HIGHLY INTERCONNECTED & ENDLESS PUZZLE: AGRICULTURE

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PREFACE

Abiotic stresses are becoming more frequent and dominant with highly diversified yield pushing farmer applications and changing climate conditions in new era. Varieties and even crop species are like falling runners in a race. Fitting multiple stress conditions is getting more important for varieties and species. Also amounts, types, sources and channels of information are diversifying where fast reaction is getting more important for competing farmers. Holistic approaches are getting more important which position abiotic stress in core. Drought, high temperature and salinity are main stress subjects for breeding studies targeting single or multiple stress tolerance and for new farmer cultivation technique and input applications. Variety registration official protocols in developing coutries must be improved and must test varieties for stress tolerance traits to inform farmers more. Also test protocols for special crop growth packages including selected single or multiple inputs might be available as one step further registration official protocols service. This official knowledge support may protect incomes of fragile farmer communities from agressive commercial actions of diversified agri-input companies. Continuous update is also required for many other agriculture intersecting sub-fields of economic activities to escape from product price inflations and farmer income losses. These update activities may be better to be conducted with the vision of seing agriculture as an important complex system but not an old fashion rural activity for the benefit of all.

Assist. Prof. Dr. Aynur BİLMEZ ÖZÇINAR

CHAPTER 1

USE OF INTERCROPPING AGRICULTURE SYSTEM AND INVESTIGATION OF OLİVE INTERCROPPING AGRİCULTURE

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INTRODUCTION

In recent years, the whole world has been threatened by rapid and unexpected climate changes. Studies have reported that temperatures will increase between 1.1 and 6.4 ° C until the end of 2050, according to IPCC. In final review published in 2007, they determined that 30 % of the total living species of 1 degree increase will be exhausted and all living things of the ecosystem will be affected by high temperatures (Brown, 2008).

There are negative effects on climate change, not only temperature but also precipitation irregularities and drought. All these negative effects pose a serious threat to productivity and sustainability rates in agriculture (Brown, 2008).

Today, population growth, industrialization, increase in global energy demand, increasing need for urbanization cause an uncontrolled decrease in green areas and agricultural areas. In addition to this, agricultural productivity and quality are gradually decreasing due to decreasing water resources, sudden temperature during plant growth period, precipitation changes, negative effects of inputs on environment and ecosystem.

Therefore, in recent days, it has become imperative to develop viable farming systems that increase efficiency in reduced production and make full use of arable land.

In this quest, the intercropping agriculture system comes to mind, the system that was very popular 2000 years ago, but disappeared with monoculture production with the transition to agricultural mechanization and came back to the agenda with climate change.

The intercropping agriculture system wants the farmer to enable the good resources effectively and gain more useful. The intercropping agriculture system increases the income of the producers, enables them to use the existing agriculture resources effectively with less environmental costs and to produce different products (Center, 2011). It is also an economically useful approach for the agricultural sector, which generates short-term income from intercropping plants (Jose, 2006).

In agriculture, the intercropping agricultural system refers to two or more types of crops or genotypes that grow together and coexist for a while (Gordon, 2004). The first known examples of intercropping agriculture in agriculture date back to 2000 years ago. Looking at the old inscriptions, the first samples showed that especially wheat was planted between the olive plant (Lelle, 1994).

Intercropping agriculture system consists of planting different types of plants between trees and also intercropping agriculture system differs from mixed single crop or rotation cultivation (Vandermeer, 1989). Intercropping agriculture generally carried out in small parcels and low-input, low-yield agricultural areas (Ngwira et al., 2012). In agriculture, intercrooping agriculture is known as an old practice that is only placed in 'modern agriculture', where monocultural production is made and where high yield products are dominated by large areas (Zhang, 2010).

1. SOİL AND AGRİCULTURE SYSTEM

When the relationship between soil and intercropping agriculture system is examined, P (phosphorus) or Al toxicity is generally observed in crop production in acidic soils (White et al., 2013). In acidic soils such as peanuts, cowpea, potatoes, sweet potatoes, corn, beans and cabbage are cultivated, the plant roots release organic acids and phosphatases into the rhizosphere, and soil P (phosphorus) increases (Li, 2007).

In alkali soils, crop is generally limited to P, Fe, Zn, Mn or Cu (White and Greenwood, 2013). Crops such as cabbage, corn, beets, and squash that are tolerant of slightly alkaline soils acidify and release organic acids and phosphatases into the soil. Thus, it increases the availability of P, Fe, Zn, Mn and Cu and uptake of mineral nutrients from the soil by usefully plants (Zhang, 2010). However, cereals that phytosiderophores increase the uptake of cationic micronutrients such as Fe, Zn, Mn, and Cu by plants (Zuo and Zhang, 2011).

In the relationship between the soil and the intercropping agriculture system, the roots of the complementary plant species used in the intercrooping agriculture system also increase the soil. Thus, it improves resource acquisition (water, nutrients) (Hallett and Bengough, 2013). In North America and Europe, there have been many studies showing both the production and environmental benefits of intercropping agriculture (Zamora, 2008). In these studies, it was revealed that the fertilizer residue in the soil and contributed to the development of the olive tree as a result of the mineralization and soil microbial biomass (Rivest, 2009).

2. WATER AND INTERCROPPING AGRICULTURAL SYSTEM

When we look at the relationship between intercropping agriculture system and water, it is seen that in cases where water is the biggest limiting factor, intercropping agriculture generally increases water availability (Morris and Garrity, 1993).

In cases where the plant root distribution to be used as intercropping agriculture and the main plant root distribution are complementary, the water is lifted hydraulically and the surface runoff is reduced (Caldwell et al., 1998).

With semi-arid savannah communities (scattered trees or shrubs), it has been found that water acquisition in intercropping agriculture is improved by using intercropping products with complementary root structures (De Barros et al., 2007).

3. DİSEASE, PEST, WEED AND INTERCROPPİNG AGRİCULTURE SYSTEM

It has been determined that the applied traditional farming methods cause to pollution of soil and water. These negative methods indicate the necessity of changing the production methods used to date to ensure the sustainability of agricultural systems and food in the future (Subić et al., 2010; Golijan and Veličković, 2015).

Looking at the intercropping agricultural system and the disease-pest relationship, it has been determined that in areas where pesticide use is not allowed (such as organic production). Intercropping with medicinal and aromatic plants is the simplest and very effective method to reduce the occurrence of pests and diseases (Golijan and Veličković , 2015).

It is widely used to combat plant diseases in intercropping agricultural systems. 73 % of the studies conducted revealed that intercropping agricultural systems generally reduce the disease rate in the range of 30-40 % compared to monoculture production (Poggio, 2005; Hatcher and Melander, 2003).

In the agricultural ecosystem, many species reduces pests and predators that delay the development and incidence of some pathogens by reducing the number of pests. Although interest in the intercropping agricultural system of medicinal and aromatic plants has increased in the organic production system, there is still a lack of research on this subject (Huang et al., 2002).

Intercropping farming systems have the potential to decrease the damage of pests against plants, increasing the diversity of pollinators and natural enemies (Finch and Collier, 2012). An example of these effects on crop yields is bananas planted with cocoa. The doubling of the midget fly, which enables the pollination of cocoa flowers, has been revealed in the studies that it increased the banana yield five times. Because in intermediate agriculture systems, it is known that the increase in natural enemy activity leads to a decrease in product damage (Hatcher and Melander, 2003).

It has been found to be caused by some factors such as disease, rain, wind and insect vectors, and pathogen. In studies, increasing plant diversity helps to preserve soil organism (Van der Putten et al., 2013).

Ecologically, in polyculture production systems, the processes that occur the negative interactions of competition, parasitism and amensalism. Ecologists have studied the agricultural systems for many years to understand the interactions of species (Vandermeer, 2010). In ecological research, plant-plant interactions have been gaining attention recently (Brooker et al., 2008).

4. PLANT SELECTION AND INTERCROPPING AGRICULTURE SYSTEM

Plant selection is very important in intercropping agriculture. In plant selection, crop types or variety combinations that increase productivity and minimize negative interactions are selected. The characteristics of the crop to be selected in intercropping agriculture are complementary and curative, focusing on overcoming resource constraints (Costanzo and Barberi, 2014). It has been determined that new approaches to plant breeding for crop cultivation systems (Hill, 1996).

In particular, crops used to evaluate the benefits and management of intercropping agriculture were generally grown and tested for monoculture systems. The interactions of multiple species, such as nutrient, water or biodiversity, have not been fully evaluated.

In the intercropping agriculture system, it has been revealed that some of the different types of plants planted between trees have negative effects while others have positive effects (Robinson, 1991). Studies have shown that plants used as intercropping agriculture have a nitrogen fixing effect and are beneficial in soil improvement. It is seen that the herbaceous plants used in the intercropping agriculture system compete with the trees for nitrogen at the beginning of the photosynthesis cycle and in this case the plants are negatively affected. However, intercropping agriculture is not desired when focusing on a single main product standardized in terms of labor and time management in agricultural production. In agricultural production, intercropping agriculture is not considered suitable for products that will be mechanized intensively (Feike et al., 2012).

According to studies, intercropping agriculture is the dominant form of agriculture in some regions and continues to be (Robinson, 1991). Legumes are very important in many cultivation systems, and seven of the 10 most commonly used intercropping types listed by Hauggaard - Nielsen and Jensen (2005) were found to be legumes. As intercropping agriculture in products with limited N (nitrogen), legumes increase agricultural productivity (Altieri et al., 2012). It turns out that legumes can produce up to 15 % of the N in the air in intercropping cultivation of other non-legumes, especially for the N component derived from air (Altieri et al., 2012).

As the first step of the evaluation of genotypes for arable farming, various germplasms of main crops are tested by producing them together as intercropping products in order to determine the characteristics that provide suitable yield. For example, companies such as KWS are carrying out breeding studies to plant beans and corn together (Costanzo & Barberi, 2014).

5. OLIVE AND INTERCROPPING AGRICULTURE SYSTEM

Olive is a strategic product of the Mediterranean region with high healing and economic returns (Özilbey, 2011). Olive has different economic benefits with different evaluation methods. It is used primarily as table and oil olives, and then in many areas such as feed for animals, firewood, biogas plant, high-value furniture and handcrafts (jewelry), cosmetics industry (cream, shampoo) (Schultz et al. 1986).

In recent years, olive cultivation has become a plant facing climate change and its sustainability is threatened. In critical periods for olives such as fruit setting, bud, flowering, when exposed to negative effects of climate change (excessive rainfall, excessive temperature increase, excessive wind) yield and quality decrease is encountered. In addition, with the periodicity event in the olive genotype, the income of our producers has been decreasing considerably in recent days.

Olive producers around the world have a tendency to the intercropping agriculture system for reasons such as gaining additional income, increasing biodiversity, weed control, and decreasing the use of pesticides.

Researches show that the use of the intercropping agricultural system in olive production, adaptation to different environments such as drought and socio-economic importance, has been determined to be involved in Moroccan agricultural policy. Studies conducted in

Morocco have revealed that the intercrooping agriculture system based on olive trees and intermediate plants was carried out in both rain-fed and irrigated areas, and the intercrooping agriculture system dates back to ancient times (Roose, 1992).

In ancient studies carried out in Morocco, approximately 75 % of olive groves were used with intercroppping plants such as wheat and barley, legumes, chickpeas, peas, coriander, vegetable products with potatoes and onion. Looking at the history of olives grown in Mediterranean countries, it was found that with the intercropping agriculture system, grain products, especially wheat, almond, argan, chestnut and oak trees were grown together with olives (Dupraz, 1997).

In the surveys carried out in recent years, it is seen that species such as carob, almond, walnut, apricot and poplar are grown along with the olive tree (Daoui, 2004). It has been found that trees generally compete for light, water and soil minerals, especially in areas surrounding the canopy of trees. However, it has been revealed that these negative situations can be prevented when plant-plant interactions and planting distances are selected well (Cabanettes, 1999).

Research has revealed that the planting width is important in the cultivation of olives and wheat together. It has been found that the yield of wheat planted 2 m away from the olive tree yields 45 to 50 % higher than the wheat planted 50 cm away from the olive trunk (Dupraz, 1994).

There is a study, it was conducted to examine on both olive tree distance and soil fertility, the effect of wheat, broad bean and chickpea plants planted between olive trees in Morocco. As soil fertility parameters, organic matter, nitrate, available phosphorus and potassium, nitrogen, potassium contents were examined. As a result of the study, it was seen that yields of 1.7, 2.5, 3 t/ha (wheat, broad bean, chickpea) respectively were obtained in olive orchards. For wheat, it has been determined that the maximum organic matter content is closest to olive tree (Razouk et al., 2016).

In another study, it was found that olive production in the farm in Molos decreased significantly in 2015 due to the negative effects of climate change during the flowering period in olive cultivation. In 2016, chickpeas were planted among olive trees, and it was observed that both chickpea yield and olive oil yield and quality increased. Producers have been reported to save on both reduced fertilizer applications and income from chickpea production (Pantera, 2014).

In a European Union project carried out in Spain, they worked on producing saffron as an intercropping agriculture in olives. The Andalusian olive groves where the study was conducted have been very inefficient and insufficient in organic matter and have problems with runoff. Therefore, they could not get the desired yield in olives. By using saffron as intermediate agriculture in olives, they have increased the yield obtained from their lands with product diversity and low input management practices, and at the same time, they have increased productivity in these lands by reducing costs (Anonymous, 2015).

In another study conducted in Morocco, the optimum planting distance of one-year herbal products applied between olive trees was examined. The olive garden is completely irrigated with rain water. The plants used as intercropping agriculture were Triticum, Vicia faba and Coriandrum sativum. As a result of the study, it was revealed that wheat cultivation in the area close to the crown projection of the olive tree reduces the vegetative component and yield of the plant, while the broad bean increases, and coriander has no effect (Razouk, 2016). It has been determined that the plant to be used as intercropping agriculture in olives should be selected from the species that can compete with olive at a minimum rate, the bean and coriander should be planted in the winter resting period of the olive. A study, in the North of Morocco to optimize the planting distance among olive trees and annual crops. In the study, crops such as olive-broad bean, olive-wheat, olive-coriander were used as an intercropping agriculture system with different planting distances. In the study, only rainwater feeding was used. Two planting distances determined, one close to the olive tree trunk and the other planted in the projection of the crown. Looking at the results, it was found that the yield of wheat with the crown projection decreased, while the yield of bean increased. However, it has been revealed that coriander has no effect on the olive tree. Olive tree shade negatively affected production in general (Bouhafa et al.;, 2015).

RESULT

The intercropping farming system is an economically for the agricultural sector (Jose, 2006). In general, the intercropping agricultural system has many positive contributions such as increase in green areas, increase in agricultural biodiversity, increase in soil fertility, increase in the number of natural enemies, decrease in pesticide use, and provide additional income. At the same time, compared to monoculture production, it provides benefits such as obtaining maximum benefit from agricultural areas, increasing yield, effective use of resources with plant-plant interactions.

As a result of many researches, when it comes to reducing the impact of climate change indirectly, the intercropping agricultural system will be very popular in the coming years. Considering the studies in recent years, it has been revealed that studies involving plant-plant interactions are insufficient and scientific studies on the intercropping agricultural system are scarce.

In the light of this review, it is important to better understand the intercropping agriculture system and to shed light on scientific studies on the development of olive intercropping agriculture. In the agricultural system, it is recommended to study the selection of intercropping products, complementary and competitive effects, repellent effects of plants on insects, planting distances in the future.

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CHAPTER 2

THE ROLE OF SILICONE APPLICATIONS IN TOLERANCE TO ABIOTIC STRESS CONDITIONS

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INTRODUCTION

Although silicon (Si) is the second most abundant element in nature after oxygen and is found in approximate concentrations with other nutrients, it is not considered an essential element for plants (Epstein, 1994). However, the importance of this element has increased due to its curative effect on plant tolerance under abiotic and biotic stress conditions, and studies have focused on its effect on stress tolerance.

The amount of silicon found in plants varies according to the plant species and even plant tissues. Some plants have the ability to accumulate silicon and therefore have a much higher intrinsic silicon content than other plants (Ma and Yamaji, 2006). According to the first studies on silicon, the accumulation of silicon in cell tissues caused changes in the morphological structure of the cell wall, protecting the integrity of the cell membrane, and creating a physical barrier to develop tolerance to stress conditions. In this way, it has been explained that the hardness and durability of these structures increase and the tolerance formation to stress conditions occurs. However, studies over time have revealed that the effect of silicon on the plant is much more complex and that there are protein and gene groups with different properties involved in the uptake and transport of silicon in different plant species (Ma and Yamaji, 2006; Luyckx et al., 2017). It is supposed that silicon contributes to the stress resistance mechanism in two different ways. First, the accumulation in the plant provides physical and mechanical protection, and the second appears by reducing oxidative stress by causing some biochemical changes such as antioxidant enzyme activities that play an active role in the tolerance of plants to stress conditions, and also by improving photosynthesis and mineral nutrient uptake (Luyckx et al., 2017).

In this chapter, the effects of silicon on the formation of abiotic stress tolerance with morphological, physiological, and biochemical changes in plants under various stress conditions were compiled. It is supposed that this review would be guided researchers to put promising new practices in agriculture into practice in order to maintain global food security.

1. EFFECTS OF ABIOTIC STRESS FACTORS ON CROPS

Stress is an environmental factor that negatively affects the development and yield of plants by causing unfavourable changes in the morphological, physiological, and biochemical systems (Yadav et al., 2020). Among these stress factors that can cause crop losses up to 70% (Francini and Sebastiani, 2019), the most common, and intensely researched drought and salinity stress. In addition, cold, extreme heat, nutrient deficiency, and high and low light intensities, flooding, ultraviolet radiation constitute other abiotic stress factors and the destructive effect of these stress factors is as important as drought and salinity stress. Drought stress caused by water scarcity in the soil and heat stress caused by extreme heat which is increasing in severity with the effect of global climate change, are abiotic stress factors that are related to each other. In addition, depending on the severity of salt stress caused by high salt concentration in the soil or irrigation water, which is also associated with drought stress, can cause serious losses in plant growth and yield by eliminating the cellular balance and the connection between physiological and biochemical processes. The combination of these stress factors is much more destructive than the effects they cause alone (Hasanuzzaman et al., 2013; Sehgal et al., 2018). Heavy metals such as iron, cobalt, copper, manganese, molybdenum, zinc, mercury accumulate in the soil through industrial wastes and sewage and cause surface and groundwater pollution. Although some of these metals are used as micronutrients in the plant, unlike organic pollutants, they are not biodegradable and accumulate in living organisms. Excessive accumulation can create toxic effects on the plant and directly affect plant growth, metabolism, and physiology (Atieh et al., 2017; Ghori et al., 2019). Heavy metals, such as zinc, manganese, and copper, whose excess is toxic in heavy metal stress, are micronutrients necessary for healthy plant growth. The deficiency of these elements, as well as the excess, causes stress. Elements necessary for plant growth and metabolism are divided into macro and micro elements. Although 17 elements are needed in plant tissues, about 60 elements have been detected in different plant tissues. The mineral composition of plants varies depending on factors such as climate and soil conditions, plant age, and genetics. Nutrient stress is caused by either low levels or excessive concentrations of the elements that the plant needs for healthy growth. This situation significantly affects plant growth, fruit quality, and quantity. Nutrient intake is important for the continuity of basic processes at the cellular level, and in case of its deficiency, leads to disruption of the homeostasis of cellular functions. In some cases, excessive concentrations of one element can cause a deficiency of another element. Deficiency symptoms appear as metabolic disorders at various stages of plant development (Reddy, 2006).

Flooding is a highly complex abiotic stress factor that damages the plant's vital functions such as photosynthesis by causing oxygen and carbon dioxide starvation. As a result of the decrease in intracellular pH especially in oxygen deficiency, intracellular biochemical processes are irreversibly impaired. When flooding is so severe that the plant is completely submerged, it can also result in the inability to complete the reproductive cycle (Jackson and Colmer, 2005).

Light, which is one of the most important environmental factors, influences plant growth and productivity, especially through photosynthesis. The effect of light stress on plants varies depending on the intensity, wavelength, and duration of the light. Light stress, which occurs when plants are exposed to excessive or insufficient light intensity, inhibits carbon and nitrogen fixation, especially through photosynthesis and antioxidant mechanisms. Although photosynthesis is directly related to sunlight, UV rays of sunlight in particular damage cellular components such as the chloroplast, where photosynthesis takes place, and this is defined as UV radiation stress. Due to the thinning of the ozone layer, greater amounts of short-wavelength rays (UV-B) reach the earth and these rays can be absorbed by cellular components such as nucleic acids, proteins, and lipids in plants. As a result of the increase in absorbance, the plant remains vulnerable, and the negative effects are supposed to occur through enzymatic reactions and phytohormones. (Salama et al., 2011; Sarghein et al., 2011; Pascual et al., 2017; Yang et al., 2019).

Cold stress, manifested as chilling (<20°C) or freezing (<0°C), is a stress factor that can lead to large crop losses by causing severe membrane damage due to acute dehydration associated with freezing. It either directly inhibits metabolic reactions or causes disruption of metabolic events in the plant as a result of osmosis disruption and oxidative stress formation due to inhibition of water intake and cellular dehydration caused by freezing. Regression in germination parameters and seedling development, decrease in leaf area, wilting of leaves, tissue necrosis has been reported as phenotypic symptoms occurring in plants (Yadav, 2010; Rasool et al., 2014). Examples of morphological, physiological, and biochemical changes in plants caused by all these stress factors are presented in Table 1.

Table 1. Morphological, physiological and biochemical changes in plants as a result of abiotic stress factors.

Crop	Stress Factor	Effect of Stress	Reference
Tomato	Salt	Adverse effects on germination parameters and plant growth, deterioration of membrane stability	Tanveer et al., 2020
Maize	Salt	Inhibited plant growth and decrease in biomass, total chlorophyll concentration, K concentrations, and K/Na ratio.	Turan et al., 2009
Cucumber	Salt	CO_2 reduction due to stomatal closure, decrease in potassium, chlorophyll, membrane stability index, and fruit yield.	Tiwari et al., 2010
Common bean	Salt	Inhibition of growth, photosynthesis activity, and the plastid pigment content and reduction of the cell water potential	Stoeva and Kaymakanova, 2008

Rice	Chilling	Lipid peroxidation rate and reactive oxygen intermediates increased	Hussain et al., 2016
Cabbage	Drought	Leaf development, leaf chlorophyll content, head size reduced	Ackah and Kotei, 2021
Potatoes	High temperature	Tuber yield and quality decrease through inhibition of carbon synthesis	Dahal et al., 2019
Carrot	Drought	Free proline, glycinebetain and total phenols increase but storage root diameters decrease	Razzaq et al., 2017, Reid and Gillespie, 2017
Maize	Drought	Extended flowering and fruit ripening time, anthesis silk interval increase, the leaf number decrease and normal root architecture loss	Sah et al., 2020
Radish	Drought	Reduce of storage root weight, leaf dry matter accumulation, and leaf area	Stagnari et al., 2018
Radish	Heavy metal	Lipid peroxidation increases, proline accumulation and changes in enzyme activities occur.	Teklić et al., 2008
Peppermint	Heavy metal	Fresh and dry weight, stem length, leaf area per plant, number of leaves, number of nodes per the main stem and peppermint essential oil decrease.	Amirmoradi et al., 2012
Common bean	Heavy metal	Dry matter production of roots and shoots decreased	Cannata et al., 2015
Tomatoes	Heavy metal	Phenolic compounds decreased.	Kısa et al., 2019
Barley	Chilling	Growth suppression, photosynthesis inhibition, and loss of membrane integrity	Joudmand and Hajiboland, 2019
Rice	Low temperature	Low germination rate, short seedling height, high mortality, increased electrolyte leakage, changes in chlorophyll fluorescence, increases in reactive oxygen species, malondialdehyde, sucrose, lipid peroxidation, proline and other metabolites	Zhang et al., 2014
Stevia rebaudiana	Cold	Reductions in net photosynthesis, intercellular CO_2, water use	Hajihashemi et al., 2018

		efficiency, and chlorophyll a, chlorophyll b, and carotenoid	
Pea and Wheat	UV-B	Suppression of plant growth, increase in antioxidant enzyme activities, anthocyanin, soluble phenols, leakage of electrolytes, decrease in chlorophyll amount	Alexieva et al., 2001
Barley	UV-B	Decrease of CO_2 fixation, PSI and PSII activities, and chlorophyll content, an increase of flavonoids, H_2O_2, malondialdehyde, proline	Fedina et al., 2009
Olive	Nutrient	Increase in stomatal resistance associated with stomatal closure in nitrogen or potassium deficiency, Significant reduction in total dry matter and leaf area, reduced photosynthesis, and complete inhibition of plant growth in the absence of nitrogen, Decrease in leaf area and chlorophyll concentration in phosphorus, magnesium and nitrogen deficiency, inhibition of root growth in phosphorus deficiency, and decrease in dry matter, carbohydrate synthesis and starch amount in Mg deficiency	Saidana et al., 2009

2. Alleviation Effects of Silicone Applications in Abiotic Stress Conditions

Silicon, which makes up about 60% of the soil structure, is an element already present in all plants. Silicon, which is defined as an anti-stress element because it is a substance that has a protective and healing effect against biotic stress factors as well as abiotic stress factors, forms a physical barrier by being deposited as a second layer under the cuticle. It is also known to be effective by activating some defence mechanisms (Ma and Takahashi, 2002; Fauteux et al., 2005; Ma and Yamaji, 2006). In addition to being economical for producers, it is also suitable for ecological use because it does not cause toxic effects on plants if it accumulates and is not polluting. These properties reveal that it is suitable for use as fertilizer in agricultural production (Malhotra and Kapoor, 2019). It is suggested that silicon, whose accumulation does not create a toxic effect, is protective under stress conditions with its accumulation in many different tissues from root to leaf. Silicon which acts as a mechanical barrier via accumulating in plants is effective against many chemical and physical different abiotic stresses by increasing the hardness and strength of the cell wall, reducing transpiration through the cuticle and so support to improve tolerance to different stress factors such as temperature and UV (Ma and Yamaji, 2006). According to the "windows hypothesis" put forward by Kaufman et al. (1979), silicon is stored as silicon particles in the epidermal cells of the leaf and thus increases the light use efficiency by increasing the light transmission to the mesophyll tissue where photosynthesis takes place in the leaf. In this way, in the presence of silicon, the photosynthetic efficiency of the plant increases, and a protective effect occurs against stress conditions. In addition, external silicon applications balance photosynthetic activities by reversing the structural deterioration of chloroplasts under stress conditions (Feng et al., 2010). Besides, silicon is also effective by activating the production of antioxidant substances and enzymes that will detoxify reactive oxygen derivatives that occur in plants under abiotic stress conditions, including light and UV radiation (Tripathi et al., 2017; Szymańska et al., 2017). There are many studies on the positive effects of silicone applications on different plants and under different stress factors. In

Table 2, the physiological and biochemical events caused by external silicon application in various plants exposed to different abiotic stresses are exemplified.

CONCLUSION

Plants develop different defence mechanisms when exposed to stress conditions. The most important issue under these stress conditions is to maintain the homeostatic balance in the plant and to ensure the survival of the plant in adverse conditions by the physiological and biochemical regulations. The exogenous silicon treatment is one of them. Silicon has been the subject of many research in recent years because it is an element that increases the tolerance of plants under both biotic and abiotic stress conditions. It is a suitable material for a sustainable environment and agriculture since it does not cause toxic effects in case of accumulation in the plant and does not have harmful effects on the environment. In this study, the effects of exogenous silicon application on plants exposed to abiotic stress conditions on plant tolerance were evaluated in terms of different plants and stress factors, and its positive effects were clearly revealed. However, studies conducted in recent years have revealed that the effect mechanism of silicon is much more complex than previously supposed. Although the curative effect of exogenous silicone application has been proven under abiotic stress conditions, there are still many unknown points about its molecular mechanism. More research is needed on this subject.

Table 2. Physiological and biochemical effects of external silicon application on various plants exposed to different abiotic stresses.

Crop	Stress Factor	Effect of Exogenous Silicon Treatments	Reference
Wheat	Drought	Significantly increased plant biomass, plant length, and spike weight	Ahmad et al., 2007
Soybean	Drought	Alleviate seedling damage by increasing relative leaf water content, proline, and photosynthesis	Shen et al., 2010
Cucumber	Drought	Increased the water holding capacity by decreasing the stomatal conductivity and able to sustain photosynthesis. Increased the biomass in the leaves	Ma et al., 2004
Rice	Drought	Positive effect on photosynthesis	Chen et al., 2011
Tomato	Drought	Increased photosynthesis efficiency by improving the distribution of light absorbed during photosynthesis between photosystems 1 and 2 in chloroplasts, decreased reactive oxygen derivatives by regulating antioxidant enzyme activities, and protected chloroplast membrane structures	Cao et al., 2015
Okra	Salt	Osmolyte accumulation, high antioxidant activity, and decrease in Na and Cl ions. Increase in plant biomass, total chlorophyll content, photosynthetic activity, relative water content, intrinsic water use efficiency and total soluble protein content	Abbas et al., 2015
Tomato	Salt	Increased leaf transpiration rate, stomatal conductivity, photosynthetic pigment and soluble protein content, net photosynthesis rate, and improved root morphological properties	Li et al., 2015
Rice	Salt	Sodium uptake by reduction in root apoplastic transport, decreased transpiration, increased seedling growth	Gong et al., 2006

Rice	Heavy metal (As)	Reduced arsenic accumulation. Improved oxidative stress by increasing the level of antioxidant enzymes and their isozymes	Tripathi et al., 2013
Lallemantia royleana	Heavy metal (Cd)	Reduced the negative effect of cadmium on plant growth by reducing cadmium translocation	Rostami et al., 2020
Cotton	Heavy metal (Pb)	Reduced MDA, H2O2, and electrolyte leakage and accumulation and increased antioxidant enzymes	Bharwana et al., 2013
Cucumber	Heavy metal (Cd)	Increased the photosynthesis efficiency by providing the structural integrity of the chloroplast and inhibiting enzymes related to nitrogen metabolism	Feng et al., 2010
Rice	Heavy metal (Cd and Zn)	Improved root properties and cell structure	Fan et al., 2016
Tomato	Heat	Increased the expression of genes involved in the expression of antioxidant enzyme activities, regulated the expression of heat shock proteins and endogenous phytohormones associated with defence and stress signalling.	Khan et al., 2020
Cucumber	Nutrient (Mn)	Increased in antioxidant enzyme activities and regulated reactions related to photosynthesis	Feng et al., 2009
Radish	Nutrient (Ammonium)	Reduced suppression of plant growth	Viciedo et al., 2020
Barley	Flooding	Reduced the intensity of oxidative destruction, promoted plant growth and biomass production	Balakhnina et al., 2021
Rice	Flooding	Biomass increased, improved in root morphological properties and chloroplast ultrastructure, increased in antioxidant enzyme activity	Pan et al., 2021
Cucumber	Cold	Reduced in lipid peroxidation and wilting of leaves and high antioxidant activity	Liu et al., 2009
Wheat	Chilling	Increased in shoot dry weight, leaf water content, and antioxidant enzyme activities	Liang et al., 2008
Barley	Chilling	Increased the antioxidant enzyme activity and the soluble carbohydrate	Joudmand and

		and protein concentrations in the leaves	Hajiboland, 2019
Wheat	UV-B	Increased in antioxidant enzyme activity and regulation of photosynthesis activity	Tripathi et al., 2017
Soybean	UV-B	Mitigated seedling damage due to increased proline and photosynthesis	Shen et al., 2010
Soybean	Light (Low)	Increased in stomatal conductivity, chlorophyll content, and fresh weight of leaves, and improved photosynthesis	Hussain et al., 2021

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CHAPTER 3

INVESTIGATION OF THE IMPACT OF CLIMATE CHANGE ON OLIVES WITH HOLISTIC APPROACHES

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INTRODUCTION

Olive tree is an indispensable product of the Mediterranean basin, which has economic value with many years of history and is considered as a miraculous healing source. Most olive areas are located in a Mediterranean-type climate by favorable climatic conditions for olive plant. The growth and development of the olive tree is effected by climatic conditions (Moriondo et al., 2015). Climate events and water availability greatly affect olive cultivation, ultimately changing crop yields (Vossen, 2007). Recent research has shown that crops will be greatly affected by climate change in Mediterranean-type climates (Galán et al., 2005).

It has been reported that the entire Mediterranean basin, especially olive groves of Southern European will struggle with climate change due to frequent and long high temperature waves and low precipitation (IPCC, 2013).

The cultivation of the olive tree (Olea europaea subsp. Europaea) is of great importance in terms of its ecology, economy and culture in the Mediterranean Basin (Carrión et al., 2010). Olive cultivation is considered to be an agricultural ecosystem with significant potential for use opportunities (e.g. oil and wood), environmental impacts (e.g. water availability, CO2 emission contribution) and cultural heritage (e.g. biodiversity conservation) (Haines-Young and Potschin, 2018).

Generally, olive struggles in different soil types, preferably light textured and well-drained soils (Barranco et al., 2005).

Olive can grow at different altitudes up to 900-1000 m above sea level (1200 m). Olive trees can tolerate high levels of drought stress but olive is affected by drought and damaged to shoot growth, leaf formation and fruit bearing. However, olive trees have physiological requirements such as cooling needs (ie a vernalization period) and can withstand different temperature regimes depending on the geographical location.

Olive trees can withstand temperatures of -8 °C and an upper limiting temperature of about 35 ° C for short periods (Krishna, 2013).

The olive plant is derived from common wild species (Olea europaea var. Sylvestris Mill.) (Terral et al., 2004). It is estimated that there are more than 2000 olive varieties worldwide (Barranco and Rallo, 2000).

However, a small number of varieties prevents the recognition of other varieties in economic terms (Diez et al., 2015). Some olive regions where economically produced varieties are grown in narrow geographical niches and have microclimatic characteristics (Rubio de Casas et al., 2002).

Studies focus on the needs of different varieties in combating climate change and how they may be affected by climate change. Because it is estimated that in the Mediterranean Basin, climate change will cause significant warming and a significant decrease in precipitation in the coming years, and will cause ecological, economic and social changes (Dell'Aquila et al., 2012),

Although olive generally grows in dispersed and low-yield farming systems, olive cultivation is increasing rapidly, especially for economic and social reasons (Loumou, 2013). In the Mediterranean, the expansion of olive leads to regional development by promoting employment and preventing rural migration (Lambarraa, 2007).

According to the results of the studies, urgent approaches are needed for the consequences of climate change and its effects on olive cultivation. This review aims to present the results of studies focusing on the effects of climate change on olive cultivation and production, as well as on CO2 emission, irrigation, erosion and sustainability.

Research of climate change on olives in the world and points out the points that should be followed in olive cultivation in order to reduce the effect of climate change in our country and aims to shed light on the future studies on this subject.

1. THE EFFECT OF CLIMATE CHANGE ON OLIVES

Tanasijevic et al. (2014) is predicted to using the climate data in the A1B scenario of the Emission Scenarios Special Report (SRES) with scenarios and spatial simulations by 2050, an increase of 0.8-2.3 ° C per year and a decrease of up to 40 %, 200 mm per year in precipitation for the Mediterranean region.

Climate change has a significant impact on olive cultivation and it is predicted to change for olive growing. Different olive varieties react differently to abiotic factors. Studies show that each variety needs to evaluate the future environmental compatibility impact and analyze the expected to effects of climate change on annual olive production.

In a study, research was conducted with seven main and wild olive varieties to develop Species Distribution Models (SDMs) with soil characteristics, geomorphology, water balance in Andalusia. Climate scenarios have been designed to reveal effect of climate change on the sustainability and yield of each olive variety.

As a result of the study, it was determined that soil pH is the most important factor for climatic scenarios as continental index, summer and autumn precipitation and winter. In general, it is predicted that Andalusian olive will decrease due to the increase in evapotranspiration and decrease in precipitation. It is estimated that olive production will decrease in almost all olive growing regions that studied (Antonio, 2020).

Olive trees (Olea europaea, L.) are perennial plants (Ighbareyeh, 2016). Olive trees have adapted to the Mediterranean climate (Rodríguez-Entrena, 2013). Considering summers with temperatures above 40 oC, a shift towards the altitude areas where there will be less frost and minimum temperatures for olive growth. It was predicted that rising temperatures will affect the phenological timings, especially the flowering time (Avolio et al., 2012; Galán et al., 2005; Orlandi et al., 2010; Osborne et al., 2001).

Studies have shown that temperatures above 35-40 oC affect the photosynthesis of olive trees, and high temperatures limit development of olives. However, high temperatures have been reported to affect the quality and yield of olive harvest by enabling the reproduction of most harmful organisms, shortening the life cycles of pests, increasing insect populations and supporting the emergence of new threats (Ponti, 2014).

It has been determined that the weather warms due to climate shocks, olive groves on high altitude or slopes will be less damaged, and low altitude will become completely inefficient. The reason that the temperature decreases as high altitude areas (Vasilopoulos, 2013).

Climate change also causes change to insect population. Studies Show that due to increasing temperatures, olive fly populations will decrease especially in the southern regions and olive fly populations will advance towards the northern regions. The reason that limitation of the life cycle of the insect population above 30 °C (Moran, 2014).

Along with the negative effects of extreme temperatures, it damages olive in extreme cold. In 1998, severe cold weather caused serious damage to olive groves in California. Because olive trees can normally handle short-term cold, but temperatures below freezing for more than a few hours cause damage to new and small shoots, decrease fruit yield in the next year, and even death of olive trees in the later stage (Moran, 2014).

2. THE EFFECT OF DROUGHT ON OLIVES

Water is the main limiting factor for olive plantation, especially under arid and semi-arid conditions (Henderson, 1979). Increased need for water in population growth or environmental protection competes for water resources by agricultural production (Hsiao et al., 2007). However, resource scarcity associated with climate change is considered to be a key component of water management in agriculture to ensure olive sustainability. Climate change makes it difficult to develop and evaluate agricultural practices to improve water management, causing environmental factors and crop yield changes.

The olive tree is a very drought tolerant species and the annual rainfall limit is around 350 mm (Ponti et al., 2014). The presence of approximately 30 mm of water in the summer months (June-July-August) is necessary for olive to reach the appropriate yield in olive cultivation (Iglesias and Garrote, 2015).

Water stress causes a wide range of adverse effects such as low blooming, flowering and low fruit set, small leaf, limited photosynthesis in the olive tree (Arampatzis et al., 2018).

In a study conducted in Portugal, water is a more difficult resource, especially in the southern and most inland regions of the country. On the other hand, the importance of water is increasing due to population growth and industrial growth and intense agricultural water demand.

Irrigation to rain-fed involves sustainability of water resources and economic, environmental and social costs in olive growing area. As a measure of adaptation to water scarcity, smart irrigation strategies are implemented that provide a balance between environmental costs and meeting plant water requirements (Tanasijevic et al., 2014).

However, the answer to the question of how much irrigation water is needed to reduce the harmful effects of climate change is not fully understood. One possible solution to investigate different climate scenarios is to apply crop models in the future (Ribeiro et al., 2009). Crop models need to be simulated dynamically of product stress responses to management practices (eg irrigation), soil properties (eg strugs, depth) and physiological responses of the product to climatic conditions (eg air temperature, precipitation, CO2).

Several models have been developed to estimate biomass yield, targeting the growth and development of olive trees. One of them is the EUROCORDEX regional climate model. By combining high-resolution climate simulations with crop models, the characterization of water requirements was obtained for olive trees (Cesaraccio et al., 2004).

In the studies, climate change predict that olive groves in Southern Europe, especially Portugal, will be endangered due to heat and drought. Alentejo, the main olive growing area in Portugal, has carried out adaptation studies in irrigation to ensure the sustainability of olive cultivation. They simulated olive tree yield with a modeling study over 1981-2005 and the next scenario (RCP4.5 and RCP8.5, 2021-2080). As a result of until 2080, an increase in temperature up to 2 oC, an increase of 40-50 mm in potential evapotranspiration, a decrease of 80-90 mm in the amount of precipitation and a decrease evopotranspiration of 50-70 mm were detected. In the future, it was predicted that the olive yield will decrease by 15-20 %, and the total olive yield will decrease between 8 and 10 t/ha by 2080 (Fraga, 2020).

It has been demonstrated that these efficiency losses will result from increased heat and water stress. When the adaptation of the olive tree is examined with the irrigation model, depending on the adaptation strategy, it points to a higher yield compared to the current values (± 1%) and thus reduces the expected future yield decreases. They concluded that although irrigation is a viable adaptation measure against climate change threats in Alentejo olive groves, this strategy may be threatened by scarcity of water resources (Fraga, 2020).

Simulation models are used to assist in the development and evaluation of climate change adaptation strategies. In a study, the Olive Water Balance (WABOL) model was conducted to reveal the water balance components that integrate orchards and soil management strategies. Different climatic scenarios were used for this research, and the two most common soil management strategies, tillage and bare soil were evaluated. The results show that when vegetation is properly managed surface water flow decreases, deep infiltration occurs, and evapotranspiration in general decreases even if precipitation decreases. An approach to evaluating different and innovative agricultural alternatives is required to assess water balance and yield (Monteiro and Lopes, 2007).

Precipitation decrease for sustainability of olive plantation, although olive trees are highly resistant for lacking of water. When the annual precipitation decreases drastically is less than 200 mm (Ropero, 2018). In this sense, flowering affects drought conditions (Orlandi, 2005).

The intensification of precipitation increases erosion processes in olive groves, exacerbates soil structure degradation and negatively affects crop productivity (Gomez, 2014). In addition, excessive rainfall in olive plantations causes water to accumulate in a short time, affecting the vitality of the plant, resulting in root asphyxia (that is, water displaces oxygen in the soil and limits the plant's breathing from its roots). An increase in crop evaporation of up to 9 % is expected to water to maintain the efficiency of olive cultivation due to increased temperatures and reduced precipitation (Fraga, 2020).

Regarding the increasing water demand of olive plantations, the increase in atmospheric CO2 concentration positively stimulates the photosynthetic process of C3 plants (olive trees). When considered physiologically, a high concentration of CO2 reduces stomatal conductivity in olive trees, causing the plant to sweat more, thus causing a reduction in plant evaporation-transpiration and increasing water use efficiency (Field, 1995).

Hatfield et al. (2011) found that CO2 concentration is increased, plant evapotranspiration would decrease by 6-8% in irrigated olive plantation. In the cultivation of crops without irrigation, they reported that it increased lack of water by 4 % up to 51 %.

3. THE EFFECT OF CO2 EMISSION ON OLIVES

The relationship between agriculture and climate change has recently gained importance due to both mitigation and adaptation problems (Young et al., 2007). Carbon emissions to agriculture contribute mainly to the expansion of agricultural land and the increase of crop applications (Tilman et al., 2002). In addition, carbon sequestration with agriculture, especially carbon sequestration, has been found to be one of the most cost-effective mitigation options (Antle & McCarl, 2003).

Agriculture gained importance in terms of contributing to carbon emissions and serving as a carbon sink in the 20th century. Agriculture covers 14 % of total anthropogenic emissions (FAO, 2006). According to the Intergovernmental Panel on Climate Change (IPCC, 2003), in the carbon emissions, reducing tillage significantly increases soil carbon sequestration by up to 0.3 tons per year and per hectare (Schneider et al., 2007).

In general, olive groves are a rich habitat source in terms of biological diversity. Although olive groves have low input density (fertilizer, pesticide use), having natural herbs and mixed crop pattern throughout the year facilitates the sustainability of olive groves (Beaufoy & Cooper, 2009).

Greenhouse gas reduction through agriculture is becoming a technically feasible alternative. However, additional research is needed to know if it is an economically viable option. However, in the last 10 years, intensive tillage, year-round input practices (modernization) that keep the soil bare have led to a decrease in ecological benefits and an increase in negative environmental factors (Beaufoy & Pienkowski, 2000).

With modernization, the spread of monoculture production to large areas, the loss of biodiversity with the intensive use of agricultural chemicals, the increase of olive cultivation towards high slope areas and the increase of erosions due to bare soil management, increased water pollution due to excessive use of herbicides and fertilizers. However, despite all these negative situations, olive trees contribute more than 900,000 tons of CO2 emissions each year (CAyP, 2008). It has not yet been scientifically demonstrated whether olive trees lead to a net reduction in CO2, as emission studies associated with the intensification process are lacking.

For olive groves to play the role of a carbon sink in the ecosystem, olive groves must increase. Research has shown that Andalusian olive groves have increased by 15% in the last 15 years, but caused a price crisis at the international level in the sector. When the carbon sink performances of the carbon related olive groves are examined, the bare soil due to excessive tillage in the olive groves, the burning of pruning residues and the very low organic matter contents of the soil show that the carbon sink performances are low (Sofo et al., 2005).

Tillage is done in more than half of the olive groves. In addition, most of the pruning waste collected from olive groves is incinerated. These practices show the lowest carbon sequestration levels in the soil. However, re-burial of pruning residues, use of vegetation, increase in soil organic matter content contribute to carbon sink performance (Gómez-Calero et al., 2009). Soil management practices not only increases the carbon sequestration of olive plantation but also reduces soil erosion (Gómez-Calero et al., 2009) and increases the biodiversity of olive orchards (De la Concha et al., 2007).

The use of fossil fuels in agricultural activities, the application of nitrogenous fertilizers that generate CO2 and NO2 emissions accelerate the changes in temperature and precipitation caused by climate change (Metzidakis, 2008).

Farina et al. (2017) found in his research that approximately 38.25 t / ha / year of CO2 was emitted from olive groves. However, there are few studies that reveal atmospheric NO2 emissions from olive plantations (Avila, 2010).

80% of the carbon sequestration in olive groves plays an important role in the presence of vegetation and stores 46.4-20.5 t / ha of CO2. Overall, it is estimated that each olive tree stores around 30.89 kg of CO2 in its first 20 years (Boja, 2015).

In studies conducted that the new olive tree planting areas (58.106 olive trees) in Andalusia between 1990 and 2011, it has been revealed that total olive trees capture 13,106 tons of CO2 and the annual carbon capture rate is 1.7 (Eurostat, 2020).

The main reason for these greenhouse gas emissions is olive cultivation agricultural management (ie irrigation, fertilization and tillage practices). Therefore, intensive tillage Their application increases the organic matter loss of the soil, decreases the fertility of the soil and increases the greenhouse gas emissions (Parras-Alcantara, 2015).

Taxidis et al. (2014), in his study, in management models such as olive groves produced with integrated production or organic production, a 10.18 % reduction in CO2 emissions compared to traditional management. This is because in these management models, tillage practices and the use of chemicals (in a controlled manner) or organic fertilizer or waste contribute to the reduction of CO2 emissions from the soil (Parras-Alcantara, 2015). However, in these agricultural practices, by using partial or total vegetation in the soil, it contributes to the capture and reduction of atmospheric CO2 (Boja, 2015).

In addition, irrigation implementation is effected to higher greenhouse gas emissions. Applications such as drip irrigation bring water directly to tree roots and reduce these emissions (Karki, 2020).

As a result, the growth of olive plantations is an important tool to mitigate climate change by reducing CO2 emissions, due to its role as a carbon scavenger (Boja, 2015).

4. THE EFFECT OF EROSION ON OLIVES

According to the data from the National Erosion Inventory (Magrama, 2012), it is reported that Spain Andalusia is the most affected by severe erosion processes. Studies show that approximately 23 % of the total surface area of the Andalusia region, 25 t / ha of soil erosion (Parra-López et al., 2009).

Soil management (burning of pruning residues, bare soil management, removal of weed vegetation) causes an increase in erosion in olive cultivation (Nekhay et al., 2009). Soil erosion also includes negative impacts that lead to pollution of rivers and water reservoirs, and clogging of reservoirs (Colombo et al., 2005). Prevention of soil erosion contributes to climate change and prevents biodiversity loss, increases soil fertility, increasing olive productivity, and decreases costs (Calatrava-Leyva et al., 2007).

EU policy makers carry out Common Agricultural Policy (CAP) reforms in order to reduce the negative situations faced by agricultural production farm activities, ensure sustainability and ensure the supply of domestic productions.

In this context, CAP seeks a sustainable agricultural system that contributes to the economic viability and environmental quality of agricultural models (Salazar -Ordónez et al., 2011).

Thus, CAP aims to achieve sustainability targets and develop agro-environment programs by redefining agricultural land use policy (De Graaff et al., 2013). In this sense, erosion put into such as leaving at least one vegetation in olive cultivation, using vegetation in olive plantation with a slope of more than 10 %, and no treatment in the soil when the slope exceeds 15 % (CAP, 2009).

The combination of the Mediterranean climate and bare land management has resulted on slopes in high erosions in many olive growing areas (Gómez et al., 2009). High erosion rates (Beaufoy, 2000), cited as one of the main environmental problems, encourage the development and implementation of cover crop in soil management in Mediterranean countries.

5. NEW OLIVE REGIONS BORN DUE TO CLIMATE CHANGE

Climate change threatens olive species with an drought-resistant of significant ecological and socio-economic importance in the Mediterranean Basin (Ponti et al., 2014). Therefore, climate scenarios anticipate an expansion of olive growing areas to the north area because of the warmer and drought (Moriondo et al., 2013).

It is predicted that temperature increase due to climate change. At higher temperatures, potential olive areas are expected to shift in Spain (Galan, 2005).

Research show that region of Catalonia which the largest olive oil production in Spain will become unavailable within 20 years due to rising temperatures and water scarcity, while olive oil production will face a 40 % yield decrease in Spain (Tupper, 2012).

This points to born of new olive and olive oil leaders. These countries are determined as China, Libya, Australia, Jordan and India (Vasilopoulos, 2013). Spain continues to work on the creation of new and innovative irrigation alternatives to combat climate change, in order to maintain its leadership in olive and olive oil. Likewise, it is estimated that similar situations will occur in other leading countries (Greece, Italy and Portugal) (Tupper, 2012). As a result of the researches, it is expected that the restricted area of the olive groves will change in the Mediterranean by 2050, assuming an increase of 0.8-2.3 ºC in temperature and a decline of up to 200 mm in precipitation per year.

It is thought that new regions of olive cultivation will shift towards regions with lower temperatures and higher humidity. It is predicted that the cooling periods will decrease due to climate changes and will affect flowering.

RESULTS

Although there are various threats to the sustainability of economic, social and environmental olive groves, climate change is one of the most important of these systems. Temperature rise and precipitation will have many effects in distribution area and phenological cycle of the olive plantation. Moreover, climate change will cause changes in the evapotranspiration of olive plantation.

On the other hand, high temperatures with falling rainfall will restrict olive area due to long drought periods and decrease olive plantations.

Finally, given the constraints on it, it is important to maintain rain-fed olive groves or water efficiency that emphasize the use of irrigation practices such as drip irrigation, SDI (subsurface) or RDI (restricted irrigation).

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CHAPTER 4

USING SMART AGRICULTURE TECHNIQUES FOR IMPROVING CROP PRODUCTION

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INTRODUCTION

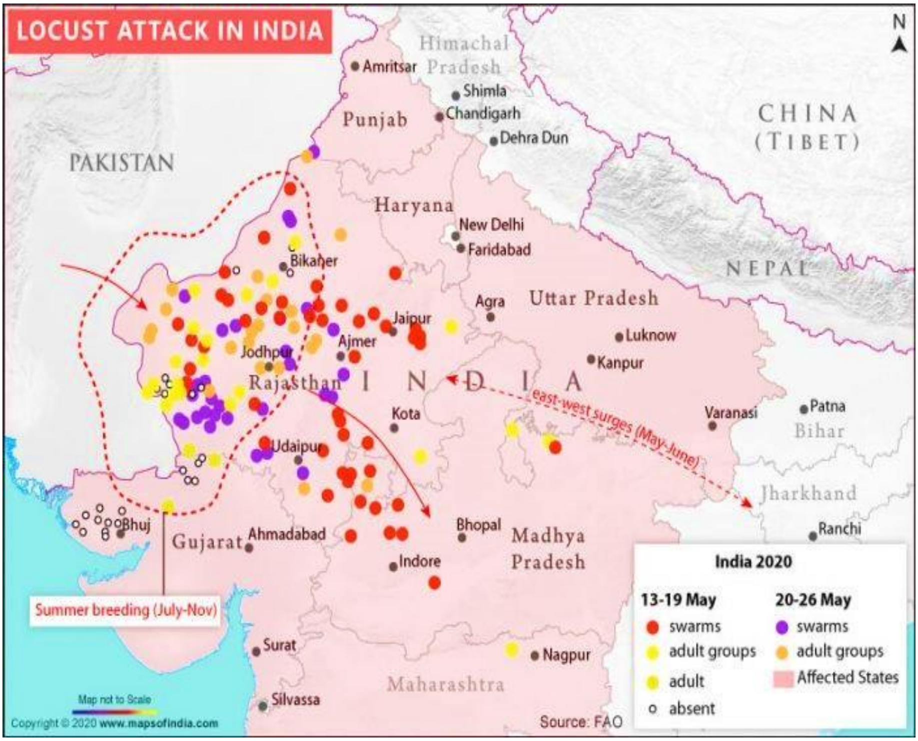
As the population grows, so does the amount of space available for individuals to live. The area in which they spend their living spaces has been growing. As a result, agricultural land is gradually diminishing. This condition is putting further strain on agricultural systems. We need to employ an approach that will boost productivity. We must also preserve the crop from destruction, in addition to using smart agriculture practices. Crop devastation results in the loss of a large number of crops each year. Crop damage is one of the major issues preventing people from meeting their food needs. From 2017 to 2019, India sustained severe crop damage on 18.176 million hectares (mha), or nearly 8.5 percent of the total gross cultivated area, due to floods, according to data provided by the government in the Lok Sabha on February 11, 2021. In this data, only one factor for destruction is shown. Other things that cause crop destruction include animals, insects, pests, fire, and so forth[1]. Humans find it difficult to resist all of these influences. As a result, IoT technologies can help us secure our crops more efficiently. High population growth influences the requirement for more communities on the land. Such a situation implies that agricultural land is likely to be constructed as a result of substantial conversion to new land uses, such as settlement or another more profitable land use. Furthermore, population pressure on the land throughout this period has the potential to impair agricultural productivity[2].In the future, the Internet of Things (IoT) will serve as the cornerstone for Smart Computing. A crucial factor is the transfer of existing technology from the home to the workplace into "next-generation computing." The "Internet of Things" is a key component of global research, notably in the field of enhanced wireless communication. Today, IoT is building the groundwork for numerous goods, such as smart healthcare, smart housing, smart schools, and technology that have an impact on people in and out of the market. Agriculture is the most researched aspect of the Internet of Things[3][4]. This research contains a comprehensive set of data that will assist IoT-based researchers and agricultural engineers in achieving the necessary level of food security. The rest of this article is organized in the same way. The overview and problem statement is discussed in Section 2. The suggested frameworks as well as their components are described in Section 3. Section 4 discusses experimental data analysis and results. Finally, Section 5 brings the process to a conclusion.

1. OVERVIEW AND PROBLEM STATEMENT

Animal attacks on crops are a regular and serious problem that results in significant losses. Local animals such as buffaloes, pigs, goats, birds, and fire have damaged farm crops in multiple cases[5]. So, this research is based on solving the problem of these attacks to some extent using IoT Techniques.

India is an agriculture-based country, with agriculture employing more than half of the population. In 2020, a locust invasion was there in almost 10 states of India as shown in Figure 1. Rajasthan, Punjab, Gujarat, Uttar Pradesh, Madhya Pradesh, Maharashtra, Bihar, Chhattisgarh, Haryana and Uttarakhand were the affected states.

Initially, the Government of Rajasthan reported crop destruction of 33% or more due to locust attack in 2235 hectares in Bikaner, 140 hectares in Hanumangarh, and 1027 hectares in Sri Ganganagar in May 2020; however, according to a revised report, the earlier submitted data was related to the initial stage of crop sown in Kharif season, and this area of crop loss has been re-classified. Due to locust invasion this year, the state governments of Haryana, Madhya Pradesh, Maharashtra, Uttar Pradesh, and Uttarakhand have estimated crop damage of less than 33% in 6520 ha, 4400 ha, 806 ha, 488 ha, and 267 ha, respectively[6].



Source: FAO

Figure 1. Locust attack in India, 2020-21 (source: www.mapsofindia.com)

Human-wildlife conflict has always been a major concern in Bhutan, with about 60% of the country's 765,000 people reliant on agriculture and animal production. In the Yangthang village of Bhutan Wild boars had eaten about 40% of the potatoes grown by most of the farmers. According to the Ministry of Agriculture and Forests, wild animals ruining crops and killing livestock is a prevalent problem across the country (MoAF). According to the 2017 State of the Nation survey, 70 percent of farmers reported wildlife destroying crops and 12 percent reported livestock losses due to wildlife attacks. Agriculture experts warn that in recent decades, the rising incidence of wild animal attacks has put farming communities in trouble. Farmers spend around four to five months a year securing their crops during the night.

The main objectives of this research are as follows:

- To reduce the crop destruction done by Animals.
- To reduce the crop destruction done by locusts/pests.
- To prevent crop destruction in the field by fire.

For fulfilling these objectives, we have proposed a model that can be implemented for protecting the farmer’s crop from destruction during the night also. No guard will be needed for guarding the farm day and night. Also, this model will produce a frequency to repel animals.

2. PROPOSED MODEL

Local animals such as buffaloes, pigs, goats, birds, and fire have damaged farm crops in multiple times. This results in significant losses for producers. Farmers are unable to encircle entire fields with barricades or stand on the field for 24 hours to secure it [7]. As a result, we've proposed an automated system to defend crops from animals and fire. This Proposed System would transform the classic inactive scarecrow into a smart, adaptable scarecrow that can not only scare away birds but also repel wild animals and guard against fire.

Working Principle

A classic scarecrow sculpture will be updated and enhanced in this suggested model by integrating sensors and Repeller Devices that can identify animals in the range of farmer's crop field, as well as a fire sensor and alarm that can notice the fire in the cropland and raise the alert. We're utilizing a GSM module to connect these sensors' output signals to the farmer's phone, so that if there's any movement detected inside the farm while the farmer is away, a message may be delivered to him[8].

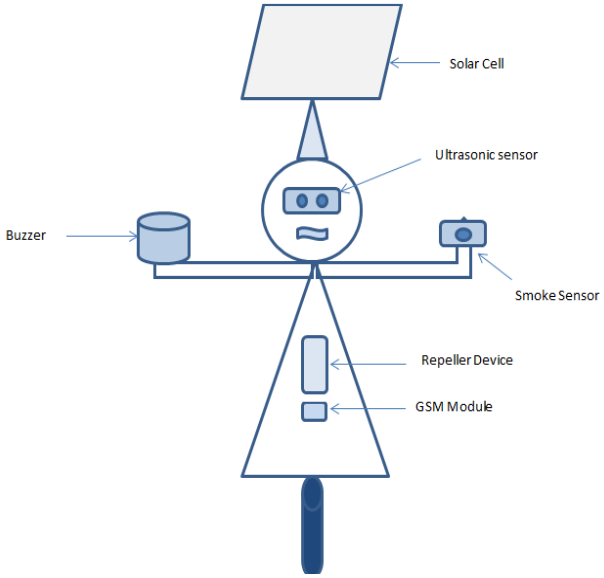


Figure 2. Proposed model in shape of traditional scarecrow

Algorithm For Animals attack prevention

Start

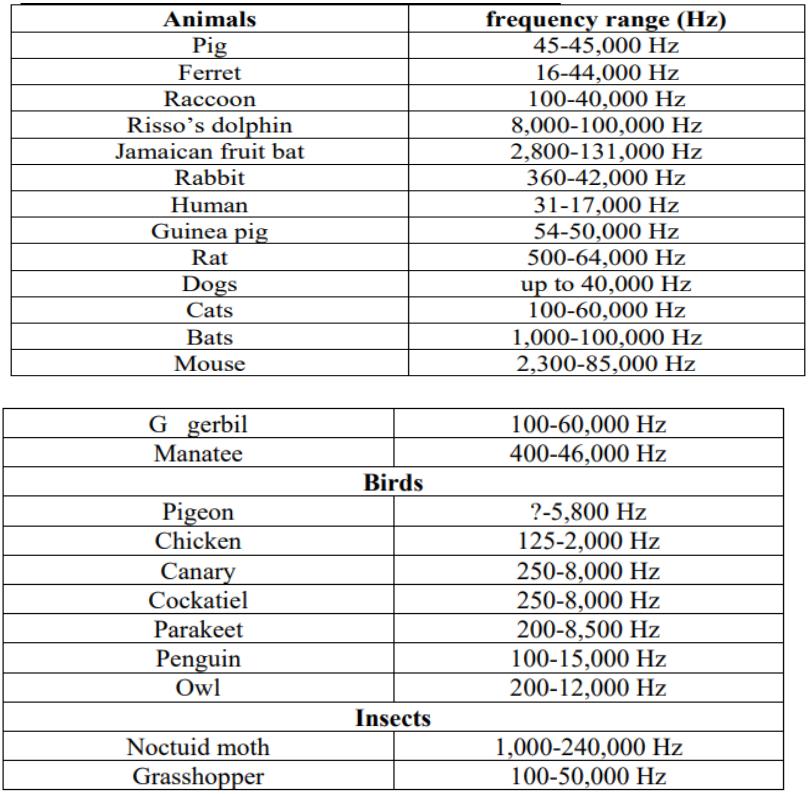
- When an animal reaches the sensor range's farmland area, the Arduino UNO receives data from the Ultrasonic sensor.
- The output pin will be activated as soon as the Ultrasonic sensor detects any animal and also detect the animal’s height.
- At the output pin, the Repeller gadget will begin making alarm sounds of various high frequencies dependent on tiny, medium, or large animals.
- Simultaneously the GSM Module sends a message to the farmer's registered mobile phone.

End

3. DATA AND RESULTS

The basic working principle of this model are based on Ultrasonic frequencies to repel Animals from Cropland especially when the farmer is not in the ground. Ultrasonic devices work by releasing short-wavelength, high-frequency sound waves that are too loud for the human ear to hear (generally accepted to be frequencies more than 20 kHz). Due to physiological constraints of the cochlea, humans are normally unable to hear sounds louder than 20 kHz, while there is considerable variation between people, especially at such high frequencies. Bats, dogs, and rats, for example, can perceive well into the ultrasonic range[9]. Figure 3 below shows the Repeller Frequency for various Animals.

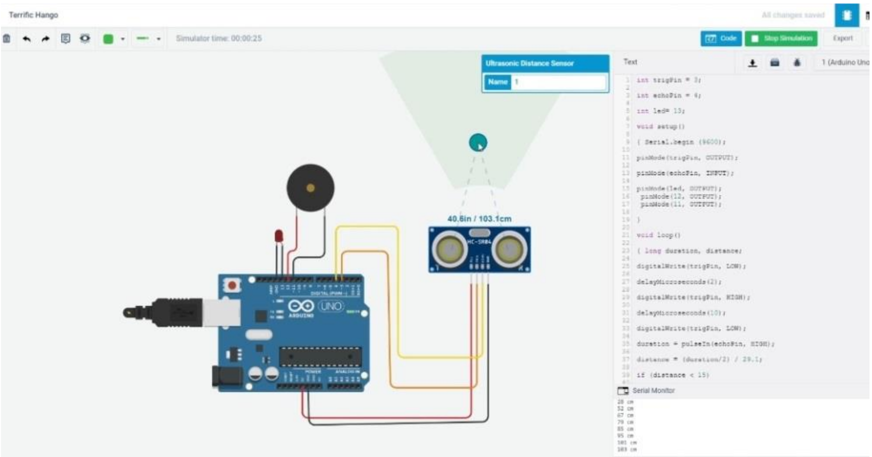
Repeller Frequency for Animals:



Animals	frequency range (Hz)
Pig	45-45,000 Hz
Ferret	16-44,000 Hz
Raccoon	100-40,000 Hz
Risso's dolphin	8,000-100,000 Hz
Jamaican fruit bat	2,800-131,000 Hz
Rabbit	360-42,000 Hz
Human	31-17,000 Hz
Guinea pig	54-50,000 Hz
Rat	500-64,000 Hz
Dogs	up to 40,000 Hz
Cats	100-60,000 Hz
Bats	1,000-100,000 Hz
Mouse	2,300-85,000 Hz
G gerbil	100-60,000 Hz
Manatee	400-46,000 Hz
Birds	
Pigeon	?-5,800 Hz
Chicken	125-2,000 Hz
Canary	250-8,000 Hz
Cockatiel	250-8,000 Hz
Parakeet	200-8,500 Hz
Penguin	100-15,000 Hz
Owl	200-12,000 Hz
Insects	
Noctuid moth	1,000-240,000 Hz
Grasshopper	100-50,000 Hz

Figure 3. Various Repeller Frequencies for various types of Species

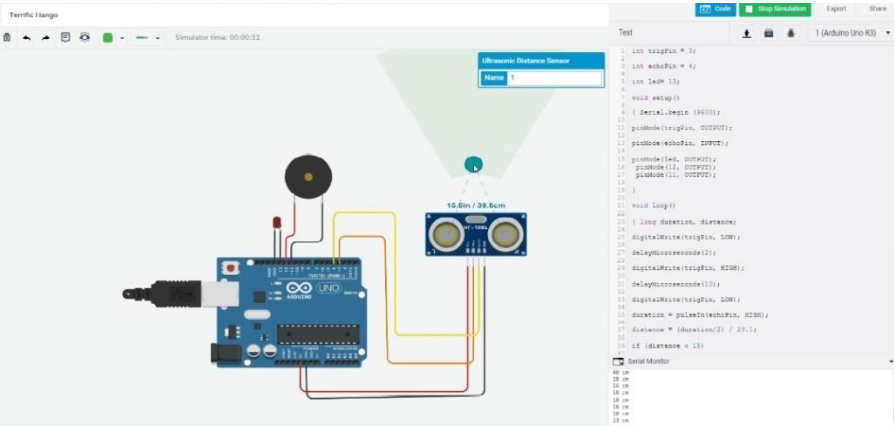
Now, Figure 4, Figure 5 and Figure 6 are showing the simulation experiment of proposed model using RED LED at output PIN instead of frequency generator.



```
int trigPin = 3;

int echoPin = 4;

int led= 13;

void setup()

{ Serial.begin (9600);

pinMode(trigPin, OUTPUT);

pinMode(echoPin, INPUT);

pinMode(led, OUTPUT);
 pinMode(12, OUTPUT);
 pinMode(11, OUTPUT);

}

void loop()

{ long duration, distance;

digitalWrite(trigPin, LOW);

delayMicroseconds(2);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);

distance = (duration/2) / 29.1;

if (distance < 15)
```

```
28 cm
52 cm
67 cm
79 cm
85 cm
95 cm
101 cm
103 cm
```

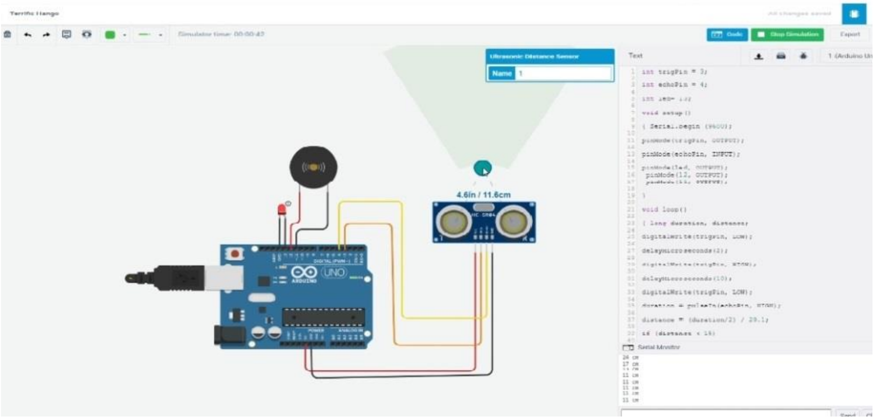
Figure 4. Object beyond the field area range (LED OFF)



```
int trigPin = 3;

int echoPin = 4;

int led= 13;

void setup()

{ Serial.begin (9600);

pinMode(trigPin, OUTPUT);

pinMode(echoPin, INPUT);

pinMode(led, OUTPUT);
 pinMode(12, OUTPUT);
 pinMode(11, OUTPUT);

}

void loop()

{ long duration, distance;

digitalWrite(trigPin, LOW);

delayMicroseconds(2);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);

distance = (duration/2) / 29.1;

if (distance < 15)
```

```
40 cm
28 cm
16 cm
18 cm
18 cm
18 cm
18 cm
23 cm
```

Figure 5. Object at the boundary of field (LED OFF)



```
int trigPin = 3;
int echoPin = 4;
int led= [illegible];
void setup()
{ Serial.begin (9600);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
pinMode(led, OUTPUT);
 pinMode(12, OUTPUT);
 pinMode([illegible], OUTPUT);
}
void loop()
{ long duration, distance;
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = (duration/2) / 29.1;
if (distance < 15)
```

```
24 cm
17 cm
[illegible]
11 cm
11 cm
11 cm
11 cm
11 cm
```

Figure 6. Object inside the Field Range (LED ON)

Thus, the above simulation of the experiment shows the working of the proposed model. In the above figure, it is clearly shown that no response is there from ARDUINO until the object comes inside the field range. Red LED is ON in the experiment only when the object comes inside the field. Thus, LED can be replaced by a frequency generator repeller device to generate frequency as the animal comes inside the field.

So, the main advantages of this proposed model are:

- 24X7 guarding of the crop-field by this system.
- Detection of animal, bird or any intruder to the field.
- No need to kill Animals as in many countries killing animals is a punishable offense. Animals can be repelled away by frightening from the frequency generated.
- Automatic fire detection and automatic switching on the motor for extinguishing the fire.

CONCLUSION

We can conclude at the end of this research the proposed model is designed for the protection of crops from animals. So that farmers should not invest their income in guarding the crops of field. This model will act as a guard from animals due to its technical application and from birds due to its physical structure like a scarecrow in the field. Agricultural farms would have to use cutting-edge technology to gain the competitive advantage needed to meet the population's growing demands. Agricultural IoT (Internet of Things) applications can help the industry improve operational efficiency, cut costs, reduce waste, and improve yield quality[10]. Smart agriculture based on the Internet of Things is a system that uses sensors to monitor watering activities and regulate crop protection in the agricultural field. Farmers can monitor the state of their farms from any location. The fundamental goal of the suggested approach is to protect crops in any circumstance and to assist farmers in controlling their land from anywhere.

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CHAPTER 5

CHANGES IN FREE AMINO ACID PROFILES OF PLANTS UNDER DROUGHT AND SALT STRESS CONDITIONS

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INTRODUCTION

As a result of the increase in the world population and the effects of global climate change, it is essential producing with genotypes that are tolerant to stress conditions for sustainable food security. However, since this is not always possible, it is important to better understand and put into practice the methods that will activate the synthesis of some intrinsic metabolites that will provide tolerance to stress conditions. Some metabolites are produced depending on the genotype with the effect of biotic and abiotic stress factors in plants (Khan et al., 2020). Identifying the proteins whose synthesis is increased or decreased in a cell under abiotic stress conditions, including drought and salt stress, and the changes in the expression levels of these proteins are very important in terms of understanding the relationships of these molecules with stress tolerance (Yıldız et al., 2020). This information allows understanding the molecular mechanisms that provide tolerance to abiotic stress conditions in cells and to identify candidate genes that will allow for the development of tolerant plants with genetic engineering studies in later stages (Barkla et al., 2016). It also provides information for some exogenous applications to be made externally to develop tolerance to stress conditions.

Drought and salt stress are common abiotic stress factors that cause significant yield and quality loss in plants. These stress factors suppress cell growth and division due to their inhibitory effects on basic physiological events such as transpiration and photosynthesis in plants (Anjum et al., 2011; Öztürk, 2015). One of the mechanisms for plants to cope with stress conditions is to make biochemical changes such as arrangements in antioxidant enzyme activities, soluble sugar content, organic acids, and amino acid profile (Ashraf and Foolad, 2007; Shulaev et al., 2008, Khan et al., 2018). Exogenous amino acid applications provide tolerance to stress conditions in plants by regulating membrane permeability and ion uptake. In addition, it is known that branched-chain amino acids such as leucine and valine accumulate due to protein degradation under stress conditions and can function as respiratory substrates (Hildebrandt et al., 2015; Huang and Jander, 2017). Changes in the amino acid profile usually occur as the accumulation of some specific amino acids such as proline. Although most of the studies have focused on proline, the investigation of other amino acids is important in terms of understanding the response mechanisms to stress conditions. It is known that exogenously amino acid applications could be contributed to the development of stress tolerance in plants (Matysiak et al., 2020). In this chapter, the changes in the amino acid profile in the plant under drought and salt stress conditions, which are predicted to be an even more important problem in the future, are examined.

AN EFFECTIVE ORGANIC MOLECULE IN STRESS CONDITIONS: AMINO ACIDS

Abiotic stress factors negatively affect plant growth by causing biochemical changes, and plants develop survival strategies by making certain changes in their metabolism under these adverse conditions. The most common plant response to abiotic stress is the regulation of primary and secondary metabolite levels produced by plants. Changing the levels of primary metabolites, especially amino acids, sugars, and intermediate metabolites of the Krebs circle appears as the main method in response to stress conditions. This event occurs with the regulation of the gene expression that synthesizes the related metabolites and protein modifications. Especially the accumulation of amino acids synthesized by different metabolic pathways in plants for tolerance to abiotic stress conditions is a quite common process. Amino acids, not only act as the building blocks of proteins, but they also help plants cope with stress by detoxifying reactive oxygen derivatives, regulating osmotic pressure and pH (Khan et al., 2020; Planchet and Limami, 2015). They also take part in signal transmission paths. Especially proline, which is among the osmolites that help in the adjustment of osmotic pressure, has an important function in abiotic tolerance (Khan et al., 2018; Dondoni and Massi, 2006). Amino acids, which play a role in stress tolerance in plants, are synthesized through three different pathways. The first of these pathways is the glutamate pathway that leads to the accumulation of proline and γ-aminobutyric acid. The glutamate pathway is very strongly activated, especially in abiotic stress conditions. The second is the Pyruvate pathway which enables the production of alanine, especially in anaerobic conditions. This leads to the production of valine and leucine, which act as alternative respiratory substrates. They also provide an alternative for osmotic pressure regulation. The third path is the aspartate family pathway, which provides energy by catabolizing the lysine. This ensures that the energy deficit in stress conditions is covered (Dondoni and Massi, 2006).

AMINO ACID PROFILE CHANGES

Drought

Drought, which is also called osmotic stress, causes morphological, physiological, and molecular changes leading to the deterioration of the ion balance of the cell, resulting in negative consequences on plant growth and development (Wang et al., 2003). Drought has direct and indirect harmful effects on plants. The basis of these harmful effects is the occurrence of quite complex events, many of which can affect each other, such as the prevention of photosynthetic pigment formation, damage to the structure of chloroplasts, disruption of the electron transport chain, and decrease in stomatal conductivity (Asada, 1999; Hasanuzzaman et al., 2013).

Amino acid metabolism in plants is under the influence of physiological conditions as well as the growth and development stages of the plant, and a decrease or increase in the amount of amino acids may occur due to stress conditions. These changes are caused by the breakdown of proteins (as in senescence) or the biosynthesis of proteins. This process is quite complex (Hildebrandt et al., 2015). Researches have shown that amino acid profiles of plants differ according to plant species, stress tolerance level, and stress severity under drought stress conditions. The processes that activate the degradation of proteins to free amino acids under normal conditions are senescence and programmed cell death, but there are studies that reveal that short-term osmotic stress conditions cause protein degradation by having a similar effect. In the Arabidopsis model plant, free amino acid accumulation generally occurred under short-term drought stress conditions and this accumulation was explained by protein degradation regulated by abscisic acid, whose synthesis increased under stress conditions. Transcriptomic analyses revealed that exposure to short-term osmotic stress produces transcriptional changes distinct from senescence. It is thought that transcriptional upregulation of some specific proteases occurred in response to drought stress. (Huang and Jander, 2017). Ullah et al. (2017) reported that metabolites, including amino acids that accumulate under drought stress, are key metabolites related to genes, biochemical pathways, and enzymes involved in the formation of drought tolerance. In their study on seven different *Triticeae* genotypes, as a result of the genome analysis performed to understand the roles of these metabolic pathways and genes related to tolerance, they determined that there was a decrease in the amount of amino acids in genotypes where there were no sequences related to drought stress. They determined that the amount of proline, glutamate, alanine, glycine, asparagine, methionine, threonine, phenylalanine, homocysteine, serine, valine, and tyrosine increased. Studies have revealed that changes in amino acid profiles of plants under drought stress conditions differ according to species. It was determined that proline, leucine, and isoleucine increased in *Lotus japonicus* accessions (Sanchez et al., 2012), and proline, valine, threonine, homoserine levels were increased in peas (Charlton et al., 2008). Valine, leucine, and isoleucine form the branched-chain amino acids group (Binder, 2010). It was determined that the accumulation of branched-chain amino acids was also induced in addition to proline under drought stress conditions. Although the role of proline as an osmolyte is well known, the functions of branched-chain amino acids on this subject are not fully understood and there are not enough studies. In drought-tolerant sesame genotypes, accumulation of aromatic and branched-chain amino acids, as well as proline, arginine, and lysine, occurred under drought-stress (You et al., 2019). Similarly, it was determined that branched-chain amino acid accumulation was found in tomato (Semel et al., 2007), maize (Witt et al., 2012), and wheat (Bowne et al., 2012), and also all amino acid amounts were increased in *Arabidopsis*, which was dehydrated for 10 days (Pires et al., 2016).

Salt

Like drought stress, salinity, which is a very serious threat to sustainable agriculture, is also an abiotic stress factor that causes great economic losses. It is known that about six percent of the total agricultural land in the world is in danger of extinction due to salt stress (Yildiz et al., 2020).

It has been found that under salt stress conditions, nitrogenous compounds, including amino acids, are accumulated in plants like other osmoprotectants. The functions of these components under stress conditions are thought to be regulation of intracellular osmotic pressure, protection of macromolecules of the cell, scavenging, and detoxification of free radicals, and regulation of intracellular pH (Mansour, 2000). Consistent with this information, it was determined that the proline level was higher in salt-resistant tomato cultivars than in susceptible cultivars under increased salt stress conditions (Doğan et al., 2010). Similarly, it was determined that the free proline content in the leaves of the Canola (*Brassica napus* L.) plant increased significantly under salt stress conditions (Ashrafijou et al., 2010).

As in drought stress, carbohydrate and protein metabolism have very important roles in the biological adaptation process in response to salt stress. Seven important amino acid metabolic pathways and eight key genes associated with amino acid metabolism in salt stress conditions were identified in tomato. In particular, it has been determined that arginine, which is a precursor molecule for the synthesis of other amino acids, and the gene whose functions in proline metabolism are activated. Although most of the studies focused on the task of regulating the intracellular osmotic pressure of proline, it was determined that proline also induces the genes responsible for salt stress response formation (Flores et al., 2008; Zhang et al., 2017). However, it was determined that the amount of some amino acids decreased under salt stress conditions. In a study conducted in broccoli, it was determined that there was a decrease in cysteine and methionine amino acids under salt stress conditions and the genes responsible for the synthesis of these amino acids were down-regulated (López-Berenguer et al., 2008).

Similarly, cysteine, arginine, and methionine contents decreased by 55% in wheat at 100 mM salt stress. On the other hand, valine, isoleucine, proline, and aspartic acid were increased (El-Shintinawy and El-Shourbagy, 2001). In the salt-tolerant green gram variety, amino acid accumulation occurred under salt stress conditions (200 mM NaCl), and the increase in the amounts of alanine, arginine, glutamine, proline, and phenylalanine was remarkable. In addition, it has been determined that there is an increase in branched-chain amino acids (Neelam et al., 2006), which are being emphasized more today. In soybean, NaCl application caused an increase in serine, alanine, γ-aminobutyric acid, and proline and a decrease in Asparagine (Queiroz et al., 2016).

CONCLUSION

As a result, as it is known, abiotic stresses cause crop losses on a global scale and therefore serious economic losses. In particular, drought stress, which is becoming increasingly important due to global climate change, and salt stress, which indirectly triggers drought stress, are two important stress factors that need to be dealt with. For this reason, it is very important to determine the intracellular metabolism of amino acids, which form the building blocks of proteins, as in other metabolites under stress conditions. Although it is known that these molecules provide tolerance to abiotic stress conditions, there are many points that need to be clarified regarding the molecular mechanisms. For this reason, there is a need for more studies on different plant species in this regard.

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CHAPTER 6

EFFECTS OF TOXIC HEAVY METALS ON THE ENVIRONMENT AND HUMAN HEALTH

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INTRODUCTION

Together with industrialization and rapid urbanization worldwide, there has been a significant increase in environmental pollution and natural resource consumption. Due to this increase, heavy metal toxicity may create dangerous consequences in living creatures as a result of its biological accumulation through a variety of exposures in our ecosystem. In addition, the ecological cycles of these metals may lead to an environmental health problem which may cause dangerous effects in the environment (Taylan and Özkoç Böke, 2007; Yi et al., 2011; Avigliano and Schenone, 2015; Islam et al., 2015; Asaduzzaman et al., 2017; Singh and Kumar, 2017; Okereafor et al., 2020).

Ecological cycles create a whole affecting each other. Negative effects to be caused by heavy metals on the ecosystem may be transmitted from one ecosystem to another either directly or indirectly. As a result of any intervention to be made in the ecosystem from outside, the system will break down and damage the ecological balance. When nature is excessively exposed to synthetic and natural chemicals and these chemicals accumulate in these environments, a toxic pollution will occur as a result of the decrease of wildlife and species, breakdown in the ecosystem functions and development of effects threatening human life (Babu and Reddy, 2014).

In physical aspects, the term heavy metal is used for metals that have a specific weight greater than 5 g/cm^3 and an atomic number greater than 20 (Seven et al., 2018; Yerli et al., 2020). They have different effects on the air, land and aquatic resources and the living metabolisms. There are nearly 70 heavy metals (Dündar and Aslan, 2005; Okçu et al., 2009; Yerli et al., 2020).

Some of these metals (Cu, B, Zn, Fe, Co, Cr, Mn, Mo, Ni) play key roles in the living metabolism unless they exceed the threshold values. However, other heavy metals may usually display a toxic effect even at low concentrations due to their higher intensity. In addition, they are generally resistant to traditional elimination procedures and do not have biodegradability (Sall et al., 2020). In this respect, most metabolic and physiological processes in living creatures are affected by exposures to these toxic substances. The World Health Organization (WHO) estimates that it is caused by the long-term exposure of one quarter of sick people to environmental pollution today (Babu and Reddy, 2014).

Negative effects of heavy metals on environmental health increase when they are transmitted between the ecosystems either directly or indirectly. Heavy metals, which reach the atmosphere in the ecosystem, also reach water resources and the soil through dry or wet sedimentation and threaten the life of creatures living there. Although heavy metals have different effects in the atmosphere, water and soil, all environmental systems should be assessed integratedly in terms of environmental health. In the study, it was tried to explain the formation resources and accumulation of heavy metals and their effects on environmental health.

1. GENERAL PROPERTIES OF HEAVY METALS

Heavy metals are defined with their high atomic weight and density. Today they are used for defining metallic chemical elements and metalloids which are toxic for the environment and humans. Metalloids have toxicological properties because they tend to create covalent bonds. Therefore, they may have toxic effects by creating lipophilic ions and compounds and attaching to non-metallic elements of cellular macromolecules. Due to having a lipophilic form, the metalloid distribution in the biosphere and toxic reactions differ from the movement of simple ionic forms. Specific metalloids and also lighter metals such as selenium, arsenic, and aluminum have toxic effects (Briffa et al., 2020).

Heavy metals lead to ecosystem pollution as a result of erosions, volcanic activities, forest fires, industrial activities, open mining, exhaust gases arising from vehicles, agricultural activities, use of chemical fertilizers, use of pesticides, treatment sludges containing heavy metals and activities associated with domestic sewerages. Figure 1 shows the heavy metal resources and their transformation in the ecosystem.

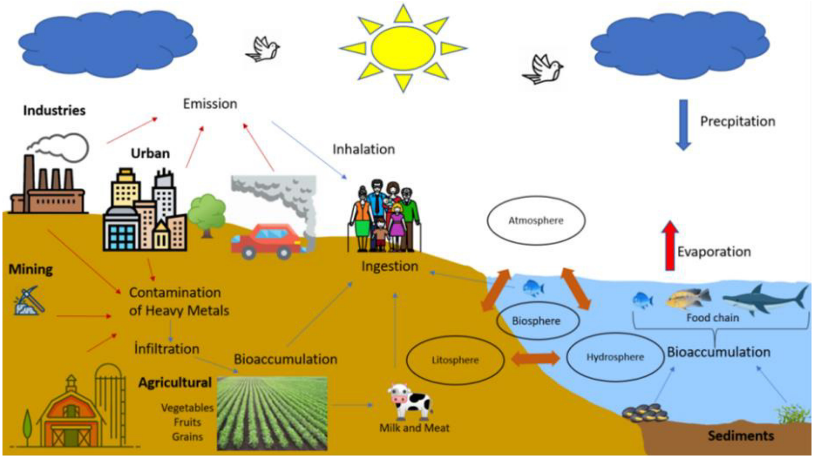

Figure 1: Heavy Metal Resources and Their Transformation in The Ecosystem

1.1. Transition of Heavy Metals to Water and Their Resources

Water pollution is examined in three groups as physical, chemical and biological according to the pollutant type. One of the resources causing chemical pollution in aquatic environments is heavy metals. Contamination of the environment brought by toxic heavy metals is basically a common problem especially in pollution resources arising from industrial activities which are based on the use of a variety of chemicals. These heavy metals are discharged into surface waters either directly or indirectly especially in developing countries (Sall et al., 2020).

Heavy metals are transmitted to aquatic environments like rivers and lakes through the dust carried by the wind, forest fires, volcanic activities, rock pieces carried through erosions, factory and domestic wastes and sewerages. They have a polluting effect on the living metabolisms in different ways (Taylan and Böke Özkoç, 2007; Aktop and Çağatay, 2020). Heavy metals causing water pollution have toxic effects on humans and aquatic creatures. Although specific heavy metals such as Co, Cu, Fe, Mn, Mo and Zn are necessary for living organisms to sustain their vital activities at low concentrations (Kır et al., 2007), the aforementioned heavy metals mixing into aquatic environments like seas, lakes and rivers cause bio-accumulation in the fish. Then, they are transmitted to other living creatures feeding on these creatures through the food chain and may affect their health negatively. Therefore, it is crucial to use effective techniques to determine the pollution level of natural waters and lower it down to the threshold level. For that purpose, there are many studies on heavy metal existence in sea waters and ecosystems and their effects on aquatic environments and the health of living creatures (Harikumar and Jisha, 2010; Varol, 2011; Saha et al., 2016; Karayakar et al., 2017; Bonsignore et al., 2018; Elderwish et al., 2019).

1.2. Transition of Heavy Metals to The Soil and Their Resources

Heavy metals are among important pollutants for soil pollution. Heavy metals mixing and accumulating in the soil create very complex structures in the soil and increase the effect of toxicity for living creatures. Also, they may lead to the emergence of many environmental and human health problems due to affecting the microbial activity negatively, reducing the soil productivity, ruining the soil fauna, leading to the losses of biodiversity, reducing the productivity and quality in products, leading to poisoning in living creatures through food chain, and creating toxic effects as a result of their accumulation (Seven et al., 2018; Yerli et al., 2020).

Due to the strong attachment of heavy metals to clay and organic substances, heavy metals usually have an intenser accumulation in the top layers of the soil (Kiziloglu et al., 2008). This causes impairment in the productive topsoil cover, a decrease in the soil productivity, an impairment in the quality of agricultural products and an increase in heavy metal accumulation in products. Several studies have indicated the existence of heavy metals in the soil and their effects on the health of living creatures (Kabir et al., 2012; Chabukdhara and Nema, 2013;

Li et al., 2013; Afshari et al., 2015; Qing et al., 2015; Kolo et al., 2018; Nwankwoala and Ememu, 2018; Mohammadi et al., 2020).

1.3. Transition of Heavy Metals to Air and Their Resources

SO_2, CO_2, N_2O, HF and hydrocarbons (HC) which are released into the air due to various reasons, contain pollutant emissions. Excess quantities of these gases may turn into acid rains. Under the influence of acid rains, the soil acidifies and heavy metals such as Cd, Cu, Fe and Zn which are available in emissions may accumulate in the soil and plants (Kara and Kara, 2018). In addition, most studies have indicated the existence of heavy metals in the air and their effects on the health of living creatures (Latif et al., 2013; Lin et al., 2015; Wan et al., 2016; Neisi et al., 2016).

Of these pollutants leading to heavy metal pollution, the most important one is industrial activities. Also, the most common heavy metals in regions polluted due to industry are As, Cd, Cr, Cu, Hg, Ni Pb and Zn (Wuana and Okieimen, 2011), which are summarized in Table 1.

Table 1: Resources of Heavy Metals Arising from Various Industries (Siegel, 2002; Çelebi and Gök, 2018)

Industry	**Pb**	**As**	**Hg**	**Cd**	**Cr**	**Cu**	**Ni**	**Zn**	**Se**
Paper Industry	+	-	+	-	+	+	+	-	-
Petrochemistry	+	+	-	+	+	+	+	+	+
Chemical Industry	+	+	+	+	+	+	-	+	+
Fertilizer Industry	+	+	+	+	+	+	+	+	-
Iron and Steel	+	+	-	+	+	+	+	+	+
Energy	+	+	+	+	+	+	+	+	+
Metal Alloy	+	+	-	+	+	+	+	+	-
Battery Production	+	-	+	-	-	-	+	+	-

Agriculture	-	+	+	-	-	-	-	-	+
Ceramic and Glass Production	+	+	-	-	-	-	+	-	-
Medical Device Production	+	+	+	+	+	+	+	+	+
Coating Industry	+	-	-	+	+	+	-	+	+
Electronic Device Production	-	-	+	-	-	-	-	-	-
Mining	+	+	+	+	+	+	+	+	-
Paint Industry	+	+	-	+	+	+	+	+	-
Machinery Industry	+	-	-	-	-	+	-	-	-
Plastic Production	+	-	-	+	-	-	-	-	-
Textile	-	-	-	+	+	+	-	-	-
Automotive Industry	+	-	-	+	+	+	+	+	+
Cement Production	-	-	-	-	+	-	-	+	-
Leather Industry	-	-	-	-	+	-	-	-	-

2. EFFECTS OF HEAVY METALS ON HEALTH

The body needs essential elements, macrominerals and trace elements to realize its functions. Building stones of most living matters comprise of four important essential elements (C, H, N and O). Inseparable elements which preserve the ionic balance of structural compounds, amino acids and nucleic acids are macrominerals (Ca, Cl, K, Mg, Na, P and S). Trace elements (Ar, Co, Cr, Cu, Fe, I, Mn, Mo, Ni, Se, V and Zn) are crucial for sustaining the skeletal structure formation, regulating the acid-base balance and providing main elements for the colloidal system maintenance (Briffa et al., 2020; Fu and Xi, 2020; Zhu and Costa, 2020). Essential metals are necessary for the body and their redundancy and deficiency may both affect the human body. Their deficiency may usually arise from an absorption disorder and diarrhea (Fu and Xi, 2020). Non-essential toxic metals (Ag, As, Cd, Pb and Hg) do not play any key role in the body of living creatures; however, as their concentration in the environment increases, they may lead to toxicity because they may affect the level of a basic element in the body (Briffa et al., 2020; Okereafor et al., 2020; Fu and Xi, 2020; Zhu and Costa, 2020). In fact, basic elements like Fe, Mn and Zn may also affect the human health negatively when their concentration is above the desired limits (Prashanth et al., 2015; Singh and Kumar, 2017). Redundancy and toxicity effects of a metal depend on swallowing or inhaling the metal, entry speed of the metal, tissue distribution and the concentration acquired and discharge speed of the metal (Fu and Xi, 2020). All substances may create a toxic effect as a result of exceeding a certain limit value in the living structure. Toxicity mechanisms include inhibition of the enzyme activity, protein synthesis, variations in the nucleic acid function and changes in the cell membrane transmittance (Fu and Xi, 2020; Özbolat and Tuli, 2016).

Heavy metals have specific mechanisms and different poisoning effects on the human body depending on the structure of the metal. These mechanisms concentrate on oxidative stress arising from an imbalance between the production and detoxification of reactive oxygen species (ROS). The toxicity of ROS is based on their ability of oxidizing intracellular and extracellular structures like nucleic acids, lipids and proteins (Kavas, 2008; Solenkova et al., 2014). Figure 2 shows this structure (Taylan and Böke Özkoç, 2007; Kavas, 2008; Solenkova et al., 2014).

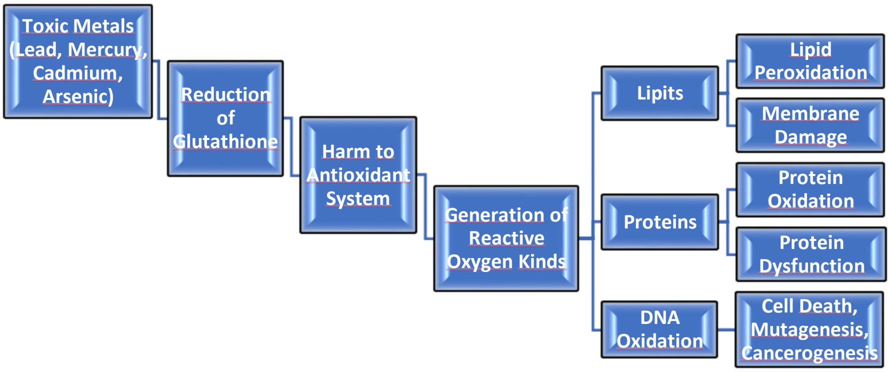

Figure 2: Systems of Metal Toxicity (Solenkova et al., 2014)

A great number of studies have showed that carcinogenesis and mutagenity of heavy metals are associated with oxidative stress induction (Fu and Xi, 2020). In the studies it is seen that redox reactions are performed by carcinogenic metal ions like nickel, chrome, cobalt and arsenic in biological systems. Therefore, free radicals produced by these reactions directly lead to an oxidative damage in proteins and DNA. Also, the species produced by redox reactions have two major functions causing cancer in human beings. One is the activation of redox-sensitive transcription factors and the other one is their role as a mitotic signal (Briffa et al., 2020; Fu and Xi, 2020). Similarly, another study suggests that another way of heavy metal carcinogenesis is a process intervening in the DNA repair (Fu and Xi, 2020).

Heavy metals stored affect the main metabolic processes of the body, imbalance of antioxidants, activity of a variety of hormones and functions of essential enzymes. With changes in the carbohydrate, protein and lipid metabolism, the infection sensitivity of the body tends to increase (Fu and Xi, 2020).

All mechanisms change a series of functions in the central nervous system by altering the synthesis and application of neurotransmitters in the body. Therefore, they produce reactive oxygen types causing oxidative stress which is a process that may lead to different cancer types, neurological diseases, an impaired renal function and other endocrine diseases independent from molecular ways that are affected by heavy metals (Sall et al., 2020; Briffa et al., 2020).

Health risks that may occur as a result of people's exposure to metals are too high. It is because metals tend to be adsorbed to the body, accumulate and biomagnify, which makes them responsible for various diseases (Herojeet et al., 2015). Toxic metals have a potential of affecting the neurological system, renal functions, ossification process and other various organs (Lohani et al., 2008; Singh and Kumar, 2017; Fu and Xi, 2020). Most studies have detected negative effects of heavy metals on human health and epidemiological studies have found that they cause human cancers (Mielke et al., 1999; Islam et al., 2015; Wei et al., 2015; Wu et al., 2019; Sall et al., 2020; Sevim et al., 2020).

Heavy metal exposure in humans occurs as a result of inhalation of air pollutants through the atmosphere, food consumption, drinking contaminated water and skin contact from the agricultural, manufacturing, pharmaceutical, housing and industrial areas (Kumar and Mukherjee, 2011; Nkpaa et al., 2016; Briffa et al., 2020; Sall et al., 2020). As a result of this exposure, heavy metals may accumulate in various organs and harm human health by causing toxicity in the living structure and being permanent for a long time (Alomary et al., 2006; Amr, 2011; Alina et al., 2012; Millour et al., 2012; Keshavarzi et al., 2015; Asaduzzaman et al., 2017, Sall et al., 2020).

In fact, metal exposure occurs with transition via food consumption (swallowing food sources such as cereals fruits, vegetables, fish and shellfish) rather than transition via respiration and dermal contact (Saha et al., 2016; Briffa et al., 2020). Under certain conditions humans are exposed to metals by consuming aquaculture organisms. The metals accumulate in adipose tissues and may have negative effects on the body (Saha et al., 2016; Ju et al., 2017). The studies have demonstrated that human health has a potential risk as a result of consuming sea products which are exposed to heavy metals (USEPA 2000; Storelli, 2008; Michael et al., 2011; Imar and Carlos 2011; Nkpaa et al., 2016). For all heavy metals, the tolerable concentration limits according to the United States Environment Protection Agency (US-EPA) and the World Health Organization (WHO) range from 0.01 to 0.05 mg L^{-1} in natural waters (USEPA, 2009; Sall et al., 2020).

Toxic effects of metals vary according to the property of every metal. However, in general, all metals affect multiple organs and systems. Therefore the “target or critical organ” in metal poisoning is used for the action area that has the highest sensitivity to that metal. For example, the most sensitive organ to cadmium is kidney. A toxic effect is observed in the liver and lungs, as well. Thus, the resources and accumulation of heavy metals and their effects on the environment and human health are discussed individually as follows.

2.1. Lead and Its Effects

Lead (Pb) is the greatest natural resource for volcanic activity and geochemical decomposition. Being one of the most important heavy metals threatening human health, lead is available in the soil, water, air and in most substances that we use daily in different amounts. In the nature it is available in inorganic and organic forms. Inorganic form of lead is available in particles in the atmosphere, while its organic form can easily be transmitted to foodstuff, soil and water resources due to its volatility (Yerli et al., 2020). In addition, it causes water and soil pollution through industrial, agricultural, domestic and liquid wastes. It is released into the environment through coal, tin and iron mining, vehicle emissions, lead melting, burning of fossil fuels, burning of lead wastes, pigment and dye production, steel products, steel welding and spray coating (Asaduzzaman et al., 2017).

Long-term toxicity of this metal is usually known as lead poisoning. Lead exposure occurs with air-borne emissions and occupational exposures, water and food or sometimes with the use of alternative healthcare products like herbal medicine (Solenkova et al., 2014; Sall et al., 2020).

In humans the daily lead intake ranges from 20 to 400 mg. The United Nations Food and Agriculture Organization and the World Health Organization have specified the Provisional Tolerable Weekly Intake

(PTWI) to be 3000 mg. For children, however, half of the aforementioned amount was accepted as the safe limit (Özbolat and Tuli, 2016).

Lead accumulates in the human body through food cycle at a higher level. With the inhalation of lead in the body, nearly 30% to 40% of it is swallowed. Of the lead swallowed, 5% to 10% is absorbed in the blood stream. In addition, its gastrointestinal absorption may be as high as 30% to 50% in children. Once it is absorbed, 99% of it attaches to red blood cells and 1% remains in the serum. The absorbed lead is excreted from the body through urine, sweat, hair and nail. Half-life of lead is relatively 36 days in the blood stream and ranges from 20 to 30 years in bones (Solenkova et al., 2014).

Although it is asserted that there is a correlation between being exposed to lead long years and cardiovascular diseases, this correlation remains uncertain. The studies have mainly demonstrated a positive correlation between blood pressure and hypertension. In the studies on lead poisoning or occupational exposure, it has been found that lead is effective on lipid metabolism (Sevim et al., 2020). Also, it has several negative health effects like neurotoxicity and nephrotoxicity (García-Lestón et al., 2010; Jović and Stanković, 2014). In adults, higher lead levels in blood affect sperm quality, sleeplessness, tiredness, memory and coordination loss, hearing loss and weight loss, increased blood pressure and cardiovascular diseases (García-Lestón et al., 2010; Yap et al., 2016). Lead poisoning may also lead to a decrease in cognitive development and intellectual performance (decrease in IQ) in children (Canfield et al., 2003).

2.2. Arsenic and Its Effects

Arsenic (As) is a naturally occurring metalloid which has properties similar to a metal. Due to anthropogenic activities like industrial activities, burning of fossil fuels and chemical fertilizers, it is possible to encounter Arsenic in the air, surface water resources, underground water resources, and soil. Arsenic is a track metal which exists in the environment and has potential toxic effects in natural and anthropogenic resources (Saha et al., 2016).

Arsenate and arsenite which are the inorganic and the most toxic forms of arsenic exist especially in the utilization of underground waters in deep draw wells as drinking water and for agricultural products and in agricultural fertilizers which are used for cultivation at higher levels. If vegetables and fruits grow in these soils, they contain higher ratio of arsenic. More than 140 million people worldwide consume arsenic-contaminated drinking water which exceeds the 10 ppb limit of the World Health Organization (Fu and Xi, 2020). Arsenic is also used as a poultry feed additive to prevent parasites. Organic form of arsenic is available in the contaminated fish as arsenobetaine or arsenocholine in large quantities. In addition, it is thought that these forms are actually non-toxic (Solenkova et al., 2014).

Primary tracts of arsenic absorption are gastrointestinal and respiratory tracts. Nearly 40% to 60% of the inhalation and 95% of the absorbed arsenic are absorbed (Solenkova et al., 2014). Addionality, arsenic-related metabolites are significantly toxic, there is limited evidence concerning the effects of arsenic metabolism on the cardiovascular system risk (Sevim et al., 2020).

In arsenic poisoning; swallowing difficulty, stomach ache, vomiting, diarrhea, muscle cramps, sense of thirst, excessive sweating, muscle weakness, color change on skin, loss of sense on hands and feet, coma and death are observed (Çağlarırmak and Hepçimen, 2010).

It is indicated that there are strong evidences that arsenic exposure is associated with an increased risk in human cancers, including skin, lung, liver, prostate cancer and bladder (Fu and Xi, 2020; Zhu and Costa, 2020).

2.3. Mercury and Its Effects

Mercury (Hg) is ranked third for the most toxic environmental pollutant following arsenic and lead. Common sources of mercury exposure are observed in the cement industry, various measuring and control instruments as a catalyst in plastic production, mining, recycling facilities, medical or municipal burning plants, coal-powered electrical plants or mercury-containing latex dye facilities. Freshwater fish or sea products containing higher levels of mercury, high-fructose corn syrup, rice and other diet products are among other sources. In addition, dental amalgam is a noteworthy cause of mercury exposure (Solenkova et al., 2014; Özbolat and Tuli, 2016).

Mercury is available in the fish the most because it prevents unicellular organisms (algae, bacteria and fungi) and the fish like steelhead trout from growing and leads to excessive amounts of embryo and larva deaths. Mercury is toxic for all species known. Also, it is almost completely (95% to 100%) absorbed when it is swallowed or inhaled and reaches its most toxic form in all organs and tissues, including the brain and placenta (Sall et al., 2020).

As mercury steam has a monoatomic structure, it is liposoluble and nearly 80% of the inhalation and 0.01% of the absorbed mercuric substance are absorbed. For inorganic mercury, the inhalation absorption is equal to 10% against the absorbed mercury. However, 2% to 3% of inorganic mercury is absorbed through the skin (Solenkova et al., 2014; Özbolat and Tuli, 2016).

Organic mercury is omitted from the body through a degradation either from the demethylation to inorganic mercury or to the L-cysteine complex in the gall. Nearly 10% of organic mercury is omitted through urine. Selenium, vitamin E and vitamin C may reduce the toxic effects of mercury via multiple mechanisms (Solenkova et al., 2014).

The studies conducted in recent years demonstrate that mercury toxicity may increase the adverse cardiovascular effect risk of methyl mercury (MeHg) exposure on populations at a greater level than the central nervous system. Another toxic effect of mercury can emerge through the inactivation of protection against lipid oxidation. It has been reported that mercury toxicity is strongly correlated with hypertension, coronary heart disease, myocardial infarction, carotid artery blockage and atherosclerosis (Sevim et al., 2020).

2.4. Cadmium and Its Effects

Cadmium (Cd) is relatively rare in the earth crust. It is released in the environment due to anthropogenic activities (Zhu and Costa, 2020). Cadmium is one of the most toxic environmental substances due to its extensiveness, toxicity and longer half-life. Excessive and unconscious use of chemical fertilizers and pesticides because of industrial activities which have increased recently, causes these pollutants to mix into the soil and water resources. While cadmium is naturally available at low concentrations, it reaches agricultural soils through cadmium-containing phosphatic fertilizers at high concentrations (Kara and Kara, 2018) and may accumulate especially in potatoes, fruits and cereals in these areas.

Cadmium is a commonly used metal in the industrial area and a metallic element which is usually compounded with zinc and lead as sulfide ores. Other important resources of cadmium can be arranged as fossil fuels, detergents, burning of waste products in refined petroleum derivatives, its use as a pigment in batteries, nanoparticles derived from cadmium compounds, solar panels, steel covering in shipbuilding due to its resilience against corrosion, dyeing industry, alloys as a PVC stabilizator, other electronic applications, inappropriate disposal of electronic wastes, and mixing of treatment sludges into the soil (Kahvecioğlu et al., 2003; Çalışkan, 2005; Çolakfakıoğlu, 2016; Nordberg et al., 2018; Kara and Kara, 2018).

It is characterized by a diatom using carbonic anhydrase whose biological function is the Cd enzyme to live in the sea environment. Cadmium concentrations are higher in the shellfish (Solenkova et al., 2014; Nordberg et al., 2018; Zhu and Costa, 2020). In most areas, people's exposure to cadmium is important for health. It is because cadmium accumulates in biological systems and leads to toxicity following the free radical formation. Cadmium exposure occurs as a result of water consumption, inhalation (especially in active smokers), industrial exposure and contaminated food (Fu and Xi, 2020).

Absorption of the inhaled cadmium in the respiratory tract, size of the inhaled cadmium-containing particles and solubility of their types are crucial. In the studies on animals, it was determined that 7% to 40% of the inhaled cadmium particles were absorbed by blood. It was observed that there was a reverse correlation between the size, solubility and value of cadmium particles (Nordberg et al., 2018). Nearly 40% to 50% of the inhaled cadmium and 3% to 7% of the absorbed cadmium are absorbed. After being absorbed, cadmium attaches to the protein through erythrocytes or albumin. Then it enters a liver conjugation with metallothionein which is a cysteine-rich protein. Cadmium-metallothionein cadmium complex accumulates in kidneys afterwards and may lead to renal failure. Also, cadmium is stored in placenta, bones, adrenal, pancreas and testicles (Solenkova et al., 2014). Other negative effects on the skeleton and cancer risks need a particular attention (Nordberg et al., 2018). In some studies it is seen that cadmium toxicity occurs through apoptosis, DNA damage and oxidative stress and Cd poisoning may lead to cardiotoxicity and hypertension (Solenkova et al., 2014; Nordberg et al., 2018; Sevim et al., 2020).

Cadmium is an element which causes serious toxic effects even at nearly 1 µg/g concentration. Its accumulation in the human body may lead to renal dysfunction, pulmonary, hepatic and skeletal damage, reproductive failure and even cancer development (Ahmed et al., 2015; Saha et al., 2016; Zheng et al., 2015; Yap et al., 2016). It is demonstrated that cadmium exposure is correlated with the risk of other human cancers such as prostate, kidney, bladder, liver and gastric cancers (WHO/IPCS, 1992; Zhu and Costa, 2020). Half-life of Cd ranges from 4 to 19 years in the liver and from 6 to 38 years in kidneys (Solenkova et al., 2014).

2.5. Chrome and Its Effects

Stimulating the insulin movement in the body and affecting the carbohydrate, water and protein metabolism; chrome is a metal which is available everywhere in the nature (Seven et al., 2018). A large part of chrome is used in steel production. Chrome has a wide range of application areas such as metal work and foundries, chemical industry, paper industry, alutation and power plants (Dündar et al., 2012). Primary anthropogenic resource of chrome is an atmospheric accumulation originating from electric ovens, steel production and coal-powered plants. Chrome-contaminated wastewater can be discharged via activities such as various industrial processes, electroplating, alutation, metal processing, textile and fur dyeing (Seven et al., 2018).

Chrome (VI) is easily absorbed in the gastrointestinal tract, skin and respiratory tract and leads to organ toxicity due to its better solubility in water, significant oxidizing property and permanence. Higher permanence of chrome (VI) originates from the oxidation of chrome (III) to chrome (VI) by soil germs and MnO_2. Genomic instability and epigenetic changes arising from oxidative stress are accepted to be the primary reasons of health issues related to Cr. There a few human epidemiological studies demonstrating that chromate may induce other cancer types including bladder, gastric cancer, prostate, brain, skin, liver and kidney (Costa et al., 2006).

Genotoxicity and DNA damage that are induced by chrome (VI) are accepted to be the primary mechanism of its carcinogenicity. Also, it is believed that the toxicity of chrome (VI) arises from oxidative DNA damage. It has been demonstrated that chronic exposure to drinking water contaminated with a low dosage of chrome (VI) may induce oxidative stress in rats and this leads to cytotoxicity or common hyperplasia in the target tissue (Zhu and Costa, 2020). It is expressed that half-life of Cr is 40 months in human serum and 129 months in urine. It is stored in kidneys.

2.6. Copper and Its Effects

One of the essential micronutrients which are abundant in various rocks and minerals, copper is necessary for a wide range of metabolic processes both in eukaryotes and prokaryotes. Copper (Cu) is an essential element because it is available in most enzymes and requires a hemoglobin synthesis (Sivaperumal et al., 2007).

Copper is especially used in the electric industry, alloy, chemical catalyst, dye and wood preservative production. Also, it is used in controlling undesired algae, specific diseases and ectoparasites which affect aquatic creatures (Eisler, 2000; Çolakfakıoğlu, 2016). Copper may contaminate an organism through the inhaled air, water drunk, food consumed or skin contact of copper-containing compounds (Özbolat and Tuli, 2016).

Copper which is available in adults at an amount of approximately 50-120 mg, is an essential element for aminoacid, fatty acids, vitamins and reactions in the metabolism under normal conditions. Copper which is available in the structure of metalloenzymes, is an important biocatalyst of the human metabolism (Özbolat and Tuli, 2016).

In addition, extremely high Cu levels may lead to acute toxicity. It is known that human deaths substantially occur as a result of deliberate intake of copper sulphate (Saha et al., 2016). Also, sea products consumption maximizes the Cu intake and may lead to negative health issues such as liver and kidney damage. However, it does not cause a carcinogenic effect on humans and animals (Gorell et al., 1997; Yap et al., 2016).

2.7. Nickel and Its Effects

Nickel (Ni) is a biologically and nutritionally important trace element which is commonly available in organisms (Fu and Wang, 2011; Fu and

Xi, 2020). Basic function of nickel is that it is a necessary element for the bacteria and plants in the biosynthesis of enzymes such as urease, carbon monoxide dehydrogenase and hydrogenase in most plants. In humans, it does not have an important role outside microbiome. There are two main ways to be exposed to nickel. These pathways are water and food contaminated with nickel-containing compounds (Fu and Xi, 2020).

Phosphoric fertilizers (DAP, MAP) and minerals in the structure of volcanic rocks comprise the resource of nickel in the soil (Kara and Kara, 2018). The Nickel solubility increases in acid soils. Nickel emissions naturally arise from forest fires, wind dust and volcanic emissions. Other nickel resources released into the air are coal burning and incineration. Another resource of nickel exposure for humans is tobacco smoke (Fu and Xi, 2020).

Pathogenic bacteria like *Helicobacter pylori* which leads to gastric cancer need Ni ions in order for the urease activity to colonize in the acid environment within the stomach. Nickel exposure leads to many health issues in humans such as Ni allergy, hematogenous contact eczema and systemic allergy syndrome (Zhu and Costa, 2020; Sall et al., 2020). In addition, as nickel is a carcinogenic metal, excessive exposure to it may lead to various health issues in animals such as lung inflammation, fibrosis, emphysema and tumors (Denkhaus and Salnikow, 2002; Yap et al., 2016; Saha et al., 2016; Zhu and Costa, 2020).

Although nickel comprises one of the lightest heavy metals with its metallic structure, its long-term contact with skin and mucous membrane may cause an itching and it may sometimes have an allergic effect. Contact dermatitis arising from the exposure of skin to nickel is usually the most common effect. Swallowing the nickel salts may lead to diarrhea, nausea and vomiting. Chronic inhalation of nickