U.S. Bureau of Economic Analysis' Personal Consumption Expenditures, sales of floral products at all retail locations totaled $31.3 billion in 2015. (2016). According to consumer trends, 20% of Americans buy flowering/green houseplants, and 46% of Americans buy outdoor bedding and garden plants. The wholesale value of sales of floriculture crops in 2020 grew 8% from 2019 according to the 2020 Floriculture Crops Summary, the most recent USDA National Agricultural Statistics Service Summary. The $4.80 billion in floriculture crops are valued at 97 percent in these operations. 24 percent of the overall wholesale value comes from Florida. Following Florida is California with 21 percent and Michigan with 11 percent. New Jersey and Ohio, with 6 and 5 percent respectively, round out the top five states. There were 5,930 manufacturers in 2020, an increase of 14% from 2019. 4,310 of the 5,930 enterprises employed people. There were typically 19 hired laborers at the height of an activity. The largest contributor to overall value sales and accounting for 49% of the reported floriculture crop produced in the United States is the wholesale value of all bedding plant production, which includes herbaceous perennials. The top five states in this group were North Carolina, New Jersey, Florida, Michigan, and California. In 2020, these states accounted for 53% of the entire value of beds and gardens. All bedding and garden plants were worth $2.27 billion at wholesale in 2020, a 13% increase from the previous year. $850 million was the estimated market value of the production of potted flowering plants for indoor or outdoor usage in 2020, an 11% decrease from 2019. Florida accounts for 29% of the value in this category, followed by California with 31%. Poinsettias in pots were worth $157 million, a 3 percent increase from the previous year. Sales of foliage plants reached $756 million in 2020, a 23% increase over 2019. Florida continues to lead in foliage plant production with 69 percent of the total value. Potted foliage plants represent 89 percent of the total foliage value. The remainder of the value is from hanging baskets (USDA, 2016).

The USA is highly self-sufficient in plants, trees and shrubs (AIHP, 2019c). The USDA-NASS estimates that the farm gate value of all ornamentals produced in the United States was €4.94 billion in 2014. Pot plants make up the majority of home production. A conservative estimate for the farm gate value of the projection for domestic output growth through 2030 is just over €6 billion. By 2030, the US ornamentals industry for flowers, plants, and gardening is anticipated to increase by 54%. Canada is in an excellent position to enhance its present export value of €250 million, which consists primarily of pot plants (AIHP, 2019b).

One of the biggest producers of nursery plants and floriculture crops worldwide is the United States. The entire US wholesale value for all producers with $10,000 or more in sales was expected to be $4.63 billion in 2018, with California and Florida being the two biggest states and accounting for nearly half of the value, according to the Floriculture Crops 2018 Summary report (USDA NASS, 2019). Bedding and garden plants had a total wholesale value of $2.16 billion, making them the largest plant category overall. In 2018, the wholesale value of annual bedding plants and garden plants alone reached $1.46 billion, an increase of 13% from 2015 and 67% of the overall wholesale value of bedding and garden plants (Khachatryan & Wei, 2021).

Annual flowering bedding plants were the best-selling plant category in 2019, according to the National Green Industry

Survey, accounting for 12.4% of all industry sales (Khachatryan et al. 2020). Despite this, the sector has recently seen consistently dropping sales as a result of significant industry consolidation, increased price competition, and comparatively poor customer demand (Madigan, 2018).

3.2. China

There is a demand for both potted plants and cut flowers online. The most popular species of container plants, according to the shops, are succulents, Scindapsus aureus, and jonquils. However, the season has a significant impact on sales. Because fall and spring offer the ideal environmental conditions for flowers to last a longer time, the shopkeepers claimed that these seasons see a considerable boost in sales. Young people choose species of pot plants including *Asparagus setaceus*, *Epipremnum aureum*, Jonquil, and succulents. Because the pronunciation of the word "longevity" in the Chinese language is similar to that of the plant "Jonquil," middle-aged people are more likely to purchase such plants. In addition to jonquil, *Epipremnum aureum*, *Pachira macrocarpa*, and Bracketplant are also widely bought by middle-aged persons. Since houseplants serve as air purifiers and decor, the majority of people purchase them primarily for their own usage. When consumers take care of them, they also make them feel accomplished. The fact that purchasing pot plants for air cleaning is quite common can be attributed to the extremely high levels of pollution in China's major cities, including Beijing and

Shanghai. Another factor is that people prefer buying potted plants over cut flowers since they may use them to decorate their homes for a longer period of time (AIHP, 2019a).

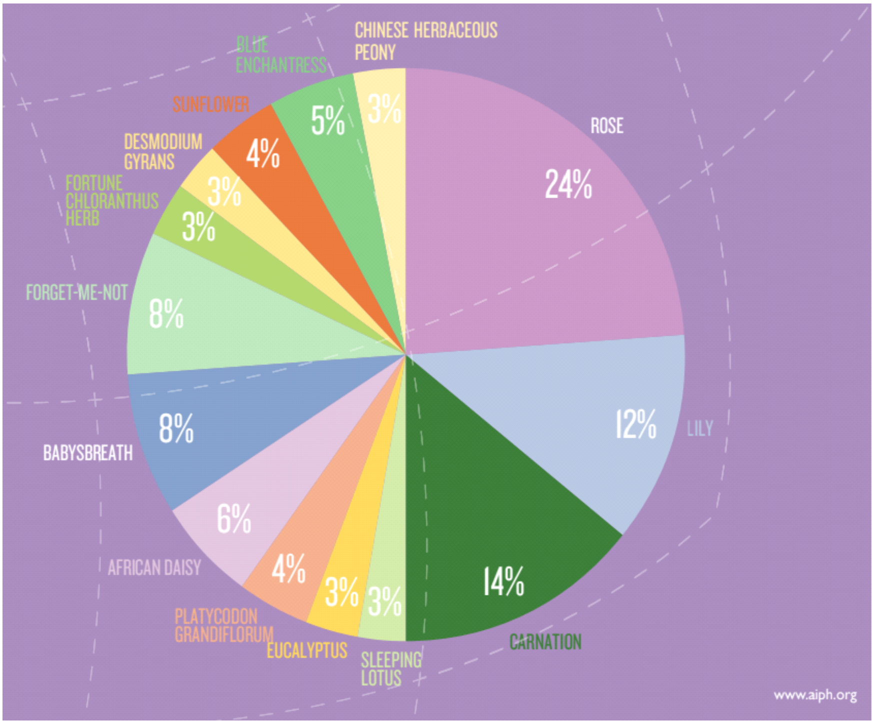

Fig. 2. The proportion of online sales flower species in China in 2016 (AIHP, 2019a)

3.3. EU

The EU has one of the highest densities of flower output per hectare in the world, accounting for 10% of global area and 44% of global flower and pot plant production due to rising levels of flower production and ornamental plant farming. The EU has a net trade surplus for live plants and floriculture products and is a net exporter of pot plants, conifers, hardy perennial plants, bulbs, and corms. It is a net importer of cut flowers and cut foliage (EC, 2020).

Through the system of flower auctions, the Netherlands has served as the global trade hub since the 1950s (Union Fleurs, 2022b). The largest nations in terms of ornamental production and consumer demand are the mature domestic producers. In other words, they are incredibly self-sufficient and are able to meet much of their own need through production. The majority of the time, trading with other countries is an exception, either to meet demand with particular products or during times of seasonal demand surges. Markets with a solid production base and ornaments at the core of their societies' traditions include North East Asia (China and Japan), North America, and Europe, which are home to mature domestic producers (AIHP, 2019b).

3.4. India

One of India's most well-known plant families, the *Orchidaceae*, which has over 1350 species in 185 genera and occurs in a variety of phytogeographical settings including tropical, subtropical, and temperate temperatures with different microclimates, is noted for its tremendous biodiversity. Despite India's abundant natural resources and ideal agroclimatic conditions, orchid-based floriculture hasn't been developed systematically, and the population hasn't yet benefited from this resource despite it having the smallest production area and the smallest share in the overall market for floriculture goods. In reality, India has lagged behind other nations in the trade of orchids. The requirement for a coordinated effort in focused research and development program to develop new hybrid varieties suitable for the country's various agroclimatic conditions, involving various institutions of excellence in developing climate-specific hybrids of temperate cymbidiums and paphiopedilums, tropical dendrobiums and vandas, intermediate cattleyas and phalaenopsis, as well as other ornamental native species for both cut flowers and pot plants, as well as their cultivation methods Additionally, it has been claimed that the R&D program for medicinally significant orchids could help increase commercial production. For the growth of a thriving orchid industry, a robust extension program of the technology- and market-driven approach has been proposed to reach the stakeholders, farmers and growers, in villages and urban clusters and involve the communities in promoting cultivation and production of the commercial orchids. The corporate sector has been encouraged to develop high-quality planting materials in big quantities, distribute them to growers and farmers in rural and urban clusters, and promote their products to benefit society and the Indian orchid industry (Hegde, 2020).

One of the top global suppliers of young plants for cut flowers, potted plants, and vegetable seeds is Florance Flora. Over 200 acres of cropland, including 75 acres of covered cultivation in greenhouses, are spread across 7 farms in India. Among a select group of health-conscious consumers, edible flowers including citrus blossoms, hibiscus, lavender, roses, and nasturtium are becoming more popular. These blossoms are abundant in vitamin C and antioxidants, which lower cholesterol levels, promote the health of the skin and hair, and improve heart function. The worldwide floriculture market offers new potential for producers to grow their operations due to the rising popularity of flowers as a healthy food ingredient. Marco Ravera, a producer in Italy that cultivates aromatic plants, plans to expand its floriculture business footprint by adding edible flowers to its product portfolio. Currently, it has allocated around 15% of its organic farm for production of edible flowers (FMI, 2022).

The Indian government has classified floriculture as a sunrise sector and given it the distinction of being entirely export-oriented. Floriculture has developed into one of the key economic trades in agriculture as a result of the steadily rising demand for flowers. Therefore, commercial floriculture has developed into a high-tech activity that takes place inside a greenhouse under controlled climatic conditions. India's floriculture industry is believed to have a strong growth potential. From an export perspective, commercial floriculture is becoming more significant. The rise of cut flower industry that is focused on exports was made possible by the liberalization of industrial and trade regulations. The ability to import planting materials of foreign types was previously made possible by the new seed policy. Commercial floriculture has been proven to have greater potential per unit area than the majority of field crops, making it a successful business. In 2021–2022, the nation exported 23,597 MT floriculture goods to the world, valued at 103 USD million. During 2021–2022, the biggest importing nations of Indian floriculture were the United States, the Netherlands, Germany, the United Kingdom, the United Arab Emirates, and Canada. Individual Sub-Products include Cut Flowers for Bouquet/Fresh, Moosses & Lichens for Bouquet/Fresh, Tubers, Tuberous Roots, Chicory plants, Unrooted Cuttings, Edible Fruit Trees Grafted or Not, Cactus, Rhododendrons (Grafted or Not) Fresh, Plant for Tissue Culture, Flowering Plants, Live Mushroom Spawn, and Plant for Tissue Culture. India has a number of agroclimatic regions that are ideal for growing delicate and sensitive floriculture goods. Following liberalization, floriculture companies made significant strides in the export sector. Production of commercial goods has dynamically shifted in this era, replacing production of food. United States, Netherlands, Germany, United Kingdom, United Arab Emirates, Canada, and Italy were the top importers. In India, there are more than 300 units focused on exports. The four states of Tamil Nadu, Madhya Pradesh, Andhra Pradesh, and Karnataka produce more over half of the crops used in floriculture. With technical assistance from foreign businesses, the Indian floriculture industry is ready to grow its market share in international trade (APEDA, 2022).

3.5. Thailand and Vietnam

A third of Thailand's production base, which is spread across about 14,000 hectares, is devoted to growing orchids. Although there are few and unreliable production figures, anecdotal evidence suggests that volume and value are consistently rising and that both domestic demand and export are expanding. Climate change is causing problems for Thailand. In the autumn of 2017, there was little to no rain, which led to issues with draught as well as flooding when there was a sudden rainfall since the soil was compacted by prolonged draught. Methylbromide is presently used extensively by farmers. Incorporating alternatives into IPM growth procedures is a good idea. According to the government, growers generally face significant production and logistics costs. The government sees an opportunity for involvement in cost reduction in these two areas (AIHP, 2019b).

A 22,000 hectare agricultural base with a 2016 farm gate value of €500 million is located in Vietnam. The tropical environment of the nation, where many ornamentals survive well with the exception of temperate ones, gives it an advantage in meeting the rising local demand. As technology advances, farmers are beginning to diversify their crops and varieties. The concentration of farmers on plant components for the pharmaceutical and aromatic processing industries is a particularly noticeable trend. Due to its extensive coastline and low height, Vietnam is one of the nations most vulnerable to climate change and increasing sea levels (AIHP, 2019b).

4. POT FLOWERS

Potted plants include succulents, ornamental plants, ground cover plants, garden trees, and bedding plants (Choi et al., 2019). Plants with attractive leaves and blossoms, such as flowering plants, foliage plants, and orchids, such as cyclamen and phalaenopsis, are referred to as "ornamental plants." There were several orchid plants on exhibit, with phalaenopsis making up the majority. Among numerous flowering plants, orchids are frequently used as potted flowers (Park et al., 2011), and phalaenopsis is well-liked all over the world (An et al., 2017). Mosses are considered "ground cover plants," whereas aquatic plants and herbs are considered "others." According to Kim and Lee (2009), "ground cover plants" are mostly employed as landscaping elements in flower beds and along roadways. New cultivars are frequently developed and marketed with regard to vegetation restoration and urban scape (Choi and Ahn, 1998).

Begonias, Geraniums, Impatiens, Marigolds, Pansies/Violas, Petunias, Hardy/Garden Chrysanthemums, Daylily, Ferns (Hardy/Garden), Hostas, Peony, Florist Chrysanthemums, Easter Lilies, Orchids, Poinsettias, Florist Roses, Spring Flowering Bulbs are sold in pots (USDA, 2021).

Open data is not available on pot plant production per plant species but to get an idea about major plant species please see the Table 4, 5 and 6, here below.

Table 4. Top selling pot plants in wholesale markets in 2020 (Plantion, Netherlands) (Pot plants by turnover) (AIPH, 2021).

	Turnover (In million EUR)	**Quantity (In million pieces)**	**Average price (EUR/piece)**
Phalaenopsis	6,0	2,0	2,93
Arrangements	3,4	0,9	4,02
Viola	2,1	4,9	0,43
Chrysanthemums	1,2	1,0	1,18
Pelargonium	1,7	1,9	0,89
Anthurium	1,4	0,5	2,75
Kalanchoe	1,3	2,0	0,63
Hyacinthus	0,8	1,5	0,55
Carnations	1,4	1,2	1,20
Hydrangea	1,0	0,3	3,02
Primula	0,2	0,3	0,64

* Source: Plantion, 2021

Table 5. Top selling pot plants in wholesale markets in 2019 (Royal FloraHolland, Netherlands) (Indoor and outdoor plants (clock sales) by turnover) (AIPH, 2021).

	Turnover (In million EUR)	**Quantity (In million pieces)**	**Average price (EUR/piece)**
Phalaenopsis	61.4	21.7	2.83
Hydrangea	13.3	5.4	2.46
Kalanchoe	13.3	23.3	0.57
Anthurium	12.4	5.0	2.50

Rosa	14.3	15.7	0.91
Arrangements	14.7	5.1	2.87
Hyacinthus	6.8	12.5	0.54
Rhododendron	7.7	5.1	1.52
Cyclamen	6.2	8.8	0.71
Chrysanthemum	7.2		
Dracaena	6.2		

Table 6. Top selling Indoor and outdoor plants in wholesale markets in 2019 (Royal FloraHolland, Netherlands) (sales figures (clock and direct sales)) (AIPH, 2021).

	Quantity (in 2019) (In million pieces)	**Quantity (in 2015) (In million pieces)**
Phalaenopsis	117.5	124.6
Kalanchoe	88.4	87.1
Hyacinthus	35.7	50.0
Rosa	48.8	47.5
Chrysanthemum	43.6	42.2
Cyclamen	25.2	31.9
Hedera	24.8	28.5
Narcissus	18.7	26.3
Begonia	16.8	17.9
Spathiphyllum	18.9	17.0
Dracaena	14.4	15.7

* Source: Royal FloraHolland, 2020

5.1. *Begonia*

Over 2,000 different species of begonia have been identified, and they are widely distributed throughout the tropical and subtropical regions of Central and South America, Asia, and

Africa. Begonias are essential aesthetic plants used as garden plants, pot plants, hanging basket plants, and plants for indoor décor. They are primarily perennial herbs with thick rhizomes or tubers. Commercial growers have introduced over 200 species, including *Begonia semperflorens*, *B. tuberhybrida*, *B. elatior*, *B. cheimantha*, and *B. socotrana*. Begonias are simple to grow vegetatively by splitting, taking stem, leaf, or top cuttings. The most popular of these traditional multiplication techniques for Begonia are leaf cuttings; they are also employed by a number of other species that can develop adventitious buds and roots on severed leaves (Nhut et al., 2010).

5.2. Geraniums

The family *Geraniaceae* includes various species of Pelargonium (Geranium). The Pelargonium genus has over 280 species, the majority of which are indigenous to South Africa. In North America and Europe, geraniums are among the most widely used potted and bedding plants, accounting for 25% of the national market in France and more than 150 million plants annually. The extensively grown Pelargonium can be divided into four main categories: aromatic leaf species and cultivars, P. x hortorum (zonal geranium), P. x peltatum (ivy-leaved geranium), and P. x domesticum (florist geranium). With 25% of the domestic French market, geraniums (*Pelargonium* spp.) are one of the most popular bedding and pot plants. On the one hand, *Pelargonium* are subject to disease pressure as vegetatively propagated plants.

However, interspecific hybridization poses certain challenges for innovation (Dorion et al., 2010).

5.3. *Poinsettia*

One of the most well-liked ornamental pot plants is the poinsettia (Euphorbia pulcherrima). Cuttings are utilized for traditional propagation, which is often concentrated on the time before the busiest selling season. The cultivation of pathogen-free plants, the rapid introduction of novel cultivars (cvs.) with desirable features, and the rapid multiplication of elite clones all serve as significant driving forces in the poinsettia industry. In the United States, Canada, Australia, and several European nations, such as France, Norway, and the United Kingdom, poinsettias are now the most widely used Christmas ornamental plants (1, 2). Poinsettias generated 170 million dollars in sales for the U.S. economy in 2006 and substantially more for the economies of other nations (Castellanos et al., 2010).

5.4. *Anthurium*

For many years, anthuriums have been grown for cut flower arrangements. They have lovely foliage and are rather simple to grow. Anthuriums produce year-round, long-lasting flowers in the proper climate. Anthuriums are grown all over the world, with the United States and the Netherlands producing the most of them. Almost all pot type Anthuriums on the market today were generated using tissue culture (Maira et al., 2010). The principal export destinations for anthuriums are the United States, Japan, and Europe (especially Germany and Italy). The Netherlands is the world's largest producer and supplier of anthuriums. Mauritius is the second-largest exporter, supplying goods mostly to the Japanese market but also to Europe and, more recently, the United States (Pizano, 2003).

5.5. *Orchids*

Several genera and species of the *Orchidiaceae* are included in the category "orchids," the most significant of which are *Dendrobium*, *Cymbidium*, *Phalaenopsis*, *Oncidium*, and *Vanda*. In 2001, Thailand, Singapore, Malaysia, and New Zealand were the top exporters (Pizano, 2003).

5.6. *Chrysanthemum*

Chrysanthemum x *grandiflorum* (Ramat.) Kitam. (synonyms: *Chrysanthemum* x *morifolium Ramat*., *Dendranthema* x *morifolium Tzvelev*., *Dendranthema* x *grandiflorum*, Chrysanthemum sinense) belongs to the Asteraceae family and is also known as the “florist’s chrysanthemum” or “mum.” Chrysanthemums come in a wide variety of varieties with various flower colors and designs. There are numerous cultivars of cut flowers, potted flowers, and garden flowers, making them one of the most economically significant flowers in the world (Nencheva, 2010). In the majority of nations, chrysanthemums are regarded as one of the most significant cut and potted flowers.

The consumer expects to see compact, inflorescence-filled plants that are tiny in size. Plant growth inhibitors are increasingly being used by growers to meet these demands (Kentelky et al., 2021). In terms of sales volume on the Dutch market, potted chrysanthemums are in seventh place (Huylenbroeck, 2010).

5.7. *Phalaenopsis (Moth Orchid)*

Phalaenopsis, also referred to as the "Moth Orchid," is particularly well-liked by commercial and enthusiast gardeners. The tropical rainforests of Australia, New Guinea, South and SouthEast Asia are home to phalaenopsis orchids. They are epiphytic monopodial plants with a small number of leathery leaves. It is unquestionably the most significant commercially cultivated orchid genus. Worldwide plant sales of millions of units every year have greatly increased the pot flowering plant market. Phalaenopsis species and hybrids are gradually becoming more in demand. According to estimates, German in vitro facilities alone generated more than 31 million Phalaenopsis species or hybrid plants in 2004 (Winkelmann et al., 2006).

Since Phalaenopsis is a monopodial genus, it rarely produces offspring. They occasionally generate vegetative offsets from the stem or inflorescence axis, known as keikis (from the Hawaiian term for "small child"), under bad culture conditions. So, in this genus, large-scale natural clonal replication is not feasible. As a result, the only technique for high frequency regeneration of this plant is in vitro clone propagation (Sinha et al., 2010).

5.8. *Cyclamen*

An economically significant ornamental pot plant, cyclamen (*Cyclamen persicum*) is also used locally as a cut flower. Although it is typically reproduced through seeds, vegetative propagation of parental lines as well as superior single plants are being studied. For several cyclamen cultivars, somatic embryogenesis is an effective in vitro propagation technique. Cyclamen is well-known as an indoor-only ornamental pot plant in Europe and Japan, and its annual global production is estimated to be between 150 and 200 million plants. Traditionally, cyclamen are propagated through the use of seeds, which are costly (up to 0.20 € per seed) and created through manual pollination. Since cyclamen are suffering from inbreeding depression, the production and propagation of parental lines of F1 hybrids dominating the market are difficult. Thus, breeders are interested in the vegetative propagation of their breeding lines. Cyclamen cannot be propagated from cuttings or tuber division (Winkelmann, 2010).

5.9. *Ranunculus asiaticus* L.

A popular cut flower and pot plant is the attractive species of *Ranunculus asiaticus* L., which is a member of the *Ranunculaceae* family. Its natural range is from the Greek Islands to Turkestan in the eastern Mediterranean basin. From there, it spread to the western half of Europe, South Africa, California, Israel, and Japan. An essential ornamental plant, *Ranunculus* *asiaticus*, is mostly grown in nations bordering the Mediterranean Sea. This plant has primarily reproduced thus far through tuberous root division and seed, but both of these methods have numerous disadvantages. An appealing alternative for expediting the replication of chosen and indexed genotypes is tissue culture (Beruto, 2010).

5.10. *Myrtus communis*

The evergreen shrub myrtle (*Myrtus communis* L., *Myrtaceae* family) is well known for its usefulness in a variety of fields. It is a significant medicinal plant for the flavor and essential oils that are extracted from the leaves, whose active principles are used in the chemical and pharmaceutical industry. The production of green cut branches for use as inside décor and the growth of potted plants for gardening are both considered to be ornamental uses. Around the Mediterranean coasts, this species' natural germplasm exhibits significant variation in terms of fruit type and size, plant architecture, leaf size, and internode length. Selected genotypes have successfully undergone sterilization and in vitro culture (Ruffoni et al., 2010).

5.11. *Passiflora*

Passiflora species and hybrids are sold as garden pot plants in the Italian floricultural market and are propagated using in vitro culture methods (Pipino et al., 2010).

6. DEVELOPMENT OF NEW VARIETIES

For the cut flower and pot plant industries to remain competitive, new native cut flowers must be introduced. As an example, Australian native flowers, such as *Conospermum* (smokebush), *Pimelea physodes* (Qualup bell), *Verticordia* and *Chamelaucium* (waxflower) offer many colours, forms and types that have potential as cut flower and pot plants. The Western Australian Department of Agriculture and Food has targeted these species. Surveys, propagation, culture, and post-harvest evaluation have all been a part of the selection process. Out of the 53 species in the genus smokebush, 12 species were found to have the ability to grow as cut flowers and container plants. These were reduced to 5 species after further analysis and surveys, which included both blue and white smokebush (*Conospermum eatoniae* and *C. triplinervium*). Other native Australian species have been chosen using comparable procedures. For the successful propagation of blue smokebush, tissue culture methods were required in addition to unique cultivation methods including trellising to control stem formation. According to test marketing, blue smokebush is best suited to the ikebana industry, although white smokebush can be used as a filler flower and to draw attention to the blue color in arrangements. Waxflower is used as a filler flower, while qualup bell and various Verticordia are more prominent cut flowers. Potted waxflowers are being successfully marketed on the

European and US pot plant and amenity or landscape flower markets (Seaton et al., 2007).

7. TROPICAL FLOWERS

A set of plants indigenous to tropical and subtropical regions of the world that are distinct from conventional floral products like roses, chrysanthemums, and carnations are collectively referred to as "tropical flowers" as a whole. For the most part, this group of ornamentals consists of birds-of-paradise (*Strelitzia* sp.), gingers (*Alpinia* sp.), heliconias (*Heliconia* sp.), anthuriums (*Anthurium* sp.), and occasionally orchids (several genera and species). Many flower buyers view tropical flowers as exotic and uncommon, and therefore should have a very good market potential, especially in temperate nations. However, they have not taken off or expanded as quickly or easily as anticipated. Their size, weight, and storage temperature requirements, which differ from those of traditional products and necessitate particular shipping and post-harvest handling procedures, as well as growers' difficulties, which typically involve propagation, are some of the issues encountered in their production and commercialization. Holland is currently the world's largest producer of tropical flowers, and it is also where the majority of production research and breeding has traditionally been done. Locations with better conditions, on the other hand, where production can be more affordable and for which it is practical to ship flowers by air, are quickly becoming significant suppliers.

Holland, Costa Rica, Ecuador, Mauritius, the United States (Hawaii), Ivory Coast, and Cameroon are among the major producers, the majority of which are also exporters. On a smaller scale, these flowers are also supplied to the global market by Jamaica, Colombia, Mexico, the Dominican Republic, Malaysia, Singapore, New Zealand, and Australia. The biggest purchasers of tropical flowers globally are the United States, Japan, and European nations, particularly Germany and Italy (Pizano, 2003).

8. PROBLEMS RELATED TO POT FLOWER TRADE

In the spring of 2017, petunia plants with peculiar orange flowers were discovered on the European market and were later determined to be genetically modified (GM) by the Finnish authorities. Numerous GM petunia types with orange flowers were discovered later in 2017 during inspections and controls conducted by several official laboratories of national competent authorities in the European Union, along with another set of strangely colored flowers (Voorhuijzen et al., 2020).

The Finnish Food Safety Authority has discovered genetically modified (GM) petunia plants imported from businesses in Germany and the Netherlands on the Finnish market. Following that, GM petunia plants were found in other EU nations. Experts have determined that there is very little risk associated with GM petunia plants in terms of both the environment and the food and feed supply chain. However, the existence of GM petunia plants on the European (EU) market is regarded as illegal because the

EU's competent authorities have not issued any permits for their sale or cultivation. As a result, all GM petunia plants discovered on the EU market must be discarded and destroyed. However, given that no registration of commercial names for petunia varieties is currently mandatory, the potential identification of GM petunia events based on commercial names is complicated by the fact that a single petunia variety may have several different commercial names and vice versa (Fraiture et al., 2019).

It is essential to consider how higher temperatures affect ornamental plants' photosynthetic activity and flowering. The photosy*nthetic activity of Agastache urticifolia, Petunia x* hybrida, *Capsicum annum, Plumbago auriculata*, and *Catharanthus roseus* plants significantly decreased as temperature increased from 20 to 40 C. (Niu et al., 2006). The annuals *Tagetes erecta, Antirrhinum majus, Nemesia foetans, Heliotropium arborescens, Nicotiana alata, Diascia barberae, Matthiola incana,* and *Osteorpermum* ecklonis dramatically shortened their duration to anthesis despite temperature rises from 14 to 26 C (Vaid & Runkle, 2013).

Antirrhinum majus, Calendula officinalis, Impatiens walleriana, Torenia fournieri, and *Mimulus x hybridus* plants cultivated at 32 C compared to those grown at 20 C had considerably fewer flowering buds and smaller flowers (Warner & Erwin, 2005). The generation of pigment is influenced by temperature during plant growth, which has an impact on blossom color. Low to medium temperatures are better for controlling anthocyanins, while temperatures above 40 C greatly inhibit their production and, thus, color intensity (Hegde et al., 2020).

9. CONCLUSIONS

The proportion of different floriculture products varies greatly between countries. The main pot flower centers are Netherlands, USA and China. Main demand markets which traditionally are concentrated in the high-income regions which have an additional advantage of networked logistic hubs to import or trade large volumes of perishable ornamentals -such as Japan, Netherlands, USA, EU, China. Core global cities such as Tokyo, London, New York, Paris, Shanghai, Hongkong, Sydney and Singapore demand growth for ornamentals.

The EU holds the first place in cut flower and ornamental pot-plant sales with 31.0% of the global value, with China and USA in second and third place at 18.6 and 12.5%, respectively. Within the EU, in the year 2016, the Netherlands had the most cut flower and ornamental pot-plant sales.

Main pot plant species are *Phalaenopsis, Kalanchoe, Hyacinthus, Rosa, Chrysanthemum, Cyclamen, Hedera, Narcissus, Begonia, Spathiphyllum, Dracaena, Anthurium, Hydrangea, Campanula, Ficus, Rhododendron, Arrangements, Buxus, Zamioculcas, Dendrobium.*

Key Countries are U.S., Canada, Mexico, Brazil, Mexico, Argentina, Germany, Italy, France, U.K, Nordic, Spain, Japan, China, India, Malaysia, Thailand, Australia, South Africa, Turkey.

Key Companies are Forest Produce Ltd., Selecta Cut Flowers S.A.U., Native Floral Group, Tropical Foliage Plants Inc., Oserian Group, Esmeralda Farms, Marginpar BV, DOS GRrINGOS LLC, Flamingo Horticulture Ltd., Danziger Group, Florensis Flower Seeds UK Ltd., Verbeek Export B.V., Florance Flora, Kariki, Multiflora, Karen Roses, Harvest Flower, Queens Group, Ball Horticultural, Afriflora, Karuturi Global Ltd., Oserian, Selecta One, Washington Bulb, Arcangeli Giovani & Figlio, Carzan Flowers, Rosebud, Benary, Danziger, Sakata, Oserian, Selecta One.

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CHAPTER 7

INNOVATION IN THE CONTROL OF GRAPEVINE PESTS AND DISEASES

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1. INTRODUCTION

Viticulture is a living phenomenon from the past to the present. People produced grapes in different main lands and evaluated these products according to their own cultural structures. Considered as the homeland of the grapevine, Anatolia is located in a suitable climatic zone (39°00′N 35°00′E) for viticulture, but it is one of the countries that have placed in grape production in the world. The amount of total grape production of Türkiye was approximately 3.670 million tons in 2020. This figure constitutes 1/5 of the country's total fruit production (Anonymous, 2021a; b). Grapes have an important place in export as both fresh and dried products. In 2020, 2.2 million tons of 70 million tons of fresh grape exports were made by Türkiye. When we look at the export of raisins, a total size of about 3 million tons was reached in the world in the same year, and 73% (2.1 million tons) of this figure belongs to Türkiye (Anonymous, 2021a). Although there are too many grape names to count, 20 varieties stand out both in terms of commercial meaning and prevalence and awareness. Sultani Seedless, which constitutes an important part of its national production, has 40% of the market share.

In order to obtain healthy and quality products, many cultural processes (pruning, fertilization, spraying…) are carried out in the vineyards. One of the most important inputs in production is the activities carried out to keep diseases and pests under control. Under the heading of struggle, different methods such as physical, mechanical, chemical, biological and biotechnical can be used. These methods, alone or together, support sustainable agricultural activities under the heading of integrated struggle. However, chemical control and pesticide use have generally been the first choice for reasons as the way it is applied and the visibility of the result. Especially after World War II, in the field of chemicals, the amount of use increased in parallel with the increase in the number of active substances (Aksoy, 1982). Today, 4 million tons of pesticides are used worldwide and around 60 thousand tons of pesticides are used in Türkiye (Anonymous, 2019a). This growth has brought about several issues, including pest and disease resistance, as well as detrimental effects on both human and environmental health. In addition, it has brought the problem of pesticide residues, which is one of the important problems experienced in grapes with economic value, to the agenda. Faulty practices have negative effects on the country's economy, environment and public health.

During the growing season for vines, numerous diseases (caused by fungal, vıral and bacterial agents) and pests are experienced (Table 1). There is no effective control method for diseases caused by viruses and bacterial agents (Figure 1a; f). It is critical to establish a vineyard with virus-free and certified saplings because of this. In addition, attention should be paid to the irrigation method, sterilization of pruning tools, grafting material and vector insects that cause the transmission of these factors.

Weeds should not be ignored. It is important to keep it under control because it competes with the cultivated plants and causes the interruption of agricultural activities.

Table 1. Common diseases and pests in vineyards

Diseases	• *Uncinula necator* (Schw.) Burr. • *Elsinoe ampelina* (De Bary) Shear. • *Plasmopara viticola* (Berk. Et Curt) Berlet De Toni • *Botrytis cinerea* Pers. • *Stereum hirsutum* Pers., *Phellinus igniarius* Quél., *Phaeoacremoniumaleophilum*W. Gams, Crous, M.J. Wingf. & Mugnai., *Phaeomoniella chlamydospora* Crous & W. Gams • *Agrobacterium vitis* (Ophel and Kerr 1990) • *Phomopsis viticola* Sacc. • Rugose Wood Complex • Grapvein leaf roll virus • Grapvein fanleaf virüs • Grapevine Bulgarian latent virus
Pests	• *Viteus vitifolii* Fitch • *Eriophyes vitis* Pgst. • *Planococcus citri* Risso, *P. ficus* (Signoret) • *Tetranychus urticae* Koch. • *Otiorhynchus (Nehrodistus) scitus* Gyllenhal, 1843, O. *peregrinus* Strl., O. *Sulcatus* (F.), O. *anatolicus* Boheman,. 1843, *Megamecus shevketi* Marsch., M. *albomarginatus* Heller, K.M., 1931 • *Lobesia botrana* Den. Schiff. • *Rubiothrips vitis* Priesner, *Thrips tabaci* Lindeman, *Mycterothrips albidicornis* Kenchtel, *Mycterothrips tschirkunae* Jachontov, *Frankliniella occidentalis* Pergande • *Asymmetrasca decendens* Paoli, *Empoasca decipiens* Paoli • *Polyphylla fullo* L., *P. oliveri* , *P. turkmenoglui* Petro • *Arctia villica* Linnaeus, 1758 • *Klapperichicen viridissima* Walker • *Theresimima ampelophaga* Bayle-Barelle, 1808 • *Arboridia erythroneura adanae* • *Sparganothis pilleriana* Schiff.

In viticulture, the dominance of the aforementioned pests and diseases changes according to the geographical location, climatic conditions and vine varieties. Two of the diseases stand out from the others and can cause trouble to the producers at almost every point where viticulture is made; Powdery mildew [*Uncinula necator* (Schw.) Burr.] and Downy mildew [*Plasmopara viticola* (Berk. Et Curt) Berlet De Toni] (Figure 1c,d).

Figure 1. Grapevine pests and diseases symptoms (a: *Phomopsis viticola*, b: *Lobesia botrana*, c: *Plasmopara viticola*, d: *Uncinula necator*, e: *Stereum hirsutum-Phellinus igniarius-Phaeoacremonium aleophilum*, f: Grapevine virus)

Although many harmful factors are mentioned in addition to these two main diseases, the European grapevine moth (*Lobesia* *botrana* Denis & Schiffermüller) stands out among the fruit moths in the order Lepidoptera. This study tried to include evaluations about what has been done in recent years, future and sustainable viticulture within the scope of combating the main pests and diseases that are a problem in viticulture.

2. RESULTS AND DISCUSSION

Viticulture on earth is carried out between 11°- 53° latitudes in the northern hemisphere and 20°-40° latitudes in the southern hemisphere (Winkler et al. 1974). The European grapevine moth (EGVM), *Lobesia botrana* Denis & Schiffermüller (Lepidoptera: Tortricidae) is one of the most important main pests in viticultural geographies. EGVM is a significant pest found in Europe, the Middle East, Russia, northern and western Africa and Japan (Roehrich and Boller, 1991; Loriatti et al., 2011). Adult wingspan is 10-12 mm, length is up to 6 mm (Uygun et al., 2010). The upper wings are patterned in blue, brown, red and olive green colors on a gray background. The lower wings are bright gray with a yellowish and blue sheen. The wing tips have fringes. They spend the winter underground and, depending on the humidity-temperature conditions, emerge from the pupal stage in the first week of March. But all of it depends on the geography. Mating adults can give 3 generations per year, and 4 generations depending on climatic conditions in some regions (Anonymous, 2019). They lay their eggs in clusters and berries. Emerging larvae cause damage by feeding in different phenological periods of the vine throughout the season (Figure 1b). The first generation is fed in the flowering period, the second generation in the berries, and the third generation in the ripening berries. if any the last generation feed on grapillons. In addition to the primary damage, a suitable environment for the development of secondary disease factors (*Botrytis cinerea*, *Aspergillus carbonarius*, *A. niger*) may be created as a result of feeding the larvae on the berries and may increase the severity of the damage (Hocking, 2007). In addition, they clump the berries with the thin filaments they secrete while moving, causing the flowers to fall and the bunches to be sparse.

In order to keep the pest under control, climatic factors, phenology and control options should be well evaluated. First of all, cultural processes; choosing a high level of cultivation, green pruning to ensure good ventilation in the vineyard, controlled irrigation and the density of weeds should be taken into account. For different reasons such as getting fast results in production and being easy to use, the chemical application is the firstly. However, due to the noticed negative effects (food safety, animal and human health, etc.), legal measures have been taken as well as training and extension studies to reduce pesticide use throughout Europe in recent years. Considering especially the scenarios of global warming and climate crisis, the importance of the number and timing of applications in viticulture has increased (Caffarra et al., 2012; Fraga et al., 2013; Soltekin et al., 2021). In this context, targets for the reduction of pesticides and antimicrobials were determined by the European Concil and announced on 11 December 2019 under the name of the European Green Deal (Anonymous, 2021c). Türkiye has joined this agreement in 7 October 2021 to reduce the use of chemical inputs and greenhouse gas emission reductions target for 2030 to at least 50% and towards 55% compared with 1990 levels (Anonymous, 2022a).

Timing and method are the two main characters of pesticide use. Studies on correct timing have gained momentum with the development of advanced technology in agricultural activities since the 1900s and the creation of early prediction and warning models for disease and pest control. Electronic forecast-warning stations work with a GSM modem and a software program to evaluate the data received from the field in a computer environment (Güngör Savaş, 2015). It is actively used for the main diseases and pests in model vineyards. For this purpose, pheromone traps are used to monitor the adult population of the EGVM, and by this means, the peaking and spraying time of the population can be determined. In recent studies, counting and evaluations can also be made remotely through imaging systems placed in traps (Hari, 2014; Lucchi et al., 2018a; 2018b; Ünlü et al.,2019). In addition to the traps, calculations are made with the monitoring of egg hatching, the vine phenology and the sum of effective temperatures. In these models, which are the reflection of agrometeorological and scientific data of pests on the field, the applications made at the right time make the struggle successful.

With this method, the amount of chemical inputs is reduced, and positive contributions are made to environmental health and beneficial activities.

In chemical applications, the method of application is as important as the timing in terms of efficiency. The effectiveness of spraying tools and machines is directly related to the phenology of the vineyard, soil and weather conditions. Sprayers and/or atomizers are generally used to apply pesticides. Frequent use of mechanization for agricultural activities such as spraying, due to the field traffic it creates, adversely affects the health of the vineyard as well as the soil properties. For this reason, the applications of information technologies, called precision agriculture, in different fields of agriculture are becoming more and more widespread (Mattese, 2020; Ezin, 2021). This development in the vineyards is the use of air vehicles, especially in the last period, unmanned aerial vehicles in spraying. With the help of vehicles known as drones, spraying applications for pests and diseases can be advantageously performed in areas with difficult terrain conditions and vineyards with large squares (Bramley and Reynolds, 2010; Berner and Chojnacki, 2017). The opportunities for using this technology to control vineyard pests keep improving (Kale et al., 2015; Ochs, 2020). In particular, studies are focused on eliminating the problems (homogeneous distribution of pesticides and losses due to drifting) experienced due to the negative effects of changing weather conditions (Koç, 2017).

Although there are many known natural enemies of the EGVM within the scope of biological control, their activities differ regionally. *B. thuringiensis*, a soil-borne gram positive *Bacillus* genus, was discovered in 1901 by Japanese researcher Ishiwata Shigetane (Gill et al., 1992). Historically, *B. thuringiensis* was re-identified in Germany in 1911 by Ernst Berliner, who isolated it from *Bomyx mori* (L.). With the endotoxins they have through protein crystals produced by some bacteria, they destroy the stomach wall cells of insects and prevent them from digesting (Toprak, 2021). Endotoxins are host specific, for example those containing *Bacillus thuriginensis* (Bt); they are effective on the larvae of Lepidoptera and Diptera species (Martinez et al. 2004). In many studies, *Bacillus thuriginensis* var. *krustaki* preparations are used (Glare and O'Callaghan, 2000). Since the beginning of the 20th century, many attempts have been made to control the EGVM with Bt preparations, and successful results have been obtained in applications performed either alone or with different insecticide combinations (Filip and Alexandri, 1977; Roehrich et al., 1979; Dolidze, 1983; Vita et al., 1985; Adamyan, 1991; Navon et al., 1994; Ifoulis and Soultani, 2004). *Bacillus thuriginensis* var. *aizawai* strain also showed similar effects and was commercialized by studying its effectiveness on the EGVM (Ifoulis et al., 2004; Dano, 2005; Kontodimas, 2008; Shahini et al., 2010). The first study with Bt in Türkiye was carried out in the Aegean region vineyard areas in 1974 (Önçağ and Cengiz, 1974). In the subsequent studies, promising evaluations were made in terms of combat possibilities (Kısakürek, 1977; Ataç et al., 1990; Polat, 2006; Aslan and Güzel, 2009).

Species belonging to the Trichogrammatidae family, which are in the Hymenoptera order, are one of the common and effective natural enemy groups of the Lepidoptera order. Approximately six hundred species have been identified so far through systematic studies on the basis of country, region and host (Pinto and Stouthamer, 1994; Öztemiz et al., 2013). Studies conducted between some species (*Trichogramma euproctidis*, *T. evanescens T. euproctidis*) and their hosts since the beginning of the 20th century showed positive results on pests (Özder, 1991; Hassan, 1993; Özpınar and Kornoşor, 1994). With the development of mass production possibilities, it has become one of the biological control options for the EGVM in vineyards (Barnay et al., 1999; 2001; Ibrahim, 2004; El-Wakeil et al., 2009; Moreno et al., 2009; Hommay et al. et al., 2010; Özsemerci et al., 2016; Thieryl and Desneux, 2018). Additionally, studies were carried out using Braconidae (Hymenoptera) species. Studies have reported that this familia species is an ectoparasite of many Lepidoptera individuals. Successful studies have been carried out with *Bracon hebetor* (Say) on the EGVM (Milonas, 2005). Today, with the help of biology, climate and host requests information obtained from parasitoid studies, the success rate has approached 100% and it is used in more vineyards. In add to these species, numerous predators of the EGVM from the orders Neuroptera, Coleoptera, Hemiptera, and Hymenoptera have been identified. Experiment on these predators' behaviors and biology is ongoing.

Downy mildew disease / *Plasmopara viticola* (Berk. Et Curt) Berlet De Toni, which is one of the common disease factors in vineyards, spends the winter on diseased leaves that fall to the ground during the season and the fungus affects all green parts of the vine. The first sign of the disease begins with the observation of yellowish round oil spots on the upper part of the leaves (Figure 1c). On the lower surface of the leaf, a white fungus layer is formed. These leaves turn brown and dry over time and fall before they should. Contaminated clusters similarly change color to brown and dry out. The disease also brings about the weakening of young shoots and the death of shoots. In optimum temperature and humidity conditions for the disease, there may be a yield loss of up to 50% to 100% in vines (Emmett et al., 1992). In addition to cultural, biological and chemical applications, alternative methods based on genetic structure are used in the control against this economically important and devastating disease.

Pruning, cutting the diseased plant parts and removing them from the environment and keeping the humidity under control as much as possible by avoiding excessive irrigation are aimed in cultural practices. In regions with favorable climatic conditions for the disease, it is recommended to carry out a control program by considering cultural practices and prediction-warning systems. The most important principle of combating diseases in viticulture is monitoring and then determining the best and most appropriate method to keep it below the economic level.

As in the EGVM, early prediction and warning systems have been developed in vineyards for Downy mildew. In a review of *P. viticola*, the main Downy mildew models for Decision Support System (DSS) in viticulture is presented. These DSSs are mainly based on information data (static and dynamic, e.g. climate, etc.) by using mathematical models implemented in software algorithms. The Mechanistic Models are; The UCSC (Università Cattolica del Sacro Cuore) model, Downy Mildew forecast model, VitiMeteo-*Plasmopara* biological model, RIMpro-Plasmopara model, POM and SIMPO model, VineSens Model, PV-sensing model (Mian et al., 2021). The system started to be used in Manisa Vineyards in Türkiye in the early 1980s and has been actively used for more than 30 years across the country for monitoring the disease and informing the producers (Güngör Savaş, 2015). Various camera equipments are used for purposes such as detecting and defining the symptoms of the disease, thus determining the application time more accurately and using less labour. Studies with data and vine images of Downy mildew disease have started to appear in journals. (Ghoury S., 2019; Ziha-Khan et al., 2022).

Chemical control in Türkiye is carried out in accordance with the instructions (first spraying, second spraying and others) in the technical instructions for agricultural control (Anonymous, 2022b). In the years when there are optimum conditions for the development and spread of the disease, 8-10 times of fungicide application is not enough and this number can reach up to 15. Chemicals can also be applied as a preventative after infection or before infection. While many active components can be used in conventional viticulture, limited input can be used in organic viticulture (Weitbrecht et al., 2021). In the examinations, *P. viticola* was accepted in the group with a high risk of resistance to fungicides, therefore it is important to be careful (EPPO/OEPP, 1999; Yeşil, 2010).

The negative effects of fungicides have increased the interest in studies with different alternatives in plant health. Compounds such as herbal extracts and essential oils obtained from plants are being tried as alternatives. It has been reported that sage (*Salvia officinalis*) extract can be effective in the fight against *P. viticola* in general and can be used as an alternative in organic agriculture (Dagostin, 2010). It has been emphasized that tea tree and clove oil have the potential to reduce the number of pesticides in integrated control, the amount of copper in organic viticulture and to be used in the control of Downy mildew in general (La Torre A., 2014). Many studies that in vitro and in vivo techniques have been conducted give promising results.

Studies on *Trichoderma* species started with Persoon in the 1970s and the identification of fungi improved with molecular techniques (Persoon, 1974; Druzhinina et al. 2006). Among them, the most commonly used are; Although there are *T. harzianum*, *T. viride* and *T. hamatum*, nearly a hundred species have been identified (Aydın, 2015). When applied 48-72 hours before the mildew inoculation of *T. harzianum* more than once in vineyards; It has been reported that it prevents the disease up to 63% (Perazzolli et al., 2008). Examining the *T. harzianum*'s properties and the mechanism of action against Downy mildew on *Vitis vinifera* cv. Pinot Gris and cv. Pinot Noir, it was observed that these applications activate the defense mechanism in the vines (Perazzolli et al., 2012; Palmieri et al., 2012; El-Naggar et al., 2012). Although there are strengths of the fungus such as hyperparasitism, antibiotic and enzyme production, the commercialization phase, as with other fungal biopreparations, requires more research and a long process. Valuable data have also been obtained in studies with *Bacillus subtilis*-containing preparations, and it has been reported that some breeds which will be commercialized and used as preparations will be effective on mildew (Hao, 2012).

One of the most studied subjects in the fight against diseases is resilience. Resistance is the ability of the plant to resist infection in case of encountering a disease agent (Dolar, 2011). The degree of resistance varies in different species belonging to the same plant genus. Among the vine varieties of the genus *Vitis*, those grown in Anatolia (for table grape and/or for wine) show this diversity in terms of morphology and the chemicals they form.

In the studies carried out with Downy mildew; In vivo and in vitro methods such as leaves and leaf discs plucked by artificial inoculation and durability in natural conditions are used. Most researchers used a mixed population of isolates obtained from vineyards with different cultivars in endurance tests (Gindro et al., 2003; Aziz et al., 2003; Steimetz et al., 2012; Boso et al., 2014; Heerden et al., 2014). Most of the *Vitis vinifera* cultivars are susceptible to Downy mildew, but there are promising cultivars that show resistance. Varieties in *Vitis labrusca* are known to be resistant to Downy mildew (Caddle-Davidson, 2008; Nascimento-Gavioli et al., 2020). Endurance studies with *Plasmopara viticola* are carried out both in natural and artificial conditions, in the form of vineyards, greenhouses, pots, plucked leaves and leaf disc applications. In Türkiye, there are several endurance studies, including local varieties. (Atak 2017; Mermer-Doğu et al. 2022). Studies on the determination of resistance levels to Downy mildew in grape varieties also guide breeding studies. The results of these studies provide significant advantages in the geographies to be bonded.

Another disease factor that is a problem in the vineyards is Powdery mildew disease / *Uncinula necator* (Schw.) Burr. The fungal disease agent spends the winter on the plant and starts its activity with the elongation of the shoots. It creates a gray, dusty appearance on the green parts of the vine (leaves, shoots, clusters) (Figure 1d). As time passes, these parts become black, the leaves curl and the berries dehisce in the diseased bunches, and their economic value decreases. With the deformation in the clusters, it can cause high product and material losses (Zobar and Doğu, 2014). In order to keep this disease under control, in addition to the careful application of cultural measures, chemical applications are recommended at certain periods.

Bacteria, which is one of the factors used for the control of fungal diseases in vineyards, negatively affects both the development and morphological structure of fungal hyphae. Preparations containing *Brevibacillus*, *Bacillus*, *Pseudomonas* and *Pantoea* for different genera have been the subject of research. In a study using thirteen bacterial isolates from these genera; The mixture (formulation E) of *Brevibacillus brevis* RK-342, *Pseudomonas fluorescens* RK-255 and *Bacillus thuringiensis* TV-72F isolates gave the most successful result and showed promise for its use as a biopesticide (Demir and Kotan, 2016). *Bacillus subtilis* and *B. pumilis* are used for this purpose; gram positive, aerobic bacteria. It is one of the bacterial strains that are common in nature and has a high success rate in the fight against Powdery mildew in vineyards (Schilder et al. 2002; Cawoy et al. 2010; Sawant et al., 2011).

Another factor used in biological control is the hyperparasitic fungus *Ampelomycetes quisqualis* (Erysiphales). It has been the subject of numerous studies for more than 50 years on the biological control of Powdery mildew in different cultivated plants (Anonymous, 2021d). This fungal agent prevents the sporulation of Powdery mildew micelles and disrupts the cellular structures of the disease.

Successful results were obtained depending on the climatic conditions in the trials made on the varieties in the genus *Vitis* (Falk et al., 1995a, b). *Ampelomycetes quisqualis* infection occurs in less than 24 hours at 25°C (Sztejnberg et al., 1989; Kiss et al. 2004). Due to the fact that it does not release any toxin during this event, it has been at the forefront of research on biological control agents in vineyards in recent years, and it has been put into use as a commercial formulation (Benuzzi and Baldoni, 2000; Whipps and Lumsden, 2001; Copping, 2004; Lee et al., 2004; Angeli et al., 2008; Legrer et al., 2011; 2015).

Orthotydeus lambi (Baker) (Acarina; Tydeidae) is a species of mite that feeds on fungi. Researchers working with this species; In 1999, different densities of mite populations were applied to vine leaves. They observed that the rate of Powdery mildew disease in grapevines was 85% less than the control (English-Loab et al., 2007). Similarly, positive data were obtained in studies on Chardonnay and Riesling varieties (Melidossian et al., 2005). Although the studies conducted with this species are promising, the possibilities of use seem limited until clear data are obtained on its being a motile organism and its exposure to pesticides to be used for other vineyard diseases.

3. CONCLUSION

Viticulture has a deep history. Economic losses occur in grape production due to diseases, pests and weeds. Pesticides are preferred first in order to prevent these negativities and to obtain high efficiency and quality products. Chemical applications; Over time, it has been understood more and more that it leaves residue on products, the resistance of pathogens, and its negative effects on human health and natural balance. For this reason, in the 20th century, there were an increase in the tendency to limit pesticide application and to different alternatives (biological preparations, resistant varieties, etc.) for sustainable agriculture. Studies agree that many biological agents available in nature are effective when suitable conditions are provided and will be beneficial in viticulture. However, the planet is undergoing dramatic changes. Especially in the global climate crisis scenarios, the water constraints and temperature increases to be experienced in countries located in the Mediterranean Basin, such as Türkiye, are worrying. With the effect of climate change, it is predicted that the useful activity in the vineyards will decrease, as well as the resistance to the EGMV and Powdery mildew diseases. It is thought that the applications to be made on the vines will enable sustainable viticulture by taking into account the integrated control programs for diseases and pests with the follow-up of today's technological developments.

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CHAPTER 8

FUNCTIONAL FOODS: PHENOLIC COMPOUNDS (POLYPHENOLS) AND ITS IMPORTANCE

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1.INTRODUCTION

The group of compounds containing a benzene ring to which one or more hydroxyl groups are attached are called phenolic compounds or polyphenols. All plants produce a large number of phenolic substances as secondary metabolites in their metabolism, but their role in the plant's own metabolism is not known enough. For this reason, there are always various phenolic compounds of different qualities and amounts in all foods of plant origin (Balasundram et al., 2006).

These natural substances, which have a high acidity level and stand out with their antioxidant properties, determine many characteristic features of fruits and vegetables, especially their taste. Phenolic substances, which enable plants to have different aromas and properties, also form natural defense mechanisms against pest and microorganism attacks. Due to the importance of phenolic substances for human nutrition, these valuable compounds are also referred to as Vitamin P in various sources. (Pereira et al., 2009).

2. PROPERTIES OF PHENOLIC COMPOUNDS

The unique bad taste and colors of fruits and vegetables are the cause of the phenolic compounds they contain. Some phenolic compounds also play a role in the formation of bitter taste. Phenolic compounds as food ingredient; It is important for human health in many aspects such as its functions, effects on taste and smell formation, participation in color formation and change, antimicrobial and antioxidative effects, causing enzyme inhibition, and being a purity control criterion in different foods. (Acar, 1998).

Phenolic compounds cause undesirable color changes in foods. The most important of these is enzymatic browning. Enzymes that catalyze these reactions that cause the oxidation of phenolic compounds are generally called polyphenoloxidase enzymes (PPO). Enzymatic browning in foods is generally considered as a loss of quality, and therefore, oxidation of phenolic substances during processing of fruits and vegetables is tried to be prevented by various methods. Phenolic compounds in industry; which are used in many places such as the production of explosives, pharmaceuticals, plastics, paper, paints, drugs, pesticides and antioxidants (Robards, 2003).

3. EFFECTS OF PHENOLIC COMPOUNDS ON TASTE, SMELL AND COLOR

Phenolic compounds can contribute to the flavor and aroma of many foods of plant and animal origin. An important part of phenolic compounds, which are the source of bitterness and acridity in foods, are very important in the formation of the flavor of fruits, vegetables and products obtained from them. Flavonone glycosides are common in citrus fruits. For example, it is a naringin flavanone glycoside that gives the bitter taste in grapefruits. In oranges, naringin and neohesperidin are found in high amounts. Ferulic acid in stored fruit juices gives an unpleasant taste(Hollman, 2001). Some phenolic compounds in foods can cause a crumping and drying sensation on the entire surface of the tongue and buccal mucosa. This sense is considered as acridity. Phenolic compounds that provide acridity can affect the acceptability of foods. Persimmon, mountain plum, cranberry and wine can be given as examples of foods that give a bitter taste in the mouth. If a food provides sourness in the mouth, it is stated that the most important phenolic compounds in it are proanthocyanidins (Gu et al., 2008). Proanthocyanidins can give both bitter and acrid taste. However, the amount of phenolic compounds must be sufficient to give a food a sour and bitter taste. For example, although phloridzin is a bitter phenolic substance and is found in apples, it does not cause bitterness due to its small amount. The bitter taste of persimmon fruit and its products is due to the phenolic compounds proanthocyanidins. The bitter taste is significantly reduced by ripening and freezing and thawing the fruit. A large group of flavonoids has an effect on the color of foods as well as adding flavor to foods. Over 4000 flavonoids have been identified in plants. Foods of plant origin may contain several grams of flavonoids per kg of wet weight. The average daily consumption of flavonoids is estimated to range from 50 mg to 1 g per person, and flavonoids form a regular component of human diets. About half of the total flavonoid ingested are anthocyanins, catechins and oxoflavonoids. Among the flavonoids, anthocyanins are water-soluble natural colorants and are responsible for the pink, red, blue and purple colors of vegetables, fruits, juices and wines. Other flavonoids, such as flavonols, flavones, chalcones, flavanones, isoflavones, and biflavonoids, can contribute to yellow or ivory colors in plants (Samanta et al., 2011). By binding different sugars to 16 different anthocyanidins found in nature, very different colored anthocyanins can be formed. This is why many fruits and vegetables, as well as herbs and flowers, come in such rich colors. In addition, pH, presence of metal ions and copigment, as well as processing and storage conditions affect the color intensity resulting from anthocyanins. Anthocyanins turn purple-red at low pH values and green-blue at high pH values. For this reason, the same anthocyanin can have different colors in various plant tissues. It was determined that the change in pH value affected the color intensity and the maximum color intensity was reached for petanin at pH 8.1. It has been observed that the anthocyanin-induced color can be preserved under different processing conditions. For example, the color stability of petanine isolated from purple potato was determined to be more than 84% after 60 days of storage at 10 °C and pH 4 (Truong et al., 2010). Anthocyanins are found in large quantities in berries such as cherries, cranberries, red grape varieties, and raspberries. The appeal of table grape varieties or wine to the consumer is closely related to the amount of anthocyanin in the berry skin. Anthocyanins; It is found in the skin, which is the outer tissue of the grape, and the color of the skin changes according to the amount of anthocyanin it contains. Different phenolic compound composition of grape varieties, especially flavonols and anthocyanins, are natural pigments responsible for the different hues of red grapes and wines, depending on the type and degree of maturity. It has been stated that there is a decrease in total phenols, catechins and proanthocyanidins during the storage of wine. Anthocyanins are the best known natural food colorants that provide the bright red color of foods and are considered an important alternative to synthetic dyes for coloring many foods (Koponen et al., 2007). Anthocyanin has been used in a wide range of food products (jam, jelly, beverages, ice cream, yogurt, canned fruit, food decorations, confectionery, etc.) as a colorant. The most common sources of anthocyanins as natural industrial colorants are grapes, elderberry, currants, red cabbage and black carrots. It has been observed that the addition of black carrot concentrate to strawberry marmalades is effective in maintaining the color of the product for a long time. Studies on pistachios, a hard-shelled fruit, have shown that phenolic compounds such as myricetin, catechin and epicatechin are present and the color in the membrane layer is caused by anthocyanins. It has been reported that leukoanthocyanidins and leukodelphinidins are effective in the change of golden yellow-brown membrane color, which occurs due to storage and is used as a quality parameter in walnuts. The amount of phenolic compounds in the seed coat of broad beans, peas and cowpea is 7-10 times higher than the whole seed. There is a close relationship between the color of the flower and seed coat and the level of phenolic compounds (proanthocyanidins). Bean varieties that do not contain phenolic compounds are characterized by white seed pods. When some fruits and vegetables such as apples, quinces and potatoes are cut or damaged, their color changes and turns brown after a while. Enzymatic browning, which occurs as a result of the oxidation of phenolic compounds by polyphenoloxidase enzymes, is considered as a loss of quality in foods, and oxidation of phenolic compounds during food processing is tried to be prevented by various methods (Quideau et al., 2011).

4. CLASSIFICATION OF PHENOLIC COMPOUNDS

Phenolic compounds, which can take different names according to their ring structure and structural elements, can be examined in five groups as seen in Figure 1. These; flavonoids, phenolic acids, tannins, stilbenes and lignans (Balasundram et al., 2006).

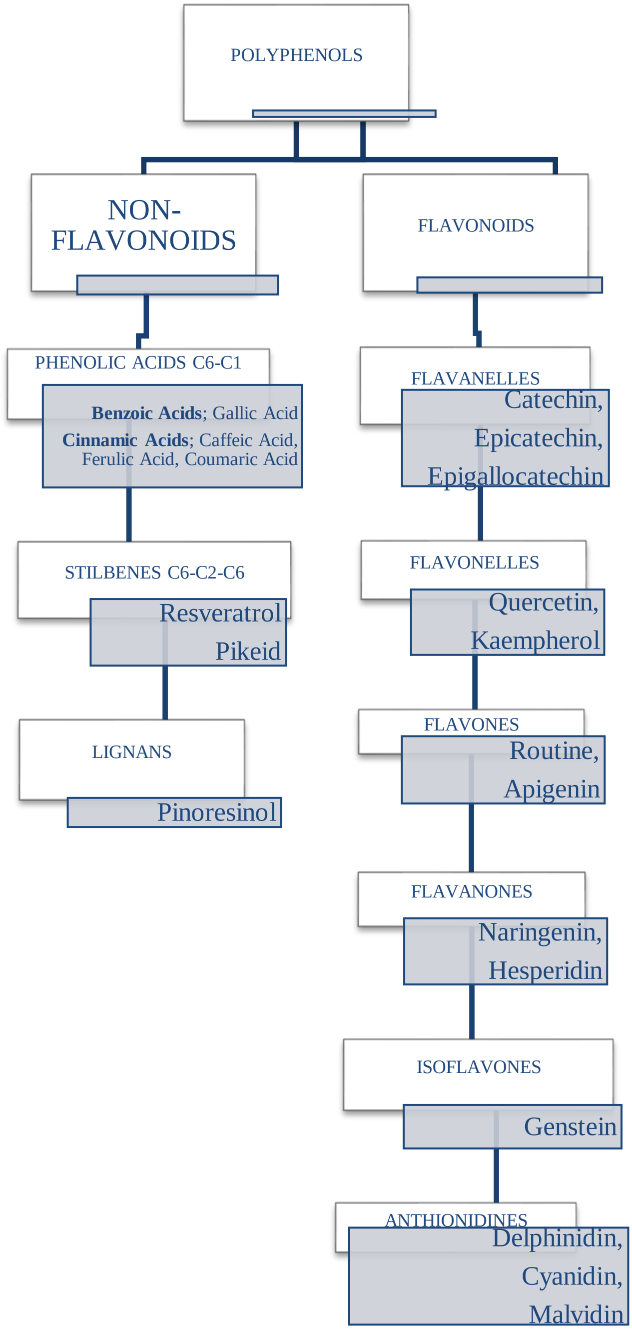


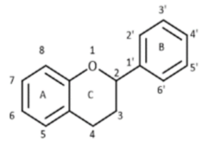
Figure 1. Classification of Phenolic Compounds

4.1. Flavonoids

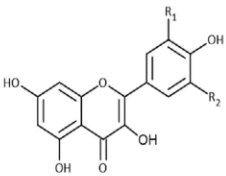
They are formed by the bonding of an oxygen-containing pyrene ring and two benzene rings. It is found in fruits and vegetables, coffee beans, spices. Foods such as green tea, strawberries, broccoli, blackberries can be given as examples of flavonoids with antioxidant effects. When used regularly, they can reduce the rate of spread of diseases such as cancer and heart diseases. Various flavonoids such as anthionines, flavanols and flavones are formed by the different number of attached hydroxyl groups, the degree of unsaturation, and the oxidation level of the ternary carbon. (Rispail et al., 2005).

Antithionines are phenolic compounds that give fruits and vegetables such as blackberries, pomegranates and red cabbage their different colors from pink to purple. In addition, plants have very important functions such as antioxidant effect, reproduction, defense and pollination (Ignat et al., 2011). Flavonols have antioxidant and anti-inflammatory effects and also have beneficial effects in the prevention of ovarian cancer. Isoflavonols are also known as phytoestrogenic. Legumes can be given as an example. Flavanols (catechins), colorless compounds that are most common in foods and can be found in almost every fruit, are called catechins. They are involved as intermediates in the formation of flavonoids. Flavonones are commonly found in citrus fruits. Flavones are light yellow compounds that can be found in almost every plant. In particular, they have a calming and muscle relaxant effect (Naczk and Shahidi, 2004). The chemical structure of flavonoids is given in Figure 2.

Basic flavonoid structure

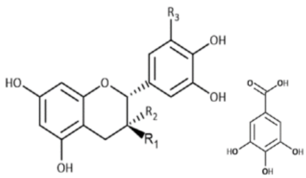


Flavonols



	R_1	R_2
Kaempferol	H	H
Myricetin	OH	OH
Quercetin	OH	H
Isorhamnetin	OCH_3	H

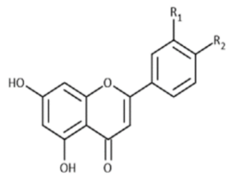
Flavanols (Flavan-3-ols, catechins)



galloyl

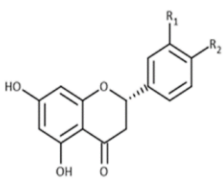
	R_1	R_2	R_3
(+)-catechin	OH	H	H
(-)-epicatechin	H	OH	H
(-)-epigallocatechin	H	OH	OH
(-)-epicatechin gallate	H	galloyl	H
(-)-epigallocatechin gallate	H	galloyl	OH

Flavones



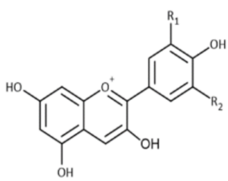
	R_1	R_2
Apigenin	H	OH
Luteolin	OH	OH
Chrysin	H	H

Flavanones



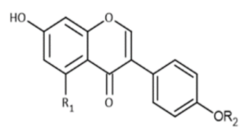
	R_1	R_2
Naringenin	H	OH
Hesperetin	OH	OCH_3
Eriodictyol	OH	OH

Anthocyanidins



	R_1	R_2
Cyanidin	OH	H
Delphinidin	OH	OH
Malvidin	OCH_3	OCH_3
Pelargonidin	H	H
Peonidin	OCH_3	H
Petunidin	OCH_3	OH

Isoflavones



	R_1	R_2
Daidzein	H	H
Genistein	OH	H
Glycitein	OCH_3	H

Figure 2: Chemical structures of flavonoids

4.2. Phenolic Acids

They can be found both tied and free. Generally bound phenolic acids are divided into two according to the OH and OCH3 groups they contain. Hydroxycinnamic acids are found in various plants such as coffee, thyme, sage, apple, anise. They show antimicrobial, anti-carcinogenic and antidiabetic effects. Hydroxybenzoic acids, hydroxybenzoic acids formed by the oxidation of hydroxycinnamic acids, are phenolic acids that are found in very little or no presence in the structure of plant foods (Mattila and Hellström 2007).

4.3. Tannins

Tannins, also known as tannic acid, are soluble in water. They are antiseptic compounds obtained from plants such as broad bean, oak and tea. They are found in the roots, wood, leaves and fruits of plants. Polyphenolic antioxidants found in berries, some teas and herbs prevent heart diseases and tumor development. In addition, thanks to their astringent effect on vessels and mucous membranes, they are included in the composition of drugs for tonsils, pharyngitis, hemorrhoids and some skin diseases (Selma et al., 2009).

4.4. Stilbenes

The most commonly used compound among stilbenes is resveratrol. Plants such as grapes, peanuts, and mulberries release resveratrol under intense stress. In addition, resveratrol, which has many benefits to human health such as antioxidant, antiviral, slowing aging, reducing obesity, is frequently used in medicine and pharmacy (Armatu et al., 2010; Cassidy et al., 2000).

4.5. Lignans

Lignans, which are abundant in flaxseed and oily grains, have approximately the same effect as stilbenes (Shahidi and Ho, 2005).

5. IMPORTANCE OF PHENOLIC COMPOUNDS IN TERMS OF FOOD QUALITY

It is due to the fact that they participate in the enzymatic browning process in fruits and vegetables as a substrate, cause color change by reacting with metal ions, are the source of the sour taste perception in foods, polymerization or react with proteins to form deposits.

6. FUNCTIONS OF PHENOLIC COMPOUNDS

Coloring the tissues where they are synthesized and secreted, transferring electrons and protons to the electron-transport chain in oxidation and reduction reactions, photosynthesis and respiration, stimulating and inhibiting the growth of height, seed formation, playing a role in the formation of supporting materials of cells and tissues, important polymer of mechanical tissues.Lignin forms the structure of the cell wall. Phenolic compounds play an important role in fulfilling the conservation function in plants, in chemical interactions between organisms, in antibacterial and antifungal activities. Phytoalexins synthesized against pathogenic fungi in plant cells are also phenolic components. They serve to maintain the health of plants (Pietta, 2000).

Phenolic components are localized in epidermal cells, absorb ultraviolet rays, protect the cell membrane from UV radiation. The phenolic components in the structure of flavonoids absorb short-range (280-320 nm) sunlight, and the epidermis cells of the leaves do not absorb 70-80% of visible light and 95% of UV rays thanks to these compounds. The biosynthesis of phenolic compounds is guided by the inheritance of necessary enzymes by UV rays through gene expression (Soto-Vaca et al., 2010).

The plants with the highest phenolic compounds are the plants of tropical and alpine regions. The main reason for this is that the plants in these regions receive more UV rays and the compounds in question are synthesized by the plant to protect them from these rays. Phenolic compounds reduce the amount of active oxygen radicals in cells and protect the lipid layer of membranes from disintegration (Rong, 2010). Phenolic compounds increase the resistance of plants against infections. The flavonoids collected in the leaves protect the plants from damage for a long time by repelling insects. Synthesis and oxidative condensation of phenolic compounds begins on a regular basis as a result of damage to plant tissues by mechanical events. Protective resins are formed as a result of oxidative condensation, which in turn form polyphenol compounds. Phenolic compounds constitute signal substances that can protect plants from microorganisms. Simple phenols destroy the cell wall and are dangerous to use internally as they are membrane toxins. Phenolic compounds, as during the normal development of plants; It is also synthesized in cases such as infection, injury or exposure to UV light (Ferraira and Pinho, 2012).

7. BIOAVAILABİLITY OF PHENOLIC COMPOUNDS

The bioavailability of phenolic compounds depends on their ability to be absorbed and metabolized, which is determined by their molecular size and solubility. Structurally, phenolic compounds are characterized by hydroxyl groups attached to an aromatic ring and range from simple phenolic substances to more complex polymerized compounds. Phenolic acids can be found conjugated with mono and polysaccharides, attached to one or more phenolic groups, or as functional derivatives of esters and methyl esters. Phenolic acids in foods are effective on color, aroma, odor, bitterness, astringency and oxidative stability (Kurosumi et al., 2007).

Heat treatment causes loss of phenolic compounds in vegetables. When boiling, steaming and microwave cooking methods are compared in terms of phenolic compound losses; the highest loss was observed in the microwave cooking method. Although boiling leads to loss of phenolic compounds, it increases the bioavailability of vegetables. For example, in a study investigating the digestibility of polyphenols; it has been observed that the consumption of nuts together with dried fruits increases their antioxidant capacity. Dried figs-walnuts, dried apricots-walnuts, raisins-hazelnuts are suitable options to increase antioxidant capacity. In another study; compared to fresh tomatoes; It has been observed that making tomato paste doubles the bioavailability of phenolic substances (Akbulut, 2018).

8. CONCLUSION

Phenolic compounds are a fascinating and unique class of bioactive compounds widely spread in nature. Studies on polyphenols have increased exponentially over the past two decades, mainly because of the association between consumption of these substances and their health benefits. Fruits are excellent sources of phenolic compounds that provide health benefits beyond basic nutrition. Extraction, isolation and quantification of polyphenols in fruits still pose a challenge. Therefore, further research is needed to better understand this class of phytochemicals and their effects on nutritional processes.

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CHAPTER 9

CROWN IMPERIAL (*Fritillaria imperialis* L.) IN VITRO CULTURE: A REVIEW

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1.INTRODUCTION

Among the most important factors that reduce the yield and quality of agricultural products, biotic factors including diseases, pests and weeds take the first place and cause losses of millions of lira every year (Alkan, 1968; Islamoğlu, 2021a, 2022). "Crown imperial" or ‘‘Tears of Mary’’ (*Fritillaria imperialis* L.) is an important ornamental plant with attractive and large flowers available in different colours. It is suitable for naturalizing, to use as pot plant or cut flowers. Bulbs of Fritillaria species are also herbal remedies in Turkish and Asian folk medicines for centuries. *Fritillaria imperialis* species a mono-cotyledon plant from *Liliaceae* family and native to Turkey and Iran. Propagation of the plants of this species instead of gathering them from the nature is a current issue in Turkey. Wild populations of *F. imperialis* are facing extinction and need urgent conservation. Among ornamental bulblet plants, this plant has special place, therefore this plant needs more attention, otherwise species will be destroyed in future due to harvesting, grazing livestock and pest and pathogens infestations. Previous studies have shown that *F. imperialis* cannot be rapidly and efficiently propagated by traditional methods. Regenerative multiplication of the plant is very difficult due to high seed dormancy. Propagation through bulblets takes 3-4 years. Whereas, using tissue culture technique for flower production requires a few months which has great economical advantages due to low cost and high population of plant production in a short period of time. In vitro tissue culture techniques have shown high potential for micropropagation of endangered plants. Based on speed and multiplication rate, traditional production methods are not adequate. The application of in vitro propagation techniques offers possibility of producing large number of uniform plants for further field cultures. About 100 species of bulbous perennials belonging to the family Fritillaria (*Liliaceae*) can be found in temperate areas of the Northern Hemisphere, primarily the Mediterranean, Southwest Asia, and Northwest America. These areas include woodland, open meadows, and steep screes (Seydi et al., 2020a). Turkey and Iran are among the Middle Eastern and Mediterranean nations where the species of the Fritillaria genus are found. There are 165 taxa, 2 sections, and 7 subgenera of Fritillaria (Rix, 2001).

Figure 1. Fritillaria imperialis L. at its natural habitat (Zagros mountains, Ilam province, Iran) (Seydi et al., 2020).

The provinces of Diyarbakir, Batman, Sirnak, Adiyaman, Bitlis, Tunceli, Hakkari, Elazig, and Mus in Turkey's South East and East Anatolia regions are home to wild populations of this species that exist in areas with elevations greater than 1500 meters (Kizil & Khawar, 2013). The spring or early summer blooms are either pendulous and solitary, or in terminal racemes or umbels, and have six tepals. The leaves are typically lance-shaped or linear (Seydi et al., 2020). As a heterozygous plant, fritillaria has unique genetic makeup in each embryo, even within a single plant (Mohammadi-Dehcheshmeh et al., 2006). You may grow fritillaria from seed. It takes approximately 6 years for it to reproduce by seed and produce flower-beating bulbs under ideal circumstances. In addition, cross-pollination, which is common, causes plants developed from seed to differ from their parents. It is ineffective to propagate fritillaria in large numbers using traditional techniques like bulb culture (Hamidoghli et al., 2015).


Figure 2. Fruit (left) and seeds (right) of *F. imperialis* (Kizil & Khawar, 2013)

They frequently propagated in natural environments from seeds or bulbs. The main issues with seed propagation are low germination rates because of physiological dormancy, weak seedlings, low survival rates, and delayed growth. The use of various explants, such as immature/mature embryos, bulblets, or bulbous scales, has been described in several successful regeneration protocols for several Fritillaria species (Cakmak et al., 2016). Because there are only a few scales (3–5) per bulb and a limited number of meristematic cells, F. imperialis cannot be effectively propagated by cutting, bulb scale, or seed (De Hertogh and Le Nard, 1993).

Figure 3. Bulblet formation from F. imperialis embryos on MS medium with 0.5 mg/l TDZ after 14 months of culture (Cakmak et al., 2016).

The best method for growing Fritillaria and preventing its extinction is micropropagation (Alizadeh Ajirlo & Kargar, 2016).

2. IN VITRO STUDIES WITH BULBS, BULB SCALE SEGMENTS, SHOOTS, FLORAL RECEPTACLES, LEAVES, LEAFLESS STEM, UNDERGROUND SHOOT PARTS, LEAFY SHOOT EXPLANTS

A study conducted by Solgi et al., (2015) to examine the effects of various vegetative propagation techniques and a few PGRs on the adventitious bulblet generation of F. imperialis. In equal amounts, NAA and BA were added to a solution in four levels (0, 100, 200, and 300 mg/L), and four vegetative propagation techniques were applied to mother bulbs (i.e. scoring, chipping with 4-chip, chipping with 8-chip and horizontal). After that, they were packed in plastic bags holding an equal volume of perlite and humid vermiculate. Results revealed that levels of PGRs and various vegetative propagation techniques differed significantly (NAA plus BA). The 8-chip approach produced the largest average number of bulblets per bulb, whereas the scoring system produced the fewest average numbers. Maximum bulblet regeneration was seen when treating bulbs with 300 mg/L NAA + 300 mg/L BA, but the least amount was seen when treating bulbs without PGRs. The largest bulblet creation per mother bulb (31.3) was obtained in the experiment when 300 mg/L NAA and 300 mg/L BA were applied in conjunction with horizontal bulb cutting. This result was much greater than the control treatment, which produced five bulblets per bulb. They came to the conclusion that using a proper vegetative propagation technique along with NAA and BA could result in a reasonable propagation rate. Direct embryogenesis of sterilized bulb scale segments was examined by Hamidoghli et al. (2015) in "MS medium" in the presence of various plant growth regulators, including NAA, IAA, TDZ, Kinetin, BA, and the combination of kinetin and NAA in various concentrations. In "2 mg/L NAA," the maximum number of direct somatic bulblets (8.33), largest bulblets (26 mm), and most roots (8 roots) were produced. In TDZ treatments, the least direct bulblet somatic production was seen; the generated bulblets preferred to produce callus rather than developing. No bulblet was formed in the solution containing BA hormone. The findings of this study demonstrated that "2 mg/L NAA" can be used to propagate Fritillaria imperialis in in vitro culture. The effects of auxin and cytokinin combinations on callus and bulblet production using explants taken from daughter bulb scale of two fritillary clones collected from Arjan and Koohrang plains of Fars province were studied. For this purpose, 3 types of growth regulator combinations containing three levels of NAA (0, 0.5 and 1 mg L-1) with one of the cytokines (2ip, Kinetin and TDZ) at three levels (0.5, 1.0 and 2 mg L-1) were applied. The base medium was MS containing 4.5 percent sucrose and 8 g/l agar. To evaluate the effects of these factors, experimental design of completely randomized factorial with 4 replications and 5 explants per repeat was used. Micropropagation is the best approach to propagation of Fritillaria and prevention of its extinction. With the help of explants from the daughter bulb scale of two fritillary clones collected from the Fars province of Iran, the effects of auxin and cytokinin combinations on callus and bulblet development were examined. Three different growth regulator combinations were used for this, each having three concentrations of NAA (0, 0.5, and 1.0 mg L-1) together with one of the cytokines (2ip, Kinetin, or TDZ) at three concentrations (0.5, 1.0, and 2.0 mg L-1). The starting medium was MS with 8 g/l agar and 4.5 percent sucrose. A completely randomized factorial experiment with 4 replications and 5 explants per repeat was utilized to assess the effects of these variables. Data analysis showed that whereas TDZ was significant on this parameter, kinetin and 2ip had no significant impact on callus induction percentage. The medium containing "0.5 mg L-1 NAA" along with "0.5 mg L-1 TDZ" showed the greatest callus formation. Sixty percent of the explants that received this treatment developed the callus. In media supplemented with "1.0 mg/l NAA" and "1.0 mg L-1 Kinetin," the greatest number of directly and indirectly regenerated bulblets were seen. In this therapy, a mean of 5.5 bulblet per explants was achieved. Because of the efficiency, expense, and environmental concerns of NAA, its lower concentration is advised for bulblet regeneration in this plant (Ajirlo & Kargar, 2016). In a study by Seydi et al., organogenesis from bulb scale explants was used to regenerate plants. The explants were cultured on Murashige and Skoog (MS) media fortified with various concentrations of kinetin (KIN, 0.00, 0.50, 1.00, and 2.00 mg l-1) and naphthaleneacetic acid (NAA, 0.00, 0.50, 1.00, and 2.00 mg l (2020). The medium containing 0.50 mg of KIN and 1.00 mg of NAA yielded the highest number of leaves (3.8), roots (5.9), and calluses (8.2) per explant. The medium supplemented with 1.00 mg l-1 KIN produced the highest viability percentage (96.7%). In vitro regenerated plantlets were cultivated in plastic pots containing peat moss and perlite (1:1). In an adaptation greenhouse, the plantlets were effectively acclimated with a 95% survival rate and regular developmental patterns. In the study of Witomska & Lukaszewska, (1996), F. imperialis cv. Rubra Maxima micropropagation experiments were conducted using several outdoor-grown plants that were lifted in April. Explants were removed from bulblets that originated at the base of the shoot, the lower portion of the shoot without leaves, and the upper portion of the shoot with leaves. To prepare the shoot explants, the shoot was sliced into 5 mm thick slices, which were then divided in half. After 1, 2, and 3 months of culture at 22°C on MS medium with 1 mg/l BA and 0.5 mg/l NAA, the rate of bulblet induction was assessed. For 16 hours each day, half of the explants were cultivated under fluorescent light and half in complete darkness. Only 4% of explants cultivated in light experienced the regeneration of scale segments with loose callus and bulblets. Shoot bases were found to be the least acceptable material for micropropagation; after one month of culture, 50% of explants in light and 76% in darkness died. The percentage of explants that successfully regenerated plantlets in light and darkness after three months in culture was 64% and 83%, respectively. Explants derived from leafy shoot segments regenerated most quickly and efficiently—84% in the light and 95% in the dark. Explants obtained from receptacles also showed bulblet regeneration, and leaves developed above the inflorescence. In the study of Witomska & ukaszewska, (2000), explants from young shoots, bulb scales, and regenerated bulblets of F. imperialis were grown on Murashige and Skoog's medium (with or without 1 mg/dm3 benzyladenine and 0.05 mg/dm3 NAA) supplemented with sucrose (30, 60, or 90 g/dm3). The explants come from underground shoot part (A), aboveground leafless stem part (B), and aboveground leafy shoot fragment (C). The proportion of bulblets and calluses that regenerate, their multiplication rate, and their size were calculated. The results revealed that explants from C cultured on a media supplemented with hormones and 60 g sucrose/dm3 produced the best bulblet regeneration, whereas explants from B cultured on a medium enhanced with hormones and 30 g sucrose/dm3 produced abundant callus. Witomska & Lukaszewska (2000) examined the effects of ABA and its inhibitor (fluridone) on Fritillaria imperialis cultivated in vitro. ABA in the range of 0.53 to 5.30 mg/cu.dm had no effect on the regeneration ability of shoot explants of various origins (underground shoot part, leafless and leafy above ground section). However, the explants' shoot and root growth was inhibited by the presence of ABA in the MS medium, which became apparent particularly after 3 months of culture and for greater ABA concentration. Fluridone inhibited the synthesis of chlorophyll in plantlets even though it was present in the medium alone and did not mitigate the effects of ABA. On MS medium in Petri dishes cultured at 4°C in the dark, Kizil et al. (2013) conducted a study on shoot tips, middle portions, and the lower portion of leaf explant (portion of lamina in between leaf sheath and middle portion of the leaf blade) obtained from germinated seedlings of Fritillaria imperialis. The purpose of the study was to assess the ability of the three explants to regenerate bulblets on MS media at varied BAP-NAA concentrations. The findings demonstrated that the leaf tip, middle, and lower portions were capable of inducing callus, shoots, and a variety of shoot counts per explant. The bottom part of the leaf explant, however, was most capable of producing new bulblets. This indicates that MS media with different BAP-NAA concentrations were appropriate for the proliferation of both species. The lower leaf section used as an explant showed the best regeneration on MS medium containing 1 mg/l BAP and 0.1 mg/l NAA. This procedure has the potential to produce a large number of uniform plants for nurseries and field culture, as well as to effectively propagate the species.

3. IN VITRO STUDIES WITH PETALS

By cultivating flower buds from the petal, Mohammadi-Dehcheshmeh et al. (2008) propose an effective method for in vitro direct bulblet regeneration of F. imperialis populations. As explants, petals at various developmental stages, including green-closed flower buds (before nectar secretion) and red-closed flower buds (at the start of nectar secretion), were utilized to assess the impact of varying cytokinin-to-auxin ratios on the direct bulblet regeneration route. In combination with increased levels of cytokinin (1 mg l1 BAP) and auxins (0.6 mg l1 NAA + 0.4 mg l1 IAA), more explants activated the direct regeneration pathway. Auxins (0.6 mg/l NAA + 0.4 mg/l IAA) with a lower quantity of cytokinin (0.1 mg/l BAP) on the other hand, led to the production of more bulblets per regenerated explant. Direct bulblets regenerated from the end of the petal where it connected to the receptacle in the green-closed flower bud stage, whereas nectar secretion site was the location of bulblet production in the red-closed flower bud stage. Additionally, two separate wild populations of Fritillaria imperialis were used to examine the genotype-dependency of the direct bulblet regeneration pathway. Different Fritillaria genotypes may use this plant regeneration technique, and the regenerated bulblets were healthy. Khalighi et al. conducted a thorough study on the capacity of developmental phases with regard to inducing several morphogenesis pathways from petal tissue (2006). Green unopened flowers, colored unopened flowers, and open flowers represented the three developmental stages. F. imperialis green unopened blooms showed direct bulblet renewal and direct somatic embryogenesis. With cold pretreatment, somatic embryogenesis via callus was established in green, unopened flowers of F. persica. Results showed that the developmental stages of petal explants play a significant role in micropropagation of Fritillaria and induction of different morphogenesis pathways.

4. DIRECT BULBLET REGENERATION FROM MATURE AND IMMATURE EMBRYOS

Mohammadi-Dehcheshmeh et al. (2006) used mature F. imperialis embryos as explants in their investigation. Embryos were removed from seeds and cultivated on B5 medium with different concentrations of BAP, NAA, and IAA (0, 0.4, 4, and 4 mg/L, respectively). Low genotype reliance between several heterogenous and heterozygote populations of F. imperialis was demonstrated via embryo explant. The direct organogenesis pathway and 1 mg/L BAP + 0.4 mg/L NAA + 4 mg/L IAA produced the best bulblet regeneration response in F. imperialis, with 15 bulblets per explant. Established in vitro propagation employing embryo explants in this study can supply a wide range of genetic resources and variances due to the numerous embryos in a plant and their diverse genetic contents. The in vitro bulblet regeneration potential of immature zygotic embryo explants of Fritillaria imperialis was examined in the study of Cakmak et al., (2016). Explants were cultivated in Murashige and Skoog's media with 0.25-1.0 mg/l of thidiazuron (TDZ), 0.25-0.5 mg/l of naphthalene acetic acid (NAA), 1.0-4.0 mg/l of 6-benzylaminopurine (BAP), and 0.5-2.0 mg/l of kinetin added as supplements (kin). After 14 months of culture, multiple bulblet regeneration was observed across all culture media. The medium with the highest frequency of bulblet regeneration were those containing TDZ and NAA mixtures. On media containing BAP and NAA, the maximum bulblets per explant were obtained. Bulblets that had been hardened exhibited longer roots of 8.19 cm in an agar and activated charcoal (AC) culture media and more roots per bulblet in a medium that were solidified with gelrite. Rooted bulblets were promptly transplanted into pots and cultivated in a greenhouse, where plants effectively acclimated and generated new foliage and roots.

5. INDIRECT ORGANOGENESIS

The effects of three distinct levels of activated carbon (AC) (0.0, 3.0, and 3.5 g/L) and three different concentrations of 6-Benzylaminopurine (BAP) on the indirect organogenesis of F. imperialis were examined in the study by Saeed and Cömertpay, (2020). For all treatments, the auxin concentration was the same (0.01 mg/L of NAA and 0.01 mg/L of IAA). It has been discovered that adding 3.5 g/L of AC to culture media supplemented with 0.10 mg/L of BAP considerably (p0.05) boosted the size and number of bulblets, as well as the number of roots and shoots in regenerated plantlets. Additionally, all examined doses of AC addition significantly decreased the length of roots (p 0.05). The highest dose of BAP (0.15 mg/L) reduced the number of bulblets in all treatments; however, when 3.5 g/L of AC was added, it was discovered to all observed values were increased. Overall, the 3.5 g/L of activated carbon and 1.5 mg/L of BAP were used to generate the optimum growth of the plant sections from callus in indirect organogenesis of F. imperialis. In the study of Rahimi et al., (2013), callus development and indirect organogenesis from Crown imperial bulb explants that had been surgically removed and examined. A factorial experiment using a randomized full design with 12 treatments and 3 replications was conducted to produce callus. Explants and media of various kinds made up the treatments. Scale, leaf primordial, and petal were the explant treatments in the three levels, while MS basic media containing 0.5 and/or 1.0 mg l-1 NAA and MS basic media containing 0.5 and/or 1.0 mg l-1 IBA were the media treatments in the four levels. The findings demonstrated that the best callus weight was achieved in callus formation media (CFM), the media containing 1.0 mg l-1 NAA coupled with scale, over a period of 6 weeks (2.1 g). Calli were obtained in media containing 0.5 or 1.0 mg l-1 IBA were yellowish, friable, and nodular were cultivated on 7 types of organogenesis media, including TDZ, as a result of producing roots in this media. NAA and IAA concentrations are minimal. The experiment included 21 treatments (seven types of media that produced callus from three different types of explants) and three replications. It was carried out as a factorial randomized full design.The results showed that indirect organogenesis media containing 1.0 mg l-1 TDZ+0.1 mg l-1 IAA had the best outcomes for developing bulblets over a 6-week period, with a mean of 3.24 bulblets. The impact of plant growth regulators (PGRs) on the callogenesis and regeneration of Fritillaria imperialis was the subject of a study by Chamani et al. (2017). From Iran's Ilam mountainous regions, bulbs in the dormant stage were placed in damp vermiculite at 4°C for 4-6 weeks. Then, bulbs were immersed in a 5% (v/v) NaOCl solution for 20 minutes with gentle agitation, surface-sterilized with 70% ethanol for 60 seconds, and rinsed three times in sterile double-distilled water. In order to induce callus growth, explants taken from the lower third of scales with basal plates were put in MS basal media supplemented with various amounts of NAA and 2,4-D. Test tubes with bulb segments were kept at a temperature of 25°C or less in a growth room for 16 hours of white fluorescent tube light illumination and 8 hours of darkness. Calluses were transplanted to MS basal media without PGRs after two months. The callus was then cut into 0.5 cm pieces and placed to MS basal media with NAA at 0, 0.3, and 1 mg/l as a supplement. In three distinct trials, three different types of cytokinins were set up with various doses. NAA was mixed with BA [benzyladenine] (0, 0.3, 0.5, and 1 mg/l) in the first experiment, with TDZ [thidiazuron] (0, 0.1, 0.3, and 0.5 mg/l) in the second experiment, and with kinetin (0, 0.5, 1 and 1.5 mg/l) in the third. Following three months, measurements were taken for the percentage of callogenesis, calli diameter, regeneration percentage, number of leaves and roots, and length of leaves and roots. The findings demonstrate the consistency of callus propagation across all studies. The maximum rate of callogenesis was observed in all trials in medium supplemented with 0.6 mg NAA/l and all cytokinin concentrations. The third experiment (0.6 mg NAA+1 mg kinetin/l) produced the largest callus diameter (7.5 cm), whereas the callus diameters of the first (1 mg BA/l and 0.6 mg NAA+0.3 mg BA/l) and second (0.3 mg NAA/l) experiments were 2.5 and 2.87 cm, respectively. The results of the regeneration process showed that cytokinin is essential for plantlet regeneration. Plant regeneration occurred only in medium containing both of kinetin and NAA, while BA and TDZ could regenerate plantlets from callus independent of NAA presence. In the study of Chamani et al., (2018), dormant Fritillaria imperialis L. bulbs were collected from the hilly Lorestan region of Iran and kept in a cold room at +4 ° C for 4-6 weeks. After surface sterilization with 70% ethanol for 45 seconds, immersion in a 5% (v/v) NaOCl solution for 20 minutes with gentle agitation, and three rinses in sterile double-distilled water, the bulbs were disinfected. The current study was carried out in two distinct experiments. In the first experiment, the impact of various Thymol and Carvacrol concentrations, and in the second experiment, the impact of various NAA and BA concentrations on the in vitro properties of Fritillaria, was assessed. Explants (1 1 cm) taken from the lower third of scales with the basal plate were put in MS basal media supplemented with various doses of thymol (50, 100, 150, and 300 ppm), carvacrol (10, 100, 500, and 100 ppm), BA (1, 2, and 4 mg/l), and NAA (1, 2, and 4 mg/l). All cultures were kept in an incubator set at 24° C, and cool white fluorescent lights with a 16-hour photoperiod delivered a photosynthetic photon flow of 40–60 mol m–2 s–1. Thymol and carvacrol had a substantial impact on bulb diameter, number and length of roots, number and length of leaves, callus induction, and diameter of callus derived from scales, but were ineffective on the quantity of new bulblets. The MS medium supplemented with 50 ppm Thymol produced the highest rate (3 Bulblets) of Bulblets production, which differed considerably from other treatments. Between Carvacrol treatments, the medium containing 10 ppm Carvacrol produced the most Bulblets (2. 5 Bulblets). Evaluation of the number and length of roots was used to investigate rooting. The results of a mean comparison of the effect of cultivar type on root number revealed that MS medium containing 50 ppm Thymol produced the most roots per explant. In mediums enriched with 300 ppm thymol and 100 ppm carvacrol, the least amount of roots were seen. The MS medium supplemented with 100 ppm Carvacrol produced the best increase in root length per explant (10.90 cm), whereas the cultures mediums containing 300 ppm Thymol and 100 ppm Carvacrol produced the least increase in root length per explant. Additionally, culture medium treated with 50 ppm Thymol produced the highest number of leaf formation when compared to other treatments. Analysis revealed that high frequency callus induction and development occurred in MS mediums with 50, 100, and 150 ppm Thymol and 10 ppm Carvacrol, and that callus induction was least frequent in culture mediums supplemented with 300 ppm Thymol and 1000 ppm

Carvacrol. Auxins were more successful at propagating Fritillaria imperialis L. through the development of bulblets in vitro than Cytokinins were. Experiments on callus formation, bulblet generation, root formation, and acclimation were conducted by Rahimi and Daneshvar (2017). In the first experiment, callus development was induced by cultivating leaf primordia and scale explants on MS media supplemented with various amounts of NAA and IBA. In the second experiment, after 6 and 12 weeks, the calli were grown on organogenesis medium that also contained MS media supplement, kin., and TDZ. The bulblets were placed into rooting media in the third experiment, which contained MS medium supplemented with varying amounts of NAA (0, 0.5, 1.0, and 2.0 mg/l). The fourth experiment involved planting the bulblets into pots filled with sterilized perlite, cocopeat, and perlite in addition to cocopeat after washing them in warm distilled water (40°C) containing 2.0 mg/l benlate fungicide. The first experiment's findings showed that scale explants on baseline MS medium supplemented with 0.5mg/l NAA and 0.5mg/l IBA maintained the largest weight of callus (3.29g). The outcome of the second experiment showed that many bulblets developed on MS medium supplemented with 0.5mg/l TDZ and 0.5mg/l kin. Whichever of these produced callus scale on MS media supplemented with 0.5mg/l NAA. In the third experiment, the bulblets were grown on MS medium supplemented with various concentrations of NAA in order to maintain rooting. The results showed that leaf primordia on MS media supplemented with 1.0mg/l NAA were where the majority of the roots (7.7) were found. In the fourth experiment, rooted bulblets were placed in pots with perlite, cocopeat, or perlite and cocopeat after being cleaned with warm distilled water for 5 to 10 minutes. The findings showed that, in comparison to other treatments, the rooted bulblets from scale growing on cocopeat substrate had kept the maximum diameter (21.64mm). The findings of this inquiry strongly suggested that adopting micropropagation is definitely a trend that might be employed to remove the obstacles that prevented Fritillaria imperiallis from improving.

6. REGENERATION OF PROTOPLASTS FROM CALLUS

An effective approach for separating and regenerating protoplasts from Fritillaria imperialis callus was reported by Tahami and Chamani (2018). Researchers investigated the variables that affected the isolation and regeneration of F. imperialis protoplasts. From the results obtained, callus Fresh Weight (FW) of 0.4 g produced the highest number of viable protoplasts, which was 1.12×105 protoplasts g-1 FW. The highest amount of viable protoplasts (1.01×105 protoplasts g-1 FW) was obtained when the mannitol concentration was maintained at 9% (w/v). The best treatment for isolation of F. imperialis protoplast (1.37×105 protoplasts g-1 FW) was treatment with 2% cellulase and 0.1% pectinase with 9% mannitol for 8 h. Different doses of casein hydrolysate (CH), 2,4-Dichlorophenoxyacetic acid (2,4-D), and benzyladenine (BA) were employed to improve protoplast division and the percentage of colony formation. The findings showed that liquid media was superior to semi-solid medium in terms of cell wall and colony formation. The highest plating efficiency (1.26×106 per g FW) and highest callus formation were obtained using the medium containing 0.5 mg L–1 2,4-D, 1 mg L–1 BA, and 200 mg L–1 CH. Micro-calli were formed after one month of culture. Many plantlets were formed on the calli after transfer of the proliferated calli to regeneration medium. The highest plantlet regeneration (100%) was obtained using the medium containing 0.5 mg L–1 (Naphthalene Acetic Acid) NAA and 1.5 mg L–1 BA.

7. EFFECT OF TEMPERATURE ON IN VITRO

The effects of bulb storage temperatures on scale explant regeneration were examined by Witomska (2000). Bulbs were stored 8 weeks at 4, 22, 30 deg C and 40 deg C/22 deg C). The effects of incubation temperature (15 and 22 deg C) on the regeneration of shoot explants were investigated. It was either supplemented with 1 ppm BA and 0.5 pppm NAA or MS medium without growth regulators. Bulblets produced more easily at 22 degrees Celsius and on growth-regulating media.

8. CONCLUSIONS

According to multiple studies conducted in different countries by different researchers, in vitro protocols can play a major role in rescuing F. imperialis from extinction. It was determined in these studies that "2 mg/L NAA" can be used to propagate Fritillaria imperialis in in vitro culture of bulbs. When explants taken from daughter bulb scale used, kinetin and 2ip have no significant impact on callus induction percentage. The medium containing "0.5 mg L-1 NAA" along with "0.5 mg L-1 TDZ" show the greatest callus formation. In media supplemented with "1.0 mg/l NAA" and "1.0 mg L-1 Kinetin," the greatest number of directly and indirectly regenerated bulblets are observable. Because of the efficiency, expense, and environmental concerns of NAA, its lower concentration is advised for bulblet regeneration.

Explants from aboveground leafy shoot fragment cultured on a media supplemented with "1 mg/dm3 benzyladenine" + "0.05 mg/dm3 NAA" + 60 g "sucrose/dm3" produce best bulblet regeneration, whereas explants from aboveground leafless stem part cultured on a medium enhanced with "1 mg/dm3 benzyladenine" + "0.05 mg/dm3 NAA" + "30 g sucrose/dm3" produced abundant callus. For indirect organogenesis from bubl explants, media containing 1.0 mg l-1 TDZ+0.1 mg l-1 IAA had the best outcomes for developing bulblets over a 6-week period.

3.5 g/L of activated carbon and 1.5 mg/L of BAP were used to generate the optimum growth of the plant sections from callus in indirect organogenesis of F. imperialis. Also shoot bases were found to be acceptable material for micropropagation. Explants derived from leafy shoot segments regenerated most quickly and efficiently. Explants obtained from receptacles also showed bulblet regeneration, and leaves developed above the inflorescence. In vitro regenerated plantlets are able to successfully cultivated in plastic pots containing peat moss and perlite (1:1).

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CHAPTER 10

SUSTAINABLE AGRICULTURE, PRINCIPLES, TARGETS AND DEVELOPMENT PROCESS

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1.INTRODUCTION

Salt is a mineral rich mineral type and is generally used as a condiment and food preservative. Intensive agricultural practices in order to reduce both agricultural areas and natural resources due to the increasing world population and rapid urbanization and to meet the increasing food demand; It causes many problems such as environmental pollution, reduction of natural resources and destruction of natural resources. In order to combat these problems, agricultural practices, which were previously aimed at increasing efficiency and production, have been replaced by sustainable agricultural production. Sustainable agriculture, which has both economic, social and environmental goals, can be achieved through the application of innovative approaches. This section has been written in order to explain the concept of sustainability in Turkish agriculture and to present innovative approaches with the example of Organic Agriculture Practices.

2. SUSTAINABILITY AND SUSTAINABLE AGRICULTURE

The concept of sustainable development was defined for the first time in 1987 in the "Brundtland Report" prepared by the "World Commission on Environment and Development", as "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland Report, 1987). According to another definition, the concept of sustainability, which is used in economic fields such as production, consumption, trade and growth, and in cultural, political, social and environmental fields, is defined as the transfer of current resources to future generations without loss (Eryılmaz and Kılıç, 2018). Caffey et al. (2001) defined sustainability as "a holistic assessment of the economic, environmental and sociological impacts of any development activity". In order for the natural resources used in agricultural production activities to produce the expected benefits from them, they should be used effectively and efficiently without touching their essence, ensuring the highest level of product yield and quality, leaving a clean environment for future generations, and finally, the production system that aims to create an economic, social and environmental balance in agricultural production is called sustainable agriculture (Martinez-Castillo, 2016).

Altieri et. Al. (2017) (2000) MacRae et al. (1990) reported that they presented a three-stage approach for the transformation from traditional agriculture to sustainable agriculture, an approach to increasing efficiency to reduce the consumption of non-renewable resources, an approach to replace materials and management practices that cause negative environmental impacts with more environmentally friendly practices, and all farm operations can undergo a transformation from traditional agriculture to sustainable agriculture with a redesign approach (Özgüven et al., 2019). In recent years, the concept of sustainability and its applications have come to the fore in almost every field related to economic activities. The main reason for this is that the nature, which people use to meet their needs, has been damaged in the last century, and it is a fact that has been proven by scientific studies and natural disasters that human existence will face the risk of extinction if the effect of these damages to nature is not eliminated or reduced. This reality necessitated redesigning the economic activities carried out to meet human needs, taking into account the natural balance. Various approaches have been proposed in the reflection of this transformation process on agricultural production. Tascioglu (2015) reported that the concept of sustainability includes different definitions according to their fields of expertise, Kuhlman and Farrington (2010) reported that for economics, sustainability is defined as the necessity of keeping living standards at a certain level, and for environmental science, it is defined as the protection of ecological life. Chapin et al. (1996) defined that sustainability as the ability of the ecosystem to function effectively continuously, Goodland (1995) defined that as the capacity to sustain an indefinite cycle and Salomone (2014) defined that as “preserving the capacity of the earth to bear the burden of humankind. Sullivan (2003) explained that the indicators for achieving the three goals of sustainability of a farm or rural community (Table 1).

Table 1. The goals of sustainable agriculture and the success indicators of these goals

Economic sustainability indicators	The net worth of the family should constantly increase.
	Family debts tend to decrease constantly.
	Businesses make profits every year, non-operational feed and fertilizer purchases are decreasing.
Social sustainability indicators	Farms support other businesses and families
	The circulation of capital is within the local economy.
	The number of families in rural areas is increasing or remains stable.
	Young people continue farm work, Educated population returns to rural society.
Environmental sustainability indicators	There is no barren land.
	Farm stream sources are clean.
	Wildlife abounds.
	Fish found in farm streams are productive.
	The vegetation of the farm landscape is different.

These indicators, which reflect the main purpose of sustainable agricultural production, actually mean preserving the natural balance, restoring the deteriorated balance and leaving a healthy environment to future generations. In the continuation of this section, sustainable agricultural production principles that will create these indicators reflecting the main purpose of sustainable agricultural production will be mentioned.

3. SUSTAINABLE AGRICULTURE PRINCIPLES

Ensuring the sustainability of the agricultural sector, which plays the most important role in meeting the nutritional needs of the society, has always been one of the most basic policies of the governments. In this section, issues related to the relationship between environmental, economic and social sustainability of sustainable agriculture will be examined (Demirkol, 2022).

3.1. Environmental Sustainability in Sustainable Agriculture: Since agricultural activities are activities carried out depending on natural conditions, they have a structure that is affected by nature and directly affects nature (Kanianska, 2016). For this reason, the main starting point in the realization of sustainable agricultural production activities is the protection of natural balance. In this section, the protection of natural resources that soil, water resources, biodiversity and non-agricultural areas used in agricultural production, the inputs used, energy resources and the management of wastes generated during the production process, climate change and their effects on the environment will be discussed.

3.1.1. Soil management: Before starting agricultural production, necessary soil analyzes should be made, and fertilization should be applied to the soil in terms of amount, content, time and method. The effects of animal wastes on the agricultural land on the ecosystem should be controlled (Singh and Rashid, 2017). Applications such as fallow, green manuring and crop rotation should be preferred. Tillage works should be carried out with the right timing and the right equipment in order to preserve the quality of the soil (Önal, (2010). Biological and mechanical control methods should be preferred to combat soil erosion. In pasture livestock, overgrazing should be prevented by keeping the animal population under control. Natural forests resulting from fire or cutting should not be used as agricultural land.

3.1.2. Water management: Water supplied from underground and surface water channels, which have been authorized within the framework of legal regulations, is used in agricultural production activities. The suitability of the water to be used by the enterprise is determined by periodic analyzes. By recording irrigation information, irrigation programs are prepared according to soil moisture and plant needs, and it is preferred to grow products with low water needs (Studer and Spoehel, 2019). How new pressure irrigation systems should be preferred to ensure efficiency in irrigation. Periodic maintenance of the calibrations of all equipment used in irrigation is extremely important for optimum use.

3.1.3. Protection and development: By determining the wildlife and natural life in the ecosystem, it is tried to be protected from the effects of agricultural economic activities carried out by agricultural enterprises (Karabak, 2017). Threatened and endangered species should be followed and agricultural activities should not be carried out in non-agricultural areas for the protection and development of biodiversity, taking into account the size of the enterprise. Operations such as hunting, catching, gathering and trading cannot be carried out for wild species within the enterprise. Different living spaces are developed within the agricultural land. By providing the development of species that bloom at different times, a green fence is created. Different product patterns are created to protect the land from pests and diseases and to preserve the organic diversity in the soil.

3.1.4. Protection of Non-Agricultural Areas: Protecting the natural balance has a vital importance in the continuation of agricultural activities. Nature has a certain ecosystem that harmonizes natural assets, living beings and human existence in order to produce the desired level of benefit from the agricultural resources used to meet human needs. For this reason, in order to preserve this balance, the diversity in the areas unsuitable for agriculture within the boundaries of the enterprise is preserved, and the vegetation is rearranged in the regions that have lost their agricultural land characteristics.

3.1.5. Energy: The energy source used in the realization of economic activities is important not only in terms of sustainable agricultural activities, but also in terms of its effects on the natural balance. Especially in the last century, the effects of the damage to the natural balance caused by the intense use of fossil fuels in economic activities and agricultural production activities, which is a sub-branch, has reached an unsustainable level. These damages to the natural balance have necessitated sustainable production methods. Accordingly, the energy requirements and uses of different areas within the boundaries of the enterprise should be determined, and the energy source that will cause the least damage to the natural balance should be selected and recorded for the control of the results. The use of renewable energy sources is preferred. Establishment of biogas facilities, preference of agricultural tools with low energy consumption and high efficiency, and regular calibration will allow fuel and energy consumption to be at an optimum level.

3.1.6. Waste management: The biggest threat to the natural balance caused by the economic activities carried out to meet human needs is the wastes that arise in the economic production and consumption processes (Sayğı, 2022). These wastes, which are not taken into account for a long time and constitute the environmental costs of economic production activities, pose a significant threat to nature, living beings and human existence. Elimination of this threat could not be achieved in the early periods, mainly due to the concern of making profit and the lack of a cost-effective technological infrastructure to process and make these wastes valuable.

However, today's technology has the ability to process these wastes and make them valuable. In addition, the scarcity of input resources used in the continuation of economic activities and the increase in production costs led to the search for cheaper production input sources. In order to prevent the structures of wastes that harm the natural balance, with the preservation, disposal, processing and evaluation of wastes, two important problems will be solved and an important economic added value will be gained (Saygı, 2022). For this reason, in the realization of sustainable agricultural activities, a waste management plan should be established in the enterprise, and according to this plan, the infrastructures of the compost production area and waste warehouses should be outside the settlement area. Operational wastes should not be thrown into places such as streams, water channels, etc. It should be preferred that all kinds of business wastes are properly processed, composted and mixed directly with the soil.

Harmful wastes generated as a result of animal production should be monitored and inspected. It should be aimed to reduce the negative effect of bad odor originating from animal production on air quality. Organic wastes should be composted properly and given to the soil. All chemical inputs should be prepared without contacting soil and water. It is necessary to prevent environmental contact by collecting the boxes of chemical wastes in containers. Non-recyclable chemicals and toxic wastes should be destroyed by considering legal obligations. An emergency action plan should be prepared and implemented when necessary. Recycling boxes should be available for different types of waste in places deemed appropriate in the enterprise.

3.1.7. Agricultural inputs: An important component to be considered in carrying out sustainable agricultural activities is the chemical inputs used in pest and disease control and plant nutrition in the production process. Since the beginning of the last century, the natural balance has been exposed to great damage from these chemicals used to increase production in agriculture. Today, all humanity pays the price of these damages, which are stated as environmental costs in the economy and agricultural production, by bearing great costs. These costs have necessitated sustainable agricultural production principles, which have caused natural disasters, disrupted the balance of ecosystems and caused climate change. Agricultural inputs allowed by international agreements and legal regulations should be purchased, used in agricultural production activities and stored. The purchase, storage and use processes of all agricultural inputs should be recorded. The areas where agricultural inputs are stored should be identified with sufficient warning signs and signboards and employees should be informed about this issue. Equipment and such wastes that come into contact with agricultural chemicals should be stored in a way that does not pose a danger to human health and the environment. Air circulation should be done regularly in the areas where agricultural inputs are stored. An Occupational Health and Safety (OHS) specialist should be employed in the enterprise or an OHS consultancy service should be purchased. Agricultural inputs should be stored separately without contact with food, water and feed. All chemicals entering and leaving the warehouses are recorded, and access to the warehouse is prevented by anyone other than the warehouse supervisor. Agricultural inputs should be used according to soil analysis and expert opinion.

3.1.8. Climate Change: Climate change is one of the important problems of today. Agricultural production activities are one of the main components of the climate change problem experienced today, since they are activities that are carried out in the natural environment and directly affect nature. In addition to the energy and chemical inputs used in agricultural production, unconscious activities such as the use of non-arable land in agricultural production, intensive water use, faulty soil cultivation, and reduction of biodiversity have disrupted the natural balance and caused climate change. In order to keep greenhouse gas emissions (methane, nitrous oxide, carbon dioxide, etc.) under control, especially in agricultural production processes that cause climate change, emission measurements should be made and this process should be followed. Inputs used in order to minimize the damage of greenhouse gas arising in agricultural production processes should be in a structure that can be transformed in the natural ecosystem that does not harm the natural balance. Likewise, environmentally friendly energy sources should be used in agricultural production tools. A suitable planting, planting and agricultural policy should be planned in the long term.

3.2. Social Sustainability in Sustainable Agriculture

Agricultural production activities affect the society in two ways, with the employment of workers and the added value produced, as well as the main effect in the process of producing the food that the society needs. In this section, issues related to the effects of working conditions, occupational health and safety, worker rights, worker training, and communication between stakeholders in agricultural production will be discussed.

3.2.1. Healthy and safe working conditions: The healthy and safe working conditions of the employees are organized by the management, these conditions are determined by laws and regulations. In cases where legislation is not regulated, internationally accepted opinion practices are taken as basis. Physical, sexual and psychological violence cannot be applied to employees. Employees should be provided with accommodation, cleaning, nutrition and treatment in line with their needs, within the scope of business possibilities. The transportation needs of the employees are provided by the business management. The management of the enterprise is obliged to have the annual health checks of the employees, to have an employee health and safety specialist and a workplace doctor in the enterprise.

3.2.2. Working hours and working wages: The wages of full-time employees must be above the minimum wage and 45 hours. When the weekly working period is exceeded, the overtime provisions of the labor law apply. One (1) day off is given for six

(6) business days without a break. Although the annual paid leave days vary according to seniority, they are determined as at least 14 days. In the case of overtime, volunteerism is essential, the employee who works overtime is either allowed or overpaid. It is not possible to work with intermediaries who demand additional payment from the employees, and disciplinary penalties in the form of wage deductions cannot be applied to the employees.

3.2.3. Combating discrimination: In accordance with the equality provisions determined by national and international legal regulations, no discrimination can be made among employees. The management treats all employee rights equally and can apply positive discrimination for disadvantaged employees.

3.2.4. Union rights and freedoms: Employees have the right to become a member of a union and to be a manager of their own free will. Employees cannot be fired or punished for these activities.

3.2.5. Managing disputes: An open communication network should be established between workers and management. In solving problems, the management acts quickly, fairly and openly and adopts an attitude based on stakeholder participation.

3.2.6. Prohibition of child labor and forced labor: Persons under the age of 15 cannot be employed within the enterprise. However, children who are under the working age due to cultural or socioeconomic reasons are allowed to assist their families, provided that they do not have difficulties at work. Participation of children under working oil in educational processes is ensured. No one can be forced to work, human trafficking and captive labor are prohibited, foreign nationals without legal permits cannot be employed in the enterprise.

3.2.7. Education: It is ensured that employees benefit from theoretical and practical trainings, the quality and frequency of which are determined within a management program. It should be ensured that the employees related to the machinery and equipment that require competence and are used in the enterprise are in a sufficient condition, and the legally mandatory documents should be recorded. Training should be given at the point of application and storage of chemicals to be used in production. Employees on sustainable agriculture should be informed periodically.

3.2.8. Relations with the local community: It should establish a system based on mutual trust and cooperation between agricultural enterprises and all stakeholders. Local workforce should be given priority in recruitment. Cooperation with relevant stakeholders should be ensured for the use, protection and sustainability of common resources.

3.3. Economic Sustainability in Sustainable Agriculture

The adoption of agricultural production activities in the society depends on the economic added value obtained from agricultural production. It is necessary to prove that there is a positive difference between the economic value obtained from these activities and the cost incurred by implementing the principles of sustainable agricultural production. The fact that applying the principles of sustainable agricultural production is the only solution for the continuation of human existence and exceeding the costs incurred for the benefits obtained has enabled these principles to be quickly adopted by the society. In this section, issues related to the management process in agricultural production, financial sustainability and product preferences that will ensure maximum yield and quality will be discussed.

3.3.1. Management system, order of records and transparency: A safe, high quality and transparent system should be established in all processes in the enterprise. The business collaborates with other businesses and stakeholders and openly shares good practices. The business management, who is aware of the legal regulations, communicates all the changes to the stakeholders within 15 days and work is done according to these changes. All applications and all entries made in the enterprise are recorded. Holistic targets for economic, environmental and social performance are determined and the process is followed.

3.3.2. Financial sustainability: For the financial sustainability of the business, it is necessary to follow a profitable and stable policy in the long run. In product selection, market structure, customer profile and climate variability should be considered. Availability and development of suitable and qualified workforce in the enterprise should be considered. Equipment with high efficiency in energy and water use and renewable energy sources should be investment preferences first. Loss rates in products are determined, optimum production is calculated. After production, applications for hygiene and food safety practices are carried out. Biosafety criteria should be established. Effective health and disease management plans and programs are created and the whole process is recorded. In cases of illness, only the drugs deemed appropriate by the veterinarian are used in doses deemed appropriate, and information on drug residues is taken into account.

3.3.3. Product selection and efficiency: The basin-based production model should be observed. The total operating efficiency is calculated by using the average yield per unit and the amount of marketable product as criteria. The continuity of the water should be analyzed. Soil and water resources are analyzed. Appropriate harvest time and product-specific harvesting techniques are determined. The selection and use of appropriate equipment in animal production is extremely important. The feed and water to be given to the animals must be of sufficient quality and quality. The living spaces of animals must be suitable in terms of hygiene. Animal welfare must be taken into account in every aspect.

4. OBJECTIVES OF SUSTAINABLE AGRICULTURE

The main benefit expected from sustainable agriculture is the realization of environmentally, social and economically sustainable activities and the use of scarce natural resources to meet today's human needs at an optimum level without reducing the welfare of future generations. In order for sustainable agriculture to produce the expected benefit, it is necessary to achieve certain goals. These goals are (Tekfen Agri, 2020);

4.1. Ensuring food safety and quality: Considering that one billion people worldwide are affected by hunger and two billion people are affected by malnutrition, and the majority of them are children, nutrition and food security have a strategic importance for the future of humanity (Toros Tarım, 2014). According to the estimates of the Food and Agriculture Organization of the United Nations (FAO), it puts a burden on the global economy of approximately 5% of the world's GDP, or 3.5 trillion dollars, every year, due only to malnutrition, loss of productivity and health costs (Toros Tarım, 2014). When the health problems faced by the world 3.5 trillion dollars, every year, due only to malnutrition population are examined, it is seen that more than one-tenth of them are caused by malnutrition (Toros Tarım, 2014).

4.2. Providing clean water and water saving: Water, which cannot be completely replaced, is the source of life and living beings and covers three-quarters of the earth's surface, is a scarce resource, especially in terms of fresh water resources that people need. Only 2.5% of the total water resources in the world consists of fresh water, which is approximately 35 million km3, and only 0.3% of this amount consists of approximately 105,000 km3 of fresh water resources suitable for the use of natural life (Kırtorun and Karaer, 2018).

4.3. Customer satisfaction and creation of a sustainable supply chain: It can also define the concept of customer satisfaction as the satisfaction rate after meeting the customer's needs and meeting their demands, or as an indicator of the value paid to the products purchased by the customer. When it comes to agricultural products, conscious customers have forced businesses that want to use nature-friendly agricultural practices in the production process, especially the protection of health and the living environment, to redesign their production processes in this sense. Customer satisfaction is not enough to present the desired product to the customer with the right promotion and pricing, it also means that it is presented to the customer at the desired place and time, which means the creation of a supply chain that enables the activities to gain economic value.

4.4. Ensuring business ethics and transparency: While business ethics expresses the right and wrong in the production and consumption of goods and services in the business world, transparency is the collection of reliable, comprehensive, comparable data about agricultural production processes, business practices of supply chains and the effects of these practices on employees, communities and the environment, and sharing this information with the public (Setaş, 2020). The use of natural resources in order to meet human needs in agricultural production processes and the fact that these resources belong to all humanity affect all people. For this reason, the quality of the activities carried out, which is mostly done in accordance with the transparent and ethical principles, is necessary for sustainable agricultural activities, briefly for the continuation of life.

4.5. Establishment of occupational health and safety: Many environmental, economic and social components need to come together in order to ensure efficiency, productivity, profitability and sustainability, which are the main objectives of agricultural production (Bektaş, 2019). Occupational health and safety in the enterprise plays an effective role in the efficiency of the enterprise by providing the protection and development of human capital. Because it will be very difficult for the personnel to be successful in an unhealthy and unsafe environment, the job satisfaction of the employees in the agricultural production enterprise and the efficiency of the personnel depend on the health and safety conditions (Bektaş, 2019). In order to ensure health and safety in the enterprise, it is necessary to establish quality assurance systems that will guide both managers and employees (Bektaş, 2019). Here, it is emphasized that customer satisfaction is observed at every stage from production to consumption in agricultural production enterprises, which is meant by quality.

4.6. Ensuring employee loyalty and satisfaction: While employee engagement refers to an employee's emotional attachment to managers and co-workers, centered on emotions and intrinsic motivation, what motivates him to exert himself at work, employee satisfaction is a value that can change according to the instant happiness and emotional state of the employee, in which all positive and negative individual feelings arising from the employment of the employee are included in the center. Both are critical to the efficient use of resources in the production process, ultimately ensuring efficiency. It should be ensured that an employee involved in the sustainable agricultural production process is both happy to be in this sector, which is of vital importance for the continuation of human existence, and fulfills his responsibilities in the business process in accordance with the principle of voluntariness.

4.7. Establishing production continuity and efficiency: One of the aims of sustainable agriculture is to protect the basic characteristics of natural resources used to meet human needs and to offer the opportunity for future generations to benefit from these resources. The basic starting point of this aim is that natural resources are scarce, as well as consuming these resources or damaging these resources, as well as threatening human existence by polluting the living environment.

4.8. Compliance with international standards and laws: Efforts made to talk about success in sustainable agricultural production practices must be done in a certain discipline, namely in accordance with the written standards and rules that have previously been determined by authorized institutions, organizations, academic units, non-governmental organizations, in short, all stakeholders. After this condition is met, the performance achieved and the targets, which are considered as a predetermined success measure, can be compared and the results can be measured.

4.9. Use of renewable energy sources, energy efficiency and energy saving: The majority of greenhouse gases that cause climate change are fossil fuels used in the production of energy consumed in economic activities to meet human needs. In 2012, the IEA stated that coal accounted for half of the increased energy use of the previous decade, and fossil fuels supply the vast majority of humanity's energy demand, and at an increasing rate. This situation causes climate change by adding CO2 to the atmosphere from human activities faster than the amount that natural processes can consume. Climate change affects almost every area negatively and changes agricultural activities in an unsustainable way. Therefore, providing the energy needed in sustainable agricultural production from renewable energy sources such as solar, wind, nuclear and geothermal energy will reduce the effects of climate change. In the realization of sustainable agricultural activities, it is to reduce the total amount of carbon dioxide emission, which is directly or indirectly caused by a product that poses a threat to climate, that is, air quality, and which is caused by human activities, called carbon footprint, in the whole life process.

4.10. Tackling climate change: Sustainable agriculture also has the function of restoring the balance of nature, which is disrupted as a result of the consumption of natural resources quickly and without giving them the opportunity to renew themselves. The disrupted natural balance in agriculture makes itself felt as climate change. Apart from the energy issue mentioned above, many activities are carried out that affect the climate change of agricultural production activities of which excessive irrigation, opening of areas unsuitable for agriculture, chemical inputs used in the production process, wastes (animal, plant and production input residues) and faulty soil cultivation. For this reason, sustainable agricultural activities are practices that reduce the negative effects of climate change, as they include agricultural production techniques that will restore the deteriorated balance of nature.

4.11. Waste management, separation and recycling, management of medicated-fertilized wastewater: It covers the process of correct disposal, preservation and evaluation of wastes consisting of animal, plant and production input residues that affect climate change and cause environmental pollution in sustainable agricultural production activities. Wastes arise as an inevitable result of the process of economic production and consumption activities. In sustainable agriculture, in order to minimize the environmental impact of these wastes, a large part of them is processed by various methods, converted into valuable inputs used in the re-production process, preserved and the remaining part is destroyed.

4.12. Ensuring the reduction of greenhouse gas emissions: The explanations regarding greenhouse gas emissions in the items of sustainable agriculture targets, waste management, combating climate change, use of renewable energy sources are also valid for this target.Greenhouse gas emissions originating from agricultural production can be examined under four main headings: energy, livestock, rice production and other activities (burning of savanna and agricultural wastes, use of nitrogen fertilizer in agricultural soils and burning of biomass in open areas) (Şahin ve Avcıoğlu, 2016). Sustainable agricultural production processes reduce greenhouse gas emissions to acceptable levels with production activities that restore the deteriorated natural balance, protect and develop existing natural resources.

5. A REFLECTION OF SUSTAINABLE ECONOMIC PRODUCTION PRINCIPLES ON AGRICULTURAL PRODUCTION

Increasing technological developments have affected many sectors as well as the agricultural sector. With the increase in the welfare level, the rapidly increasing world population has led to an increase in the need for agricultural materials to produce more food, and chemical fertilizers and pesticides have been used intensively in order to obtain more products from the unit area and this situation has created a threat to nature, living beings and human existence over time. In order to take precautions against these threats, the countries of the world have started to put on their agenda the principles and philosophy of organic farming (biological agriculture, ecological agriculture), which is a reflection of sustainable agricultural activities on the agricultural field (Merdan and Kaya, 2013; Dalbeyler and Işın, 2017). Realizing that the agricultural production methods applied in the 1900s, when the use of chemicals in agriculture began, were faulty, some farmers in Europe drew attention to the concept of soil fertility in agricultural production and showed different approaches, and thus the ecological farming method, which is the basis of the organic farming method, was created (Kristiansen et al., 2006; Er, 2009).

As a result of sustainable agricultural concerns in the world, studies on organic agriculture started with the "An Agricultural

Testament" written by Albert Howard in 1910 (Worster, 2017). Studies on organic agriculture came to the fore with the "Biodynamic Agriculture Method" course opened by Doctor Rudolf Steiner in 1924 and the "Biodynamic Agriculture Institute" founded by Doctor Rudolf Steiner in 1928 and in the 1930s, controlled organic production started (Rehber et al., 2018). The term "organic" was first used by W. Northbourn in 1940 in his book "Look To The Land" to describe the ecological farming system. In 1959, the Organic Farmers Association "Groupement d'agriculteurs biologiques" was established in France, and with the discovery of pesticides and chemical fertilizers in the 1970s, intensive farming practices that caused great damage to the natural balance spread rapidly. Discussions have begun on whether these practices, called "Green Revolution", which aim to obtain high yields from the unit area, can provide sufficient increase in agricultural production and whether they can solve the problem of hunger in the world, and researches proving that the faulty practices of intensive agriculture disrupt the natural balance and human health have been put forward (Dalbeyler and Işın, 2017). In the first years, with the application of green revolution agricultural techniques, an increase of almost 100% was achieved in some products, but these agricultural techniques caused high environmental costs by quickly disrupting the natural balance and made agricultural production activities almost unsustainable (Ak, 2004). In this period, the importance of organic agriculture began to be understood and IFOAM was established in Germany in 1972 to contribute to organic agriculture. Since the 1980s, organic agriculture production has moved to a commercial dimension in line with the increasing demands of environmentally sensitive consumers about the effects of products produced in agricultural production on the natural balance (Dalbeyler and Işın, 2017).

6. CONCLUSION

Considering that the natural resources used to meet human needs are not unlimited, the necessity of using these resources correctly, effectively and efficiently is a fact that emerges spontaneously. Although this reality has been proven by scientific studies, people have forgotten this reality consciously or unconsciously, consuming natural resources and causing great damage to nature. In order to eliminate these damages to nature, it is necessary to create, develop and apply environmentally friendly production methods. This new production approach, which is expressed with the term sustainability in the economic literature, includes environmentally friendly production systems aiming to protect the natural balance. In this new production approach, it is aimed to benefit from these resources without affecting the ability of the natural resources used in the production process to renew themselves, and thus to leave a clean and healthy environment to future generations with these resources.

It is necessary to increase economic, social and environmental efficiency in solving the problems that arise with the increasing world population and related urbanization, to develop sustainable agricultural production methods (biological agriculture, ecological agriculture and organic agriculture) by making use of technology, and thus to protect, develop and maintain nature, living beings and human existence. For this purpose, it is extremely important that all strategies and policies related to agricultural production processes are handled and developed with a holistic approach, according to the principles of sustainable agriculture, in order to both protect nature and meet the increasing demand for safe and healthy food.

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CHAPTER 11

AGRICULTURE 4.0: INNOVATION AND SOLUTION IN MODERN AGRICULTURE

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INTRODUCTION

Agriculture, food and horticulture are important sectors in the countries of the world, which account for a significant amount of each country's gross domestic product. Due to the increase in population, climate change, increase in urbanization level and reduction of labor force in the agricultural sector due to the reduction of the rural population, there is an urgent need for quick and new solutions along with new technologies for the agricultural sector (Rose and Chilvers, 2018).

Technological changes are caused by digital changes. Agriculture, which is important and unremarkable for every society in the world, can also be a part of this digital transformation. Agriculture 4.0 is smart farming program supported by new technology. The agricultural sector is undergoing digital transformation to create high potential for producers and consumers. Digitization of the agricultural sector and significant advances in industrialization and mechanization of agricultural production processes, data management can be the next revolution in the history of agriculture. Basic topics in agriculture 4.0, technologies that can be used in agriculture 4.0, robotic products and artificial intelligence, precise and sustainable agriculture, improving data management, increasing automation and mechanization processes in agriculture, improving software and programming, determining agricultural models, increasing accuracy, speed and efficiency in the processes of the agricultural sector (Zhai et al.,2020).

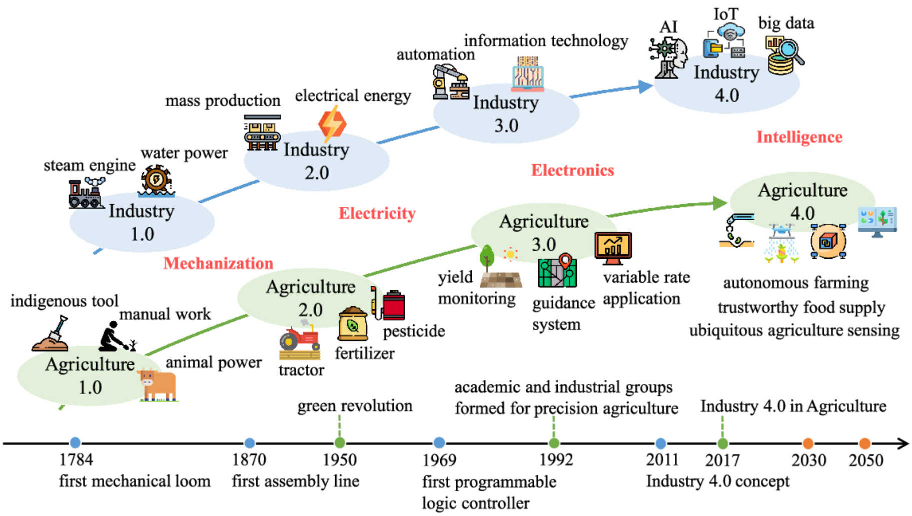

Figure 1: Time lines of industrial revolutions and agricultural revolutions (Liu et al., 2021)

Unfortunately, we see that there are various factories near many agricultural areas, especially heavy industry factories should not be near agricultural areas. As a result of such areas, changes in the air, water and soil, the deterioration of the ecological balance and the formation of many pollutions that may directly or indirectly affect human health are possible. It is known that, depending on the amount and interaction time of some elements in the soil, they can have a toxic effect when exceeding the limit values (Bellitürk, 2005). Agriculture 4.0 can prevent these changes and give us appropriate warnings in risky areas and prevent negative effects. Agriculture 4.0 has positive effects on productivity and environmental protection, thus creating positive social effects. Therefore, more participation from farmers should be done for the implementation of new agricultural systems, and in this regard, for social sustainability, the officials of the agricultural sectors should also cooperate with farmers and agriculture 4.0 producers and performers (Lezocheet al., 2020). Agriculture 4.0 is a term used to describe major advances in the industry, including a greater focus on precision agriculture, the Internet of Things (IoT), and the use of big data to increase business efficiency in the face of population growth and water changes. Agriculture 4.0 includes the entire operation of the evolution of precision agriculture, and it is said that all the actions that are carried out in agriculture based on the detailed analysis of data and information collected and transmitted through advanced tools and technologies. Agriculture 4.0 avoids the excessive consumption of water and can perform accurate calculation of the water requirement of the crop. It can also detect plant disease or the presence of plant pests in the field or gardens before the start (Sott et al., 2020). Agriculture 4.0 saves time and money and makes detailed planning on planting and harvesting programs. Soil quality and nutrients can be easily tracked using agricultural processes 4.0 and ensure sustainable agriculture. Agriculture 4.0 in the agricultural sector provides achievements such as the use of new technologies, the ability to manage agricultural data and the ability to analyze the results by using of useful and fast methods (Zhou et al., 2015).

1.1. AGRICULTURE 4.0: ROBOTS, AS NEW TECHNOLOGY FOR AGRICULTURE 4.0

Science and technology cause the evolution of agriculture, the Internet increases the speed of work in agricultural processes and thus IOT reaches the fields. Technical methods to improve agricultural technology should be as:

Optimizing production efficiency should be optimized and continue with the highest quantity and quality; environmental damages will be minimized and risks related to production will be eliminated or minimized (Zambon et al., 2019).

Examples of these methods are: precision agriculture, application of block chain technology in agricultural work chains such as transportation, storage, washing, grading, packaging, labeling or processing, use of artificial intelligence to detect early detection and management of pests and diseases, remote sensing such as satellite images and drones, and the deployment of special sensors on the ground such as soil analysis and mapping stations, farm and orchard status stations, as well as weather stations and equipment automatic for agricultural operations and works in the field or gardens for planting and harvesting and crop protection operations. Agriculture 4.0 offers many possibilities in the fields of agricultural activities in front of farmers and researchers (Mulla, 2013). Unmanned aerial vehicles and remote sensing devices can process information in real time and record images, see various agricultural factors and about soil, crops and agricultural pests and diseases or the increase of weeds to give the necessary warnings to the farmers. In order to manage all the new agricultural systems and properly exploit these technologies, farmers and agricultural specialists must learn new skills. For this reason, public and private sectors are facing new challenges to provide the basis of such technologies (Morris et al., 2005).

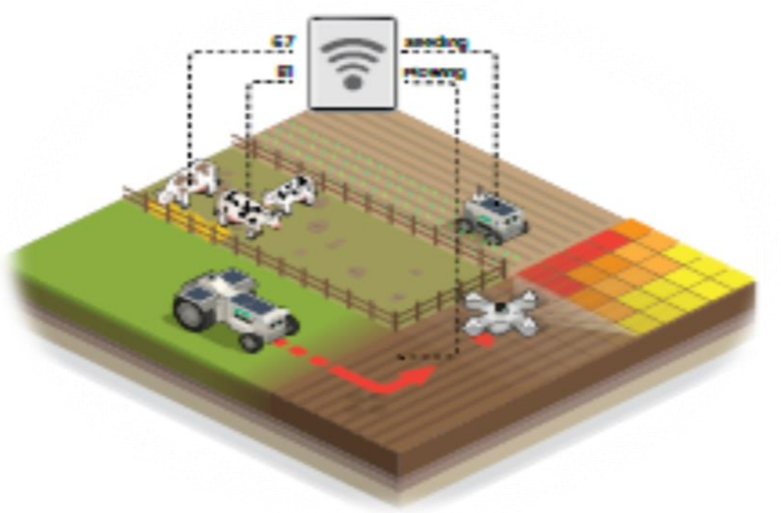

Figure 2: Graphic concept of Agriculture 4.0 at farm operation level

1.3. AGRICULTURAL ROBOTICS

There is no specific definition for "agricultural robot" or "agrobot" because the operations of agricultural robots are variable and different.

It is a mobile and independent device that can make decisions with its own artificial intelligence and is a macaronic device that can perform tasks such as participating in crop production and performing agricultural tasks such as preparing agricultural soil, planting, weeding and weed control and harvesting. Human supervision but without direct human intervention was called agricultural robot. These agricultural robots are programmable and are able to perform tasks that are programmed (Shafi et al., 2019).

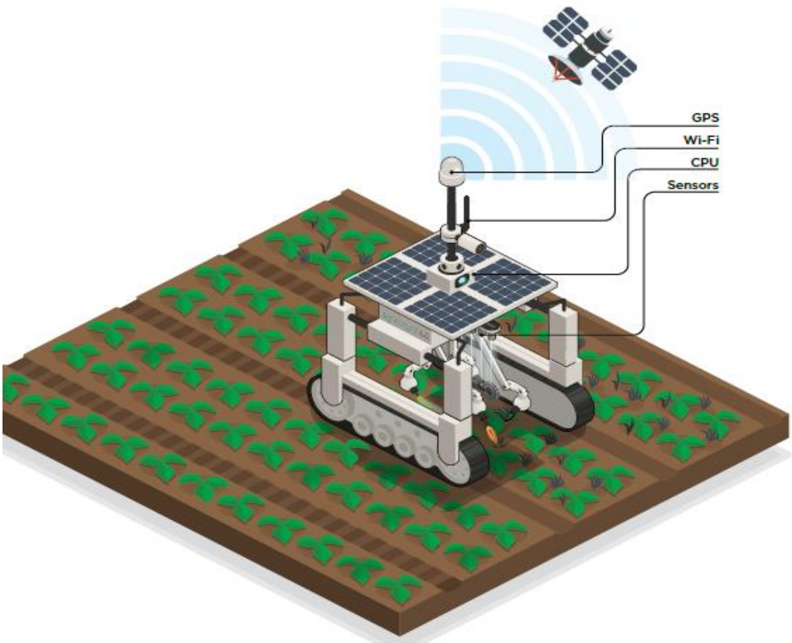

Figure 3. An agrobot working on the field as mechanically by using of sunenergy

According to agricultural tasks, the application of agrobots is different. There are basic samples of robots that perform simple agricultural tasks and advanced samples of robots that perform decomposition operations and diagnosis. The level of complexity of each robot and the level of robot technology have an important effect on the cost of its preparation and maintenance. The users of agricultural robots should adjust the capacity of their work according to the technology and costs of the robots. Of course, the needs of each agricultural region and the costs of robots also have a significant impact on the amount and distribution of robots in agricultural regions. In the field of agricultural activities, mechanization and automation are increasing (Ojha et al., 2015). Automation and mechanization make things more accurate and reduce human involvement. In agriculture, especially in the field of horticulture, there are many problems regarding manpower and harvesting operations. For this reason, the efficiency of agricultural mechanization and agricultural robots in the field of harvesting garden products can be of great help in the agricultural sector.

In order to create precision agriculture, the use of robots in agriculture is an important option. By using robots, repetitive tasks become easier and time is saved, too. Agricultural robots can be used in weed detection, herbicide and pesticide application, irrigation and harvesting, and other agricultural operations (Jawad et al., 2017).

1.3.1. Benefits of using agricultural robots

Robots can harvest different crops, so the farmer does not have to hire human labor every year to harvest his own crops. Especially in operations that are dangerous for human health, such as spraying various products, robots can be very useful. At the time of planting, visual and human error is eliminated by using robots to determine the planting location and prepare the planting plan. By using cameras and detection algorithms and imaging programs assembled on robots, it becomes easier and more accurate to detect weeds, pests and plant diseases (Ojha et al., 2015).

1.4.REMOTE SENSING

In remote sensing methods, it analyzes the condition of soil, vegetation and water from a distance by using optical spectra.

1.4.1.Vision-Based Sensors

RGB cameras are among the primary sensors based on vision. Color data is very important in agriculture to determine plant, soil and water parameters. Changing the ambient light conditions can affect the reception of sensor data and provide different results. To harvest different colored fruits and vegetables, using color cameras to automatically identify fruits or vegetables at the time of harvesting will make the work easier.

1.4.2. Range Sensors

Ultrasound amplitude sensing consists of a short-duration, high-frequency sound pulse that travels through air and strikes a target, then returns as an echo. The time of producing the sound and receiving the echo signal determines the electronic distance of the sensor. This distance and the data obtained from the sensors can express the density and height of the product in the farm (Fountas et al., 2020).

1.5. AGRICULTURE 4.0 CORE TECHNOLOGIES

The use of data in the field of agriculture is not a new issue, but digitalization in the agricultural sector has not yet found its place. Also, the quality of these data is an important issue that is very important in data processing and data management. Advances in agricultural robotics technology provide farmers with access to real-time data. In addition to data, it also creates information support. The figure below shows the flow between data and data support and the technologies used (Araujo et al., 2021).

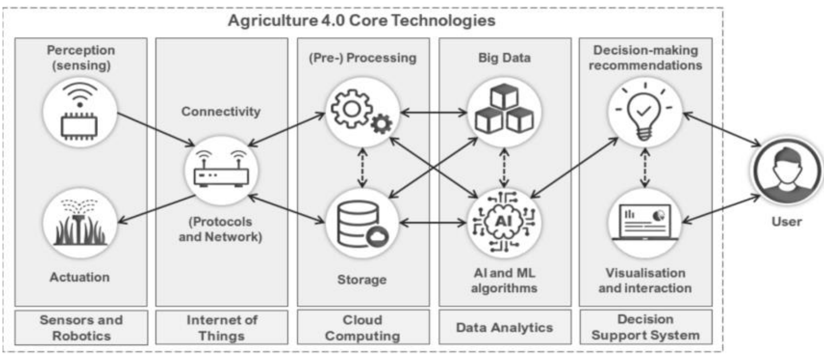

Figure 4. Data flow between the core technologies of the Agriculture (Araujo et al., 2021)

1.6. AGRICULTURE 4.0 APPLICATIONS

The new opportunity offered by Agriculture 4.0 can be evaluated in different fields. These fields of application can be classified into four main categories:

(a) Monitoring (b) control (c) forecasting and (d) logistics.

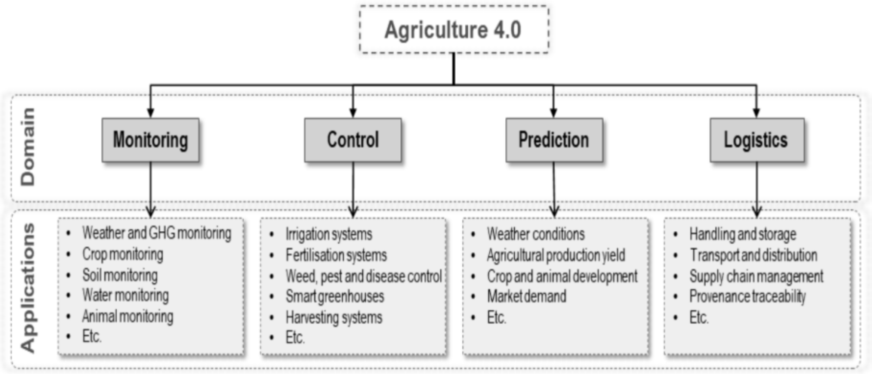

Figure 5. Distribution of Agriculture 4.0 applications domains and respective examples of applications (sub-domains) (Araujo et al., 2021).

1.7.ADOPTION, USES AND ADAPTATION OF AGRICULTURE 4.0 ON FARMS

Agriculture 4.0 includes modeling the costs and benefits of services provided to precision agriculture, which examines economic factors according to existing variables. The age and education of farmers can be effective in the acceptance of new technologies. Material and cultural aspects can play a major role in the application of new technologies in the farm. Although a lot of research is being developed in the field of industrial agriculture, in some regions and countries the issue of accepting or not accepting agriculture is questionable and a lot of focus should be done on this issue (Hunter et al., 2019). Agriculture 4.0 stimulates the development of applied agricultural science and brings new systems to the villages. Research in the fields of agricultural technology is growing and developing every day, and it will exert its influence, both small and large, in rural areas. Also, agriculture 4.0 can take its place in the agricultural market by affecting the economic trend of agricultural branches and be more accepted in terms of social aspects. If the study of the benefits and harms of agricultural technology 4.0 points to the prosperity of the agricultural market, it can be easily used in a short period of time (Apolo-Apolo et al., 2020).

1.8. AGRICULTURE 4.0 CHALLENGES AND RESEARCH OPPORTUNITIES

Despite the benefits of Agriculture 4.0 in the agricultural sector, there are some problems that need to be discussed. Finding different solutions for agriculture 4.0 can affect the acceptance of this issue in the agricultural sector.

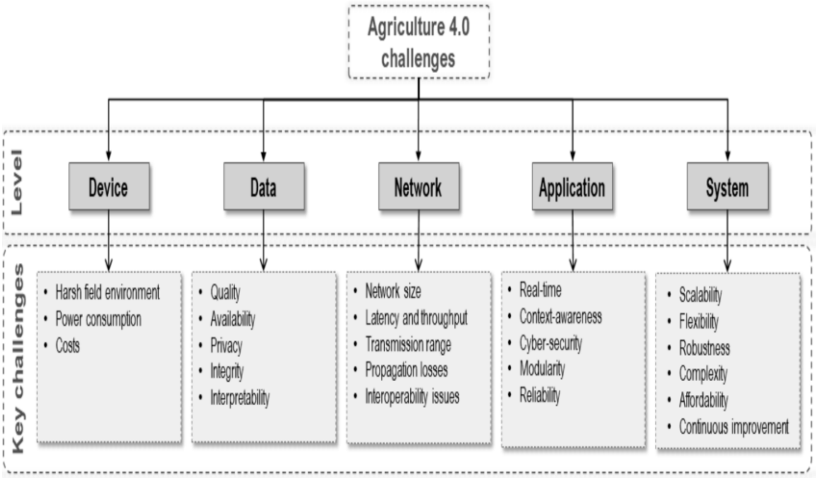

Figure 6. Some of the key challenges to be addressed in Agriculture 4.0 (Araujo et al., 2021)

Agriculture 4.0 Over time due to the use of new technologies will cause important changes in the field of agriculture. The most important of these features is artificial intelligence, which can play a significant role in all agricultural operations under special planning. Currently, farmers consider agriculture 4.0 as a risk and do not want to invest in this field. However, in some agricultural operations such as harvesting, they also feel a clear need for professional robotics. Therefore, in the future, 4.0 big changes are expected in the fields of agriculture (Wolfert et al., 2017).

1.9. DISCUSSION

Classical agriculture has a negative impact on the entire food supply and trade chain and slows down the movement in the chain. With agricultural technology 4.0, the method and amount of production, sale of agricultural products to wholesalers and from wholesalers to retailers can be monitored and food waste can be prevented. Agricultural technologies 4.0 enhance communication and reduce transaction costs, creating potential in the agricultural and food industries. Agriculture 4.0 is a strategy that makes agricultural activities more sustainable. Agricultural technologies 4.0 enable informed decisions, increase work productivity and reduce waste. This technology can play an important role both inside the farm and outside the farm.

In agriculture 4.0, data is collected for the purpose of calculations and planning operations and functions of agricultural fields. These data include environmental conditions, soil, land orientation, torography, crop conditions. Then, using this information and advanced technologies, predictive models are created and the amount of irrigation and fertilization is determined. These models save time and money and have significant benefits for the environment. Because they also reduce the use of chemical fertilizers. The arrangement of the farmer can also get a good yield from the crops and minimize the problems of climate change. Technological advancements revolutionize agricultural operations and provide different solutions to farmers' problems. These technologies play a role not only in the field of agricultural operations but also in the field of human health and the environment. Agriculture 4.0 creates technological standards in various fields of agriculture and guarantees producers and consumers in line with the services provided. This will increase investment in agriculture 4.0 and the industrial system will take the place of the traditional system. Agriculture 4.0 is an unstoppable trend in the agricultural industry. In the coming years, it will be tried to communicate this technology and data output from these technologies to farmers through personal mobile phones, and thus the connection between data and the implementation of operations will be stronger. This will make things easier and reduce costs and will strengthen work potential.

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CHAPTER 12

CHEMICAL WEED MANAGEMENT IN VINEYARDS

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1. INTRODUCTION

Due to immigration and asylum from rural areas and neighboring countries for various reasons, cities now have an excessive population density. The invasion of weeds in vineyard areas has long-term harmful effects. For the areas where vineyards will be created, choosing locations free of weed issues would be a good place to start. The planting spacing between and above the rows should be set so as not to inhibit weed management and other maintenance duties because vines in vineyards have a long economic life. Even if the vines in an established vineyard are deemed unproductive for the first few years (do not produce a harvestable crop), weed control will still be done. To put it another way, established vineyards should perform weed control around their established plantings. Effective weed control throughout long-term vineyard growth will hasten the start of production on non-fruiting vines and improve the crop's long-term health and output. However, it must be kept in mind that they are now susceptible to both mechanical and chemical treatments.

Because they compete with young vines for resources like water, minerals, light, and space, weeds should be kept at least one meter away from plants. Effective weed treatment will help reduce competition in the summer when weeds leave the vines behind. Vineyard weed management solutions that combine a few different approaches and adjust to the environment and crop requirements may change over time. It's important to keep an eye on weed numbers and select methods of management that work. There are three methods for controlling weeds in vineyards: cultural, mechanical, and chemical. Chemical weed control is widely used in vineyard areas since it is effective and economical. Herbicides are used both before and after emergence for chemical control. It is important to note that vineyards that are young or have green shoots are more vulnerable to herbicides when post-emergence herbicide application is being done (particularly when broadleaf herbicides are applied). Most pre-emergence herbicides have little to no impact on the root zone because the roots are well-established and appropriately submerged in the soil. Since the mature vine's bark is not green, it is less susceptible to various post-emergence herbicides. To control weeds after the vines are planted and before they ripen, a pre-emergence herbicide can be applied as a tape (strip) in an area of 1-2 meters around each vine. Herbicides can still be utilized to control weeds after they have appeared. Nonselective (total) herbicides, broad-leaved herbicides, and soil herbicides should not be used in vineyard areas if possible because selective herbicides can be used to control grass weeds in the first three years. Then, care should be taken to make sure that the herbicide being used does not encounter the vine's young, green leaves. Chemical weed management alone is insufficient to effectively control weeds in vineyards; a combined strategy combining cultural and mechanical methods is required.

2. CHEMICAL WEED CONTROL

Herbicides can be used in vineyard areas both preemergence and postemergence (Ying & Williams, 2000). There are two types of herbicides employed postemergence: nonselective (contact and systemic) and selective (Pateiro-Moure et al., 2013). For weeds with grasses, broad leaves, or both, several selective herbicides are effective. Preemergence or pre plant herbicides are sprayed on the soil's surface as opposed to tillage (Fiera et al., 2020). Although this varies by region, herbicide efficiency can occasionally be boosted by putting the chemical into the soil prior to planting (Louchart et al., 2001). The easiest plants to manage with post-emergence herbicides are grasses. These typically have relatively low phytotoxicity (Gur et al., 1979). After emergence, broad-leaf herbicides should not be used. The vine's green parts should not be disturbed. It also applies to all pesticides (Sanguankeo et al., 2009). In mature and older vineyards, herbicides can be used considerably more safely, but in newly planted young vineyards, the situation is different (Prodanova-Marinova et al., 2019). It's crucial to use legal herbicides in vineyard areas, according to the label's directions. The proper herbicide should be applied by licensed operators at the proper time, dose, and rate.

Existing weeds must be controlled in areas where new vines will be planted (Pala, 2020; Sanguankeo et al., 2009). Tillage is often used to control sprouting weeds, while post-emergence herbicides, such as total herbicides such as glyphosate, can be used to manage emerging weeds following tillage (Arlettaz et al., 2012; Mandl et al., 2018). Use total herbicides to eliminate all weeds with thin or broad leaves. Alternatively, before planting the vines, the soil can be mechanically amended with a pre-planting herbicide. Using an herbicide prior to emergence can also create a surface barrier on the soil. It's crucial to keep in mind that vine roots should not be encircled by herbicide-treated vineyard soil either before planting or before emergence (Zaller et al., 2018).

To reduce weed competition with the vines, herbicides are applied in centered strips to the grape row in established vineyards (Pala, 2020). In the vines, the herbicide strip is roughly 0.5 meters broad. Herbicide application in the form of strips will be useful for weed management in the vineyard. Tillage, mowing, mulches, cover crops, and post-emergence herbicides are the most often used techniques for weed management in the middle of rows (Elmore et al., 1997; Reinecke et al., 2002). When trees are dormant, strip weeds are typically controlled with pre-emergence herbicides (Donaldson et al., 1988). Before pre-emergence herbicides are applied on the strip, plant and leaf debris must be removed from it using brushes or blowers. Later in the growing season, tillage or at least one post-emergence herbicide spray are usually applied after this treatment (Tourte et al., 2008). This strip weed treatment method effectively gets rid of most annual weeds in vineyard settings. On the other hand, perennial weeds remain a problem and need for frequent post-emergence herbicide applications and/or tillage to lessen weed competition.

Only a small number of herbicides are approved for use in vineyard areas, so mechanical methods should be utilized in addition to chemical management (Pala, 2020). No-till farming methods have recently gained in popularity (Baumgartner et al., 2008). No-tillage management, sometimes known as "no tillage," describes the regular cutting of all vegetation or the application of stem-to-stem herbicides prior to and following emergence during the winter. Maximum frost protection, lower labor and equipment costs, improved water and fertilizer consumption, and quicker orchard maturation are all benefits of this technique. Even though no-till farming is more expensive for some growers because to higher costs for fuel, equipment, and labor, it is becoming more popular in some areas since it can be utilized with all types of irrigation and in most soil types. Problematic soils are a key limitation for herbicide-based weed control (Baumgartner & Veilleux, 2004). For instance, extremely silty soils can form a crust (surface seal) that stops water from penetrating, causing further erosion and soil movement away from the site. In coarse soils with little organic matter, excessive soil herbicide application might raise the danger of herbicides being carried off-site, reduce crop development, and gradually increase phytotoxicity. The upfront costs of a no-till program may be higher than those of other options, but benefits typically outweigh disadvantages, and this tactic has a lot of promise as a tool for better vineyard management techniques.

To effectively control weeds in vineyards, it is best to pick herbicides with a variety of modes of action (Elmore et al., 1997). Otherwise, weeds may become resistant to or lose their effectiveness to the same natural herbicides when used frequently (Olmstead et al., 2012). Pre-sowing or pre-emergence herbicides prefer herbicides with a long half-life and persistence in the soil, whereas post-emergence herbicides prefer herbicides with a short half-life or persistence (soil herbicides). Herbicides used before planting or before emergence are sprayed on bare soil in the spring and fall after tilling and when it is suitably moist (Monteiro & Moreira, 2004). Early on, when winter and summer weeds are germination and actively growing, post-emergence herbicides are sprayed (for example, during tillering for broad-leaved weeds). In order to lessen the risk of harm to the vines that will be planted there if a new vine is planted as a result of changing or removing the vines in the vineyard area for a variety of reasons, care should be taken to avoid applying herbicides in the vineyard in the previous two years (for example, removing the vines in the vineyard due to phloxera and planting American rootstocks in their place). Green tissue might be less exposed to post-emergence herbicides used in vineyard areas by taking preventative measures (Pala, 2020). To avoid contact with the herbicide, the vine stems may be covered in cardboard or plastic. As a result, the vine will be more stable. Another effective way to increase crop safety in vineyards and reduce off-target drift is to use shielded sprayers. A technological approach to the use of herbicides in vineyard weed control is essential to prevent the product's phytotoxicity. The environment, human health, and problems with weeds developing herbicide resistance are all made worse by only employing chemical methods to control weeds in vineyard areas. The use of both cultural and mechanical weed control methods should be used with this.

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CHAPTER 13

THE PLACE AND IMPORTANCE OF AGRICULTURAL WASTES IN A SUSTAINABLE ENVIRONMENT

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1. INTRODUCTION

Our country has a rising potential in terms of the agricultural sector. The rapid increase in population also increases the needs. The aim of meeting the increasing needs requires more intensive agricultural activities.

The increase in the variety and amount of production for modern living conditions shows that more agricultural waste will come out of the existing areas. In other words , with the increase in agricultural production, agricultural wastes will increase at the same rate.

Our country, which shows an increasing trend in terms of environmentally friendly energy resources, also has an important potential in terms of agricultural wastes. The increase in the number of cultivated planted areas every day means that the amount of waste to be generated increases.

The evaluation of agricultural wastes, which will become a problem in terms of environmental health and order day by day, is important both in terms of economic and environmental health. Correct disposal of these wastes is important in a sustainable environment approach. Waste materials released in agricultural areas should be recycled and evaluated for use in the renewable energy cycle or in many different areas. There are also wastes in all areas where agricultural production is made. Apart from the production made only in the field or in the garden, there is an intensive cultivation under cover such as greenhouses. Greenhouses are areas where modern technology is used in agriculture. Especially in areas such as greenhouses where technology is used intensively and where more conscious and controlled production is made, the amount of waste is more dense.

The factor that plays an important role in the realization of all activities in all areas of life is energy. It not only shows the development levels of the countries, but also constitutes the basis of sustainability.

In this study; We will talk about biomass energy, which is one of the renewable energy sources, which attracts attention with the fact that fossil energy sources are exhaustible and their reserves are gradually decreasing.

There are two main reasons why biomass and biomass energy are frequently mentioned in today's conditions: These are; economic and environmental concerns. These concerns make biomass resources an indispensable potential resource for a sustainable world.

2. BIOMASS

Biomass; It is the total amount of mass that the living organisms of a society have at a given time.

Biomass resources; fruit wastes and peels, vegetable wastes, fruit seeds, shell parts of hard-shelled fruits such as almonds, hazelnuts, coconut shells , olive seeds and pulp, annual plants, agricultural plants and their waste, agricultural plant stems, all woody and herbaceous plant wastes, forest and wood wastes, agricultural by-products and wastes such as shells.

Figure 1: Almond Shell

Figure 2: Fruit Kernels

Biomass energy is the energy obtained from biomass sources. It is one of the important renewable energy sources in the world. Many developed countries see bioenergy as the main energy source of the future (Anonymous, 2011a). Biomass is a strategic energy source because it can be grown anywhere, contribute to environmental protection, and can be used in electricity generation, chemical and fuel production (Bilgipasaji Web page, 2009).

As a result of the use of fossil resources for energy production, the amount of carbon dioxide in the world's atmosphere has increased. Carbon dioxide creates a greenhouse effect in the world's atmosphere, causing a change and warming in the world's climate (Jones and Warner, 2016).

The burning of biofuels does not result in a net increase of carbon dioxide in the earth's atmosphere. Therefore, researchers argue that biofuels should be used instead of fossil fuels in order to prevent the increase in the amount of carbon dioxide in the atmosphere (Whittaker and Likens, 1975).

Energy deficit, environmental friendly biomass energy studies aiming at sustainable energy production in the world have been accelerated. In our country, the use of biomass in energy production is becoming increasingly important.

Renewable resources are an important energy source not only because they are renewable, but also because they can be grown everywhere and quickly, provide socio -economic development, are environmentally oriented, produce chemicals with various conversion methods, produce electricity and be used as a fuel source for vehicles (Onay et al., 1996).

Biomass; While it meets 40% of the energy need in developing countries because it is renewable, cheap and abundant, it provides 14% of the world's energy need. Since it is an environmentally friendly energy source, it has an important place and an increasing interest worldwide (Tsai et al., 2007). In addition to fuels such as bioethanol, biogas, biodiesel obtained from biomass, many other fuel types such as fertilizer, hydrogen, methane and wood briquettes can also be obtained from biomass (Anonymous, 2011c).

1.1. Usage Areas of Biomass

1.1.1. In Energy Production

Energy is the most important factor affecting the economic structure of a country. In recent years, with the rapid increase in population and the development of technology, the need for energy has been increasing day by day. Therefore, the search for new energy sources has become an important issue for the whole world (Bongiorno and et al., 2013). In bioenergy plants, especially in biogas production, vegetable biomass can be used in energy production. In this way, the disposal of wastes and the disposal of these wastes into the nature without evaluation are also prevented.

Our country has rich biomass resources in terms of both variety and quantity in energy production. It is important to evaluate biomass resources, which show an increasing trend, in order to provide environmental health and economic benefits. Environmentally friendly energy sources are of great importance in terms of their existence in the world, as well as being sustainable. The importance of renewable energy sources is increasingly understood due to reasons such as foreign dependency on fuel, high import costs and environmental problems, as well as the rapid depletion of fossil fuel reserves in the world (CO, 2004).

Air pollution is an important environmental problem in our country as well as all over the world. Biomass energy sources are also effective in ensuring sustainable energy development and reducing air pollution in our country. There are biomass power plants established in many different provinces of our country.

Residues of agricultural products (shells of fruits such as almonds, pistachios, walnuts, pulp released after olive processing, etc.) can be burned in biomass facilities to produce electricity and heat energy.

Figure 3. Olive Pit

Figure 4. Olive Pulp

1.1.2. In Pellet Production

Wood, straw, paper and many vegetable fibers are an important source of energy. These are dried and then compressed under very high pressure to form pellets and briquettes, thereby reducing the volume/weight ratio. Conversion of waste into pellets will facilitate transportation, storage and use. Pellets and briquettes have a high calorific value.

Wood pellets or briquettes are used for heating purposes in houses and buildings. There are different types of Pellet stoves and stoves with pellet fireplaces.

Figure 5. Pellet

Biopellets can be co-burned with coal as renewable energy, contributing to the reduction of CO_2 emissions (Mizuta, 2010). Wood briquettes from sawdust and wood scraps; Pellet production is made from vegetable residues such as corn cobs, cotton and sunflower stalks, vine branches.

There are plants producing pellets in our country. Increasing the number and capacity of pellet production facilities will also make significant contributions to the bioenergy production potential (Saraçoğlu, 2010).

1.1.3. As Raw Material Activated Carbon Extraction

Today, biomass is used as a raw material source in the production of activated carbon; In this way, both wastes are evaluated and activated carbons with better pore structure and surface properties can be obtained (Gündüzoğlu, 2008).

That activated carbon is a valuable product that can be used as a raw material in many different industries in the field of gas masks, purification of drinking water, medicine and pharmacy in recent years, according to the researches, the carbon content in the outer shells of fruit seeds and especially hard-shelled fruits is sufficient for the production of activated carbon, and It is foreseen that if evaluated, it can provide an economic advantage.

Figure 6. Types of Activated Carbon

Husk and stems are exposed when products are processed in related agricultural enterprises and industry. These residues are sold at very low prices for the sole purpose of being incinerated regarding their calorific value. When the chemical structures of such agricultural residues are examined (Table 1), it is seen that the carbon contents required for activated carbon production are quite rich (Akçakal, 2017).

Table 1. Elemental Analysis (Ultimate Analysis) Results of Some Agricultural Residues (Akçakal, 2017)

Materiel	**Ultimate Analysis (%)**					**Reference**
	C	**H**	**N**	**S**	**HE IS**	
Apricot kernel	51.57	6.34	0.57	0.027	40.68	Şentorun-Shalaby et al., 2006
Almond Bark	44.63	6.32	0.77	-	48.28	Chayande et al., 2013
Peach Seeds	51.35	6.01	0.58	0.14	40.32	Atimtay, 2010
Olive seeds	51.50	6.30	0.20	0.1	41.90	Petrov et al., 2008
Cherry Seed	48.72	6.41	1.85	-	43.02	Angin, 2014
Walnut shell	48.34	6.16	0.69	0.03	44.78	Open, 2011
Hazelnut Shell	51.60	6.20	1.60	0.04	40.20	Fixtures, 2002
Pistachio Shell	44.62	5.81	0.32	-	49.25	Açıkalın et al., 2012
peanut shell	48.30	5.70	0.80	-	39.40	Sivakumar and Mohan, 2010
Tea Production Surplus	47.90	5.90	2.40	0.30	43.60	Gundogdu et al., 2013

With the use of shells with high carbon content, a woody hard material obtained as a result of the crushing processes of hard-shelled fruits such as almonds and walnuts, which have attracted attention with their increase in production in recent years, it is a porous product with high carbon content, which is a product with high added value and has wide use in many fields. It has been emphasized that the production of activated carbon with this structure can contribute more to the country's economy and that the peel of these fruits is as valuable as the edible inner part.

In addition, obtaining an important adsorbent such as activated carbon from domestic sources Being easily available and cheap will also contribute to our country's economy.

1.1.4. Obtaining Materials such as Peat, Fertilizer

The wastes generated in the garden, field, greenhouses and other growing environments can be collected from these places, collected in certain collection points, and converted into vegetable inputs such as fertilizer and peat after the necessary processes.

Figure 7. Peat

1.1.5. Ground Cover or Mulch Material

It is possible to see plant biomass resources that can be used as soil cover or mulch material in many areas in agriculture. It is possible to see a plant biomass source as a substitute product for sawdust used in organic fertilizer and mulch in agricultural areas.

Figure 8. Mulching with Straw/Grass

Figure 9. Mulch Application on Potted Outdoor Ornamental Plant

1.1.6. In Evaluation as Fuel

Agricultural wastes (stalk, straw, wood shavings, hard fruit peels, etc.) are used as solid fuel or heat source in homes, workplaces, ovens, dairy farms, some businesses, food and industrial facilities. When these environmentally friendly wastes are burned, coal will emit less carbon than natural gas and pollute the air much less than fossil fuels.

Figure 10. Wood Chips

CONCLUSION

Developing technological activities increase the demand for necessary energy day by day, which creates needs for more energy production. Although different raw materials can be used in energy production, it is important that the raw material used is cheap, easily accessible and abundant. Biomass resources are very suitable for this tariff. Especially our country, which is an agricultural country, is lucky in this regard, but the desired level in the evaluation of biomass has not been reached, there are many reasons for this.

Used in many other fields such as furniture, paper, insulation material various technologies are used to obtain solid, liquid and gaseous fuels. The fact that much less SO_2, NO_x and CO_2 compounds are given to the environment in the combustion process compared to oil and coal proves that biomass is an environmentally friendly energy source. That modern heat facilities and bioenergy plants that will enable the conversion of biomass resources into electricity and heat energy by burning and increasing their numbers.

With the existence of bioenergy power plants; protecting the environment, job opportunities for hundreds of thousands of people It will have numerous benefits such as contributing to the country's economy by providing.

With this application, both the waste materials of the country will be evaluated and the country's energy production will be increased. It will also enable important steps to be taken in the fight against the threat of global warming and climate change, which has been mentioned a lot in recent years.

The energy generated as a result of combustion in bioenergy plants or heat plants is either converted into electrical energy and given to the electricity network, or water is heated in heat plants.

Fruit growing, which has an important place in the world, is becoming more and more widespread in our country. Hard-shelled fruit types and stone fruit types, which are frequently consumed in our country and can be grown in many regions, have an increasing potential in recent years . With the increasing production in our country, the amount of waste generated is also increasing. That hard fruit peels and fruit seeds, which have an important place in terms of the economy of our region, have sufficient carbon content to obtain activated carbon as a raw material source. In this study, it is possible to emphasize that apart from the consumable fruit pulp and fruit pulp, the fruit peel and seed are also valuable products.

Biomass energy, which is a renewable energy type, will reduce dependence on oil and coal and will not send extra carbon dioxide emissions to the atmosphere. The use of inactive agricultural wastes originating from biomass as raw materials in many areas will provide a significant advantage to the country's economy.

Evaluation of these idle wastes will also prevent pollution from an environmental point of view, since these wastes occupying space in nature are removed from the environment, new areas will be opened and visual pollution that has occurred or is occurring in the environment will be prevented.

During the season, intensive spraying and fertilization are carried out in the garden, field and greenhouses. It is possible that these chemicals may mix with the atmosphere during the disposal of these wastes by incineration. It will be better for environmental health if these wastes can be collected and evaluated under appropriate conditions.

These wastes, which are not burned but spilled near the greenhouse, garden and field, and are expected to be destroyed by themselves, cause visual pollution, as well as negative consequences such as odour, pests and hosting some pests.

Direct burning of wastes instead of being evaluated will harm the nature in terms of CO emissions. At the same time, it is possible to say that there will be many negative situations such as damage to the underground and above-ground creatures that stay in the place where the wastes are burned.

Our country lags behind developed European countries in terms of evaluating their wastes. Our biggest problem is that the number of bioenergy facilities is low and the existing facilities are concentrated in major cities. Small businesses can also be opened in small cities. This will be beneficial both for the evaluation of wastes and for the economic development of that region.

In the first place, government supports and applications that will guide the producers will be economically beneficial. Thanks to such facilities, the wastes will be freed from being a pile of garbage and the images that will pollute the nature and the environment will also disappear.

If we consider agricultural wastes and their evaluation, agriculture is an ocean in itself. Agricultural practices and the processes that can be applied afterwards cover much wider issues, therefore, the issues should be handled, researched and examined one by one. While some of the wastes are evaluated in our country, unfortunately, the agricultural wastes that are still released are either thrown directly on the land and are expected to decompose in nature, while sometimes these wastes are directly incinerated or collected and thrown into landfills together with other wastes.

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CHAPTER 14

ECONOMIC COMPARISON OF TURKEY'S LOGISTICS INVESTMENT IN AGRICULTURAL PRODUCTION IN 1923-1948 PERIOD AND 2000-2022 PERIOD

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1. INTRODUCTION

While the Republic of Turkey entered the 21st century; the effects of the cold war, especially the post-1990 post-cold war unipolar and 50-year relations with the United States of America, were brought to a higher level by producing more strict Neo-Liberal policies, leaving completely independent policies and becoming more dependent and integrated tht emerges in the civil structure, having shaped its institutions according to this relationship.

In order to stay out of the Soviet influence after the Second World War, its integration with the American structures took place simultaneously with Europe, and after the devaluation and nationalist mixed policies in the 1948s, acting under the influence of American neo-liberal policies; In the coordination of the institutional structures in the IMF, World Bank, NATO and the United Nations, which are the additionally supportive/mandatory memberships in the missing points and the Marshall aids on the economic support side and the funds such as Full Bright on the education side are fully integrated into the system when necessary.

While the planned economic structure was replaced by a nationalist structure in the 1950-1980 processes, which was tried to be controlled by the social structure, especially by supporting the global changes, the Petro-Dollar system and the policies of isolation of the Soviets imposed by the Bretton Woods system. Feudal structures, Sects and Communities, Non-Governmental Organizations, against which the Republic struggles, are used as an element of social pressure; in the case of a return to national policies in case of incompatibility with the global system, first of all, economic embargoes (the Cyprus problem and the events after 1974), the military coups of 1971 and 1980, have turned into a structure that offers threatening and socially damaging transformations and economic prescriptions. Of course, these internal structures organized by the existing Civil and Military structures, with the neutralization of nationalist policies and the imposition of the free market of the system right after the 1980s, are actually dependent on high technology imports and do not have national production permits, exporting raw materials and labor / brain power, It has been designed as one-way dependent and ideologically and economically, where all the needs of the system are met cheaply. The Republic of Turkey lost its structures in the establishment period with the World War II, and especially in the process that led to the disintegration of the Soviet Union in 1990 and global raw material sharing until the 2000s, privatization and duty-free entry of products, in fact increasing one-sided dependence and causing further impoverishment. By the way in agricultural activities, the bans of the 1970s turned into a one-way dependency, especially at the level of seeds and agricultural inputs, with political changes and cooperation. On the other hand, through the social and diplomatic agents within the system, legal arrangements have been made regarding which agricultural products should be purchased and where, in order to strengthen unilateral dependence on the system. It is seen that the privatization processes, especially after the 1990s, were made at low prices and physical gains (with exceptions) were integrated into Neo-Liberal policies at very low prices, as foreign currencies invaded economies through exports and free markets.

As can be seen, the nationalist activities in Turkey between the 1st and 2nd World Wars were carried out by force from time to time, instead of the American policies that designed the global system in every field.

In addition, while terror spread with terrorist organizations, barriers were created on the condition that unstable areas were created and it was carried out with the threat of transformation of civil society, there were a serious corruption in the terrorist regions and the population is forced to migrate from the regions and the control in the field is unstable by creating unstable regions by using irregular warfare, mafia systems, especially oil and so on the supply of raw materials has been made.

What the Sheikh Said rebellion was in the Republican Period, in this regard the Nationalist Greek movements in Cyprus (the Greek society system was manipulated and used with money for its continuity), also the Armenian terrorist movements that reached their peak in the 1970s, and organizations such as the PKK and DHKPC that still exist today are all these things; are devices used to create instabilities.

Particularly the years 2000 – 2020 has begun to evolve towards a period that requires the transition from a unipolar world to a multipolar system. However, there is also the necessity of creating new institutions and new policies, and where such efforts began widely and the People's Republic of China that came into existence with planned development as of 1979, increased its influence both economically and ideologically with global coordination and became a global player. That situation emerges in the inside of neo-Liberal systems, are tried to be liquidated, but environments of conflict are created. (DUTTA, 2005)

2. 1923 - 1948 Economical Analysis of Turkey's Transportation Infrastructure

After the proclamation of the Republic, the most basic sub-sector of the transportation sector is considered to be railways within the scope of creating a self-sufficient national economy (SAATÇİOĞLU, 2016). Because in this period, ports, commercial areas and important settlements in the country were mostly connected by an railway network (İncekara, 2016). The main purpose of the mixed economy production and investment policies with a focus on state investment in the 1923-1945 period is to ensure that the distribution of agricultural products to both domestic and foreign markets, especially to the factories that process agricultural products, in which the investment of agricultural products is made domestically, and fresh vegetables and fruits to the domestic markets, from their source, also for export as a healthy transportation of the products produced by rehabilitating ports and railways, purchasing them and constructing new lines and regions.

After the Second World War, while the use of railways decreased, the dominance began to shift to road transport. That means, it was aimed to build all kinds of infrastructure, repairs and roads that modern transportation vehicles need (İncekara, 2016). The main reason of the situation is the investments for agriculture, public works and logistics, brought about by the state-supported mixed economy in Turkey's domestic political conjuncture, and the desire to create a new peasant, farmer class and middle class in the new model. It envisaged that the old landowners and their wealth, which had already emerged in all areas of politics in the old order, would be re-distributed by the state by threatening their existence, and the establishment of a more stable structure was causing serious disturbances. The structures, which existed during the Ottoman Empire, were sects within the framework of religion, landlords on land belonging, etc. they do not want to give up their wealth, even if they have already set foot in the commercialized environment of the period. (Meral BALCI, 2018).

this respect, we can consider the conditions and important events of the period in Turkey, by taking into account the investments in the post-war period of 1923 - 1948 and the trends in the global order after their return.

- Soviet threat
- Recep Peker 15th Republic Government and 1946 Turkey's first devaluation
- Turkey's request to join the Western Block

- 1947 IMF founding membership
- 1947 Truman Doctrine and Marshall Plan
- 1948 Brussels Treaty

After the Second World War, the Republic of Turkey was more secure and stable in the eyes of the states in its region. However, when evaluated in terms of economic activities, it seems to have become introverted and unable to self-sufficient, and it is seen that the existing financial structure in the new vision is not self-sufficient.

Due the Soviet threat, the 15th Republic Government decided to follow a policy towards the West instead of an independent policy, contrary to its founding philosophy. In this state, it aimed to create a foreign trade balance in order to increase domestic production and consumption and to benefit from the situation of post-war European countries in terms of exports by realizing a devaluation of the Turkish Lira in 1946(TUNA, 2007).

The devaluation known as the 7 September Decisions, the Turkish lira lost nearly 40 percent of its value in 1946 (TUNA, 2007).

The 1946 devaluation had severe economic consequences. Apart from the realization of the targets, as a result of the excessive depreciation of the Turkish lira, the public budget deficit increased, exports decreased, and the demand for imported products increased. There was a serious decrease in the purchasing power of the people.

In addition, Turkey joined the International Monetary Fund (IMF) in 1947 as a founding member. During this period, it was aimed to increase monetary expansion, increase consumption through borrowing, and support it in production as such. As a result, the desired amount of financing could not be provided and the financing gap that increased with the devaluation could not be met.

The regulations made on September 7, 1946, which is the first devaluation of the economy of the Republic, is one of the most important decisions in the history of Turkish economics. Despite the effects of internal developments, this operation, which bears the traces of the US-led economic and political winds of change that emerged after the Second World War, aims to increase production, restore foreign trade to a healthy structure and become a member of the International Monetary Fund (IMF) (BORATAV, İktisat Tarihi (1908-1980), Türkiye Tarihi, Cilt:4, Çağdaş Türkiye 1908-1980, 1997). However, since the implementation process did not bring the desired success, especially in the fields of production and foreign trade, the decisions were increasingly subjected to extensive criticism. As a result, the devaluation of September 7, 1946 can be considered as a policy aiming at the rapid liberalization of the country's foreign trade, but not successful in fundamental points, since sufficient economic and political analysis could not be made.

This is an indication that a fundamental policy change is being made economically and that more liberal policies are being adopted from the mixed system. Of course, the political disturbances and political disintegration that existed during the period of the CHP governments will carry the process of military organization, especially in the USA, completely under the guidance of Western countries, and becoming a member of NATO in 1950, this situation seems to be a breaking point that started to develop contrary to the policy of full independence.

On the positive side; Turkey has started to increase its commercial relations with the world over time and has become more integrated with the outside world.

In this context, the USA contributed to the evolution of the system to liberal policies under the guidance of the USA by providing material military and political support to Greece and Turkey by putting the Truman Doctrine and the associated Marshall Plan into effect in 1947 despite the Soviet threat.

The transition from the mixed economic model to the liberal economy did not provide the expected breakthrough in the foreign trade volume, and prevented the country from reaching its goals. However, during the Second World War, investments were largely interrupted by security policies, and the mixed model was abandoned in the hope that the welfare level would be increased, and it could not manage the post-war economic crisis by going the way of devaluation and borrowing. Under these circumtances, instead of railway investments, it has turned to road-based targets in the same way with American and European liberal policies that will support the production of oil and its derivatives.

In terms of public works, the land reform movements could not be completed or even prevented. By the way, the feudal structures were completely settled and the problem, which had a solution, was further deepened and rendered unsolvable, and its effects are still present.The agricultural development moves of the Young Republic did not reach the desired levels in agriculture, due to the inadequacy of agricultural tools and equipment.

Seed breeding stations were established, but the improvement works were interrupted after a while, the import route was preferred. With the guidance of liberal policies after 1948, the use of improved foreign seeds and fertilizers was put into use under the name of productivity, reducing soil quality.

Research and development studies and farm practices were insufficient. Atatürk's targeted development move was abolished after his death.

Village Institutes and Agricultural Institutes, which are among the breakthroughs Atatürk made in education, were closed after his death or were thrown into the background, and the progress of the education was damaged; This situation also necessitated the migration of the uneducated and landless farmers, and paved the way for the formation of big cities developed by expanding the trade centers with a liberal model, and became a system that would encourage rural to urban migration. In addition, the capital and labor force created in the cities after 1950. As a result of the migration of workers and peasants, starting from the villages and hamlets, it has moved to Europe and the big cities. This situation has created an uneducated and landless peasant social layer, and the villages have been emptied, migrated and the population structures in the cities have changed.

Basically, the establishment of a distribution network of transportation, logistics, public works and production in inner regions to other cities is one of the main duties of the state of a self-sufficient country, and this is one of the cornerstones that directly affect military and civilian human life. The economic structure, which was included in the founding philosophy of the Republic of Turkey and then evolved into a planned mixed economy, determined the areas of development and investment, and an effort was made to implement it in the right way until the years of the 2nd World War.However, the vision developed with the death of Mustafa Kemal Atatürk could not be followed. In addition, the representatives and generations of the feudal structures that already existed with the habits of the Ottoman Empire period, using the war and the situation of domestic economic conjunctures as an excuse, did not hesitate to manipulate the domestic economic order in order to maintain their order.

The fundamental policy changes after 1945 caused the most serious political breakdown years of the Turkish Republic, and contrary to the founding philosophy, changes were made with the cooperation of the Western States in almost all fields, and with the model created, today's Turkey is very different from the founding model and has completely broken away from the basic philosophy.

In its final form, we can summarize the Public Works, Logistics and Agricultural activities carried out in the first years of the Republic as follows:

Road Inventory During the War of Independence:

- Of the total roads, 18,335 km of roads remain, of which 13,885 km are dilapidated and in need of repair, and 4450 km are dirt roads.
- A total of 8,619 km of railways have been built in better condition than railways, but 4,112 km of existing investments. It remained within the borders of the National Pact.
- Merchant fleet capacity is negligible and Port and facilities are almost non-existent (OZDEMIR, 2006).

Road Inventory up to 1948 :

- With the law enacted on April 22, 1924; purchasing activities, Haydarpaşa Port Management - Purchase of the Anatolian - Baghdad railway within the borders of the National Pact (Haydarpaşa-Ankara, Eskişehir-Konya and Arifiye-Adapazarı railways and Haydarpaşa port and dock, with all its branches and outbuildings, also Baghdad

Purchase of the operation and construction of the part of the railway after Konya)

- Its budget has been determined as 15 Million TL for 5 years, but the total investment is well above this budget.
- In 1928, 346 km of Konya-Yenice, Mersin-Yenice - Adana were purchased.
- Sivas - Amasya - Samsun line was built in 1932.
- In 1933, the 42 km Samsun-Çeşamba line was purchased.
- In 1934, the 703 km Izmir-Kasaba line was purchased.
- In 1935, the Izmir-Aydin line of 607 km was purchased.
- In 1937, the 337 km Eastern Railways line was purchased.
- Construction of Irmak - Zonguldak line again in 1937, construction of Zonguldak - Kozlu line in 1945
- In 1941, 28 km Ilıca Pier – Palamutluk (Bursa - Mudanya) was purchased.
- In 1944, the Fevzipaşa - Narlı - Malatya - Yolçatı - Diyarbakır - Kurtalan line was built.
- In 1947, the Elazig - Palu - Genç line was built.
- In 1948, Baghdad Railway lines contracts and privileges were purchased by breaking

(Bakanlığı T. U., 1973).

Table 1. Budget Allocated for 1924-1945 Railway

YEAR	Allocated from The Butget (TL)	Railway Length (Km)
1924	8.700.000	203
1925	29.000.000	251
1926	43.900.000	513
1927	72.300.000	595
1928	151.500.000	783
1929	161.400.000	1232
1930	203.300.000	1392
1931	225.600.000	1690
1932	232.600.000	1955
1933	245.700.000	2012
1934	260.800.000	2399
1935	282.300.000	2705
1936	301.300.000	2849
1937	320.400.000	3012
1938	341.600.000	3227
1939	363.000.000	3277
1940	383.900.000	3277
1941	398.500.000	3306
1942	410.700.000	3360
1943	438.000.000	3360
1944	454.700.000	3383
1945	463.500.000	3447

(OZDEMIR, 2006).

Unrealized Projects:

- The Trabzon – Eriklibel – Erzurum railway project both prevented its realization due to its high cost; however, this situation adversely affected the trade between Tabriz and Trabzon port. In this period, the Trabzon port was the port of the Transit trade and today it had the function of Mersin port (240 KM).
- Afyon – Antalya Railway Project (325 KM), (GAZETE, 1935).
- The construction of the Burdur-Korkuteli line (106 KM) was put on the agenda, but the project could not be realized due to lack of budget and geographical conditions (Deniz, 2011).
- Diyarbakir - Kurtalan - Cizre - Iraq line (291 KM) was planned, however, due to the difficult geographical conditions of the Tigris valley, the insufficient technology, the operation of the Mardin - Diyarbakir line, which is the owner of the business in the region, by a foreign company and the presence of the line on the border in parallel with this projected line caused the investment to be disrupted. and allowed it to be done up to Kurtalan. The aim of this line was the development of transit trade with the Turkmens in the north of Iraq and the use of the products in this region in the international and national markets (Dergisi, 1935).
- Diyarbakir - Gevaş - Van - Iran line was abandoned and it was decided as Elazig - Tatvan - Ferry - Van. This route

was one of the most convenient and important methods of trade with Iran. In addition, this line is of importance to provide communication with the Turkmens of Urmia.

- Other lines that could not be designed but realized are; Adapazarı and Arifiye - Mudurnu- Bolu- Gerede-İsmetpaşa (243 km.), Bozüyük- İnegöl- Bursa-Mudanya (182 km.), Bursa-Mustafa Kemalpaşa-Okçugöl (95 km), Somucak - Construction of Osmancık- Gümüşhacıköy-Merzifon-Amasya (265 km.) lines is planned. It was aimed that the line between Adapazarı and Amasya would later merge with the Erzurum line, but it was not realized due to the construction of other railways, the effect of Atatürk's death and the budget constraints caused by the 2nd World War (AS, 2006).

Due the terror activities (such as the Dersim Rebellion, etc.) and especially in the Eastern and Southeastern Anatolian regions, even if a share is allocated for security expenditures due to budget constraints both in agriculture and investments, both due to such physical effects and the inability of technology to invest, even if the budget is exceeded, the planned investment of 1747 KM could not be realized.

Under these circumtances, with the rehabilitation of the existing roads as 5194 KM as railway and highway, the total inventory was realized as 23529 KM with 18335 KM as of 1948.

66% of the planned and budgeted investments were made physically. However, if it is taken into account as a budget, the budget, which was determined as 15 million TL for the first 5 years, was realized with a realization of 305 million TL with 20 times more expenditure. It provided political freedom due to the conjuncture of the war, but it caused the costs to increase.

1. Economic Analysis of 1923 - 1948 Turkey's Agricultural Infrastructure

The agricultural sector, which contributed greatly to the country's economy, as in every field, was also discussed with the establishment of the Republic. Atatürk emphasized the importance of agriculture in the opening speech of the Grand National Assembly of Turkey on March 1, 1922 and published the first declaration on agriculture even before the Republic was declared. Accordingly, Atatürk wanted the abolition of the Tithe tax, the reorganization of tobacco agriculture and trade, the support of farmers with more suitable and more loans by increasing the capital of Ziraat Bank, the importation of agricultural machinery, the improvement of animal breeding and measures to increase their numbers. The economic policy of the Turkish Grand National Assembly and the Government primarily prioritizes the development of rural areas (ATATURK, 1922). After these developments, İzmir Economy Congress was held on 17 February 1923 under the leadership of Atatürk.

The decisions taken for the agricultural field at the Izmir Economy Congress are as follows:

- Tithe tax will be abolished.
- Tobacco agriculture and trade will be free, exported tobacco must be processed and the taxes on these products will be collected from the consumer.
- Regi will be removed.
- Agricultural credits will be regulated.
- Road tax revenues will be spent on road construction.
- Forest villages will be taken care of.
- Struggles against animal diseases will be accelerated.
- Fish will be raised in the lakes.
- Repair workshops will be established.
- Agricultural tools and machinery will be standardized.
- Practical agriculture lessons will be included in school programs.
- Higher education students will be sent to the villages within a certain period of time.

(BORATAV, 100 Soruda Türkiye'de Devletçilik, 1974)

Table 2. 1920-1930 Budget Revenues and Expenditures

Years	Budget Revenues	Budget Expenses	Difference	Actual Budget Balance
1920	46839868	63018354	16178486	-
1924	129214610	140433369	11218759	-6%
1925	153406854	183932767	30885913	-31%
1926	190158854	190103544	55310	-8%
1930	222646523	222732000	85477	-7%

(GÖKBUNAR, 2012)

In particular, the 1929 World Crisis interrupted export and foreign input activities, and as a result of the crisis, the integration of public works and logistics activity investments with other areas of the economy and the opening of investment areas under the leadership of the State, and their transformation into investments in a planned manner, provided that the previous Agricultural and Logistics activities were carried out by the state itself. intended.

- Increasing logistics investments
- Providing and arranging farmer and peasant support in rural areas
- Law of the Land
- Planning of industrial investments of agricultural products
- Identifying and promoting strategic products
- Determining the areas where the private sector is not sufficient and conducting investments by the State

For this purpose, a planned period was started in the industry on April 17, 1934. The First Five-Year Industrial Plan was adopted. It was cooperated with the Soviet Union, which was not affected by the 1929 World crisis, which first implemented the five-year development plan in 1928. Turkey also prepared the First Five-Year Development Plans with the Soviet Union in 1930 with the help of Soviet experts in 1932. (UNLU, 2012). Along with the planning, importance was given to the establishment and expansion of food and textile industry areas for the processing of raw materials obtained from the agricultural sector.

- 1934 Bakirkoy Cloth Factory
- 1934 Turhal Sugar Factory
- 1935 Kayseri Cloth Factory
- 1937 Nazilli Printing Factory and Eregli Cloth Factory
- 1938 Gemlik Artificial Silk Factory
- Bursa Merinos Factory

In 1934, the first milk powder factory in Bursa and the rose oil factory in Isparta were opened in the country. In 1935, Turkey Sugar Factories Joint Stock Company, Kayseri Cloth Factory was established. In 1937, in order to protect forests, the Forest Law, Konya Ereğli Cloth Factory was opened. In 1938, Gemlik Artificial Ipek and Bursa Merinos factories were opened, and Grain Products Office was established to receive the production of the villagers. (CALGUNER, 1971).

With a law enacted in 1936, paddy cultivation in the country is bound to certain rules. Accordingly, paddy commissions will be established in each province and planting will be carried out by these commissions. Meanwhile, the obligation of the state to directly participate in economic and commercial activities in agriculture and animal husbandry arises and as a result; New State Enterprices such as TMO, EBK, Türkiye Şeker Fabrikaları A.Ş., Yem Sanayii, Yapağı ve Tiftik A.Ş., TZDK, SEK are created.

At the same time, the variety and number of public services taken to plant production gradually increases. T.R. The use of credit, which is fulfilled by Ziraat Bank and TTKs, has a function that seriously affects the sector. The volume of loans used reached 8 million TL in 1923, 48 million TL in 1938, and 400 million TL in 1950. (KIREYEV, 1987).

Agricultural Combines Administration was established in 1937 with the Law No. 3130 in order to purchase and introduce agricultural tools, machinery and pesticides to the public. It is tried to provide agricultural tools, agricultural machinery and pesticides to those who are engaged in agriculture in rural areas through the combines.

In 1938, the State Agricultural Enterprises Institution was established with the Law No. 3308. This institution is intended to be an example and guide to the public in regionally spreading agricultural methods and types of agriculture, determining their time and application. With this aim, it has been determined as the duties of the institution in general to establish agricultural business centers, factories and workshops, to make silos and warehouse works, to establish agricultural enterprises or to participate in them financially. (CALGUNER, 1971).

2. Economic Analysis of 2022 Logistics and Public Works Infrastructure

Especially in the period when the effects began to be seen in 1980 and emerged with the deterioration of the two-block structure after the Second World War in the 1990s, the Republic of Turkey was completely separated from the mixed economic model with Liberal and Neo-Liberal policies.

However, we see that the structure that is tried to be established with the Presidential System and the state power are more involved in free economic policies today. In addition, we see that the infrastructure is renewed both in the field of energy and in the field of public works and transportation with new models (build-operate-transfer, direct government investments, etc.).

As of 2022, with a total of 68526KM Land and 12803 KM Railway inventory, it has been realized as 81329 KM in total. According to the data, the rate of investment realized with the targeted is 82%.

If we examine the budget performance, we see that the transportation budget for 2022 has been determined as 71 billion TL, but when the 2023 target is compared to 181.8 billion TL, we see the problem created by the World Economic Cycle by the end of 2022 and caused by an unmeasurable inflationary and monetary size.We are faced with revised budgets, which have been focused on Build - Operate - Transfer projects in terms of foreign currency input problem and timely completion and delivery of investments, but far from spending control and measurability criteria, which are far above the budget targets in the first years of the republic. (Başkanlığı, 2021); (Bakanlığı T. U., ULAŞTIRMA BAKANI KARAİSMAİLOĞLU: 2022 TOPLAM BÜTÇE ÖDENEĞİ YAKLAŞIK 71 MİLYAR TL, 2021); (Bakanlığı T. U., ULAŞTIRMA VE ALTYAPI BAKANI KARAİSMAİLOĞLU: 2023 TOPLAM BÜTÇE ÖDENEĞİ YAKLAŞIK 181.8 MİLYAR TL, 2022)

When today's logistics infrastructure inventory is examined, it is seen that in the 2053 logistics master plan, which was presented by the Minister of Transport of the Republic of Turkey Adil Karaosmanoğlu on 05/04/2022 was targeted:

- The total divided highway network reaches 38 thousand 60 kilometers.
- 8 thousand 325 kilometers of the total highway network
- 8 thousand 554 kilometers of total railway line and connection of high-speed train lines to 52 cities
- The number of airports reaches 61

Republic of Turkey Minister of Transport on 05/04/2022 Extracted from Adil Karaosmanoğlu's Presentation. (Ajansı, 2022)

Highway Inventory:

Table 3. Road Network by Surface Type

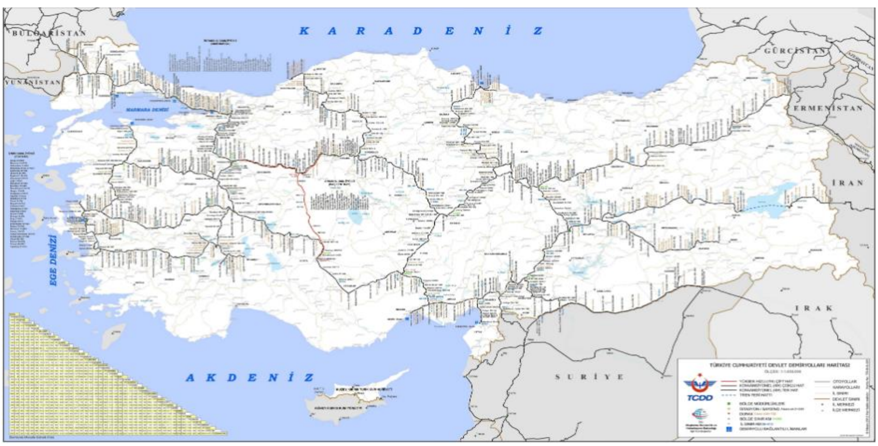
SATIH CİNSİNE GÖRE YOL AĞI (KM.)
Road Network According To Surface Types (km)

(01.01.2022)

YOL SINIFI Road Types	ASFALT BETONU Asphaltic Concrete	SATHİ KAPLAMA Surface Treatment	PARKE Stone Block	STABİLİZE Stabilized	TOPRAK Earth	GEÇİT VERMEZ Primitive	TOPLAM UZUNLUK Total Length
OTOYOLLAR Motorways	3 532	--	--	--	--	--	3 532
DEVLET YOLLARI State Highways	19 280	11 314	46	22	0 000	303	30 965
İL YOLLARI Provincial Roads	5 494	25 573	241	303	339	2 079	34 029
TOPLAM Total	28 306	36 887	287	325	339	2 382	68 526

(Müdürlüğü, 2021)

Demiryolu Inventory:



- The total length of the railway network, which was 10,948 km in 2002, was increased to 12,803 km in 2019.

High-speed train lines, which were not available in our country in 2002, were increased to 1.213 km in 2019.

- While 73 million passengers were transported annually by railways in 2002, the number of passengers transported by railway exceeded 246 million in 2019. While 14.6 million tons of freight was transported by railroads in 2002, the amount of freight transported by rail increased to 33.5 million tons in 2019. (Başkanlığı, 2021)

Airways Datas:

- The number of airports, which was 39 in 2002, reached 56 in 2019.
- While there were 110 aircraft in the airline fleet in 2002, this figure increased to 540 in 2019. From 2002 to 2019, the number of aircraft in the airline fleet increased by approximately 10% annually on average.
- While the total passenger traffic (domestic + international) of the airports was 33.5 million in 2002, the total passenger traffic increased to 209 million in 2019.(Başkanlığı, 2021)

As of 2022, the existing transportation infrastructure has grown by 75% on average compared to the first years of the Republic. In order to create a more stable and controlled structure, it is essential to establish satellite and signaling communication units in a healthy way.

3. Economic Analysis of 2022 Agricultural Activity Infrastructure

Since the main factor that determines Turkish agricultural policies is the EU harmonization process and the Common Agricultural Policy (CAP) based on this, it is necessary to first examine how the adaptation to the CAP has progressed in order to talk about the future periods of Turkish agriculture. There is no stable agricultural policy in Turkey. The most important document in which agricultural policies are officially mentioned in Turkey is the five-year development plans and programs. (Birliği, 2014)

Therefore, the things to be accomplished in Turkey's agriculture are determined by the five-year development programs. Reforms are needed in order to realize the strategic plans and objectives presented in these development programs. The future of Turkish Agriculture depends on the 2013-2017 Strategic Plan until 2020 today.

The articles of the 2013–2017 Strategic Plan regarding agricultural policy (2013–2017 Strategic Plan):

1. Ensuring access to quality agricultural products and food security by protecting agricultural production resources; for protecting agricultural and environmental resources, to develop appropriate methods and technologies to increase efficiency and quality in production, and to ensure supply security in agricultural products and foodstuffs. It is aimed

to create a competitive agricultural sector, which provides reliable product supply thanks to traceability and sustainability in agriculture, strengthened by the insurance system where risks are identified and made manageable.

2. For ensuring food safety in accordance with international standards from production to consumption; It is one of the important objectives of the strategic plan to ensure food safety in accordance with international standards and to protect consumer health at the highest level during the production, processing, preservation, storage and marketing of all kinds of foodstuffs and materials and materials that come into contact with food, starting from the first stage when raw materials are obtained.
3. For increasing plant production by preserving quality through environmentally friendly and effective phytosanitary measures. Studies on plant health are extremely important in order for herbal production to have a competitive and sustainable structure. It is aimed to develop and expand internal and external quarantine services, integrated control methods, and control and inspection services of plant protection products and application equipment in herbal production.
4. To control and destroy animal diseases and pests, to ensure animal welfare; It is aimed to implement effective animal health measures in order to develop animal husbandry in our country and to produce animals and animal products in accordance with international hygiene

rules. Likewise, it is aimed to protect public health by reducing the risks of zoonotic diseases and to provide the necessary welfare conditions during the production, transportation and slaughter of animals.

5. Developing agricultural and social infrastructure services, increasing the attractiveness of rural areas by providing rural development and welfare; It is aimed to improve the living conditions and increase the income of individuals and communities living in rural areas and making their living from agriculture. It is aimed to diversify the economic activities in rural areas, to reduce the fragmentation of the land, to establish on-farm development services and modern irrigation systems, and to increase the irrigation efficiency. National and international funds allocated to support rural development will be utilized effectively. Non-agricultural use of agricultural lands will be prevented and soil and water resources will be protected and improved with environmental awareness. By developing an agricultural information system, easy access to the data obtained by decision makers and users will be provided.
6. To provide corporate excellence in order to provide fast, effective and quality service. Institutions try to fulfill their duties and responsibilities with their personnel and other resources. Many factors need to be considered together in order to mobilize human resources and operate them efficiently. It is aimed to develop the sense of corporate

belonging of employees, which is one of the most important factors affecting working efficiency, to increase their motivation and to provide a comfortable working environment. It is aimed to ensure that the changes and developments in the field of duty and responsibility are followed up-to-date by the employees, and to increase the knowledge level and personal development of the personnel. A technical infrastructure will be created to facilitate employees' access to data and an administrative structure will be developed.

If we look up the SWOT Analysis:

Strengths:

• Regional location and logistics advantages

• Increasingly dissemination of organic agriculture and good agricultural practices systems in plant production

• Taking great steps towards making legal regulations in line with EU legislation and monitoring changes.

• The high potential to have a say in the world organic product market in products where we have a high competitive power such as hazelnut, fig, apricot, grape and cotton.

• The high potential of renewable energy sources and the possibility of self-sufficiency in energy supply.

• The fact that it has the potential to grow different agricultural products in terms of soil structure, water resources and climatic conditions, and that there is a situation suitable for completing the transition process in a short time in some regions where artificial inputs such as pesticides and fertilizers are not used much.

• Since organic agricultural products require labor-intensive labor, the existence of idle labor force and cheapness is an important advantage for the intensive agricultural labor force and family in the rural population.

• Turkey is rich in natural resources and biodiversity.

• Since synthetic chemicals are used little or not at all by most of the farmers in Turkey, the transition to organic farming is easier.

Weaknesses:

• The land is very fragmented and the enterprises are small.

• Lack of planning in agricultural production

• Not enough resources are allocated to R&D

• Inadequacy of market regulation intervention agencies in agricultural products

• Insufficient use of technology

• The low population engaged in organic farming and the inability to benefit from market opportunities in the world.

• Inadequate organization when examined from both consumer and producer dimensions.

• Lack of national and international databases on organic agriculture.

• Inability to achieve market dominance and branding, especially in products such as figs, grapes, apricots and hazelnuts in which it has a say in world production.

• The share of animal production in organic agriculture is quite low.

• The high prices of organic products and the absence of a control and inspection mechanism.

• Small scale of enterprises engaged in organic farming.

Opportunuties:

• Initiation of EU supported organic agriculture projects since 2006.

• Increasing demand for organic products in the world day by day.

• Increasing employment areas in the organic agriculture sector and being in continuous development.

• Turkey's proximity to the main markets due to its geographical location.

• Continuous increase in interest in healthy, quality organic products with the development of consumer awareness.

Threats:

• The high dependence on foreign sources in the supply of organic inputs.

• Increasing government support for organic agriculture in countries that Turkey considers to be competitors in organic agriculture production.

• Higher organic food prices compared to conventional products

• The negative impact of environmental pollution, which has been increasing continuously especially in recent years.

• The impact of global climate changes and regional droughts

• Our gene resources are not patented

• Increasing dependence on foreign technology in the field of technology.

(Birliği, 2014)

Turkey's Agriculture and Livestock budget as of 2022, which was 12.9 billion TL in the initial target setting, has been revised and updated to 25.8 billion TL; However, the fact that the budget was realized as 39.2 Billion TL as of November 2022 and the budget target of 54 Billion TL was set for 2023 shows that it is uncontrolled in terms of measurement criteria. (BAKANLIĞI, TARIM VE ORMAN BAKANLIĞININ 2022 YILI BÜTÇESİ PLAN VE BÜTÇE KOMİSYONUNDA KABUL EDİLDİ, 2021); (BAKANLIĞI, TARIM VE ORMAN BAKANLIĞININ 2023 YILI BÜTÇE TEKLİFİ TBMM'DE PLAN VE BÜTÇE KOMİSYONU'NDA KABUL EDİLDİ, 2022)

6. Conclusion

In the first years of the Republic, the existing infrastructure and related transportation infrastructure investments and public works activities were planned to support agricultural and production activities with fully independent policies, both in terms of export and domestic market, as well as taking into account human relations and transportation. carried out through; In cities and villages, it seems that this structure is shaped on the axis of railway - highway. In addition, with the effect of a planned development period, budget balances are predictable.

But today, especially with the change of political and economic vision in the 1948-1950s, especially with western countries alliances and Liberal Policies, an export-oriented growth and investment, especially the production of heavy and light industry products, has been characterized as income generating activities for the post-1980s.

This situation caused the liberal policies to move the highway-oriented policies to a higher level and to shift to other industries instead of agricultural activities as of the 1950s, and the disappearance of the state enterprises that supported agricultural activities with the start of the privatization movements that existed in the 1980s.

In fact, as of the beginning of the 2000s, the unipolar world policy perspective and liberal policies have become much more widespread and the social production activities of the state; It is seen that the support function in areas such as agriculture and animal husbandry has been removed. In addition, due to the politically coordinated guidance of the European Union, the World Trade Organization and the states of the countries with which it is cooperating, activities have been shifted to the private sector.

In addition, as it can be seen in the comparison, while the development plans included the whole country in the first years of the Republic, today these policies are also considered in separate lanes and they are not built on supporting agricultural activities or supporting production activities by breaking away from the basis of investments. This situation reveals the emergence of idle investments and an unplanned economic structure with unmeasurable targets but not realized.

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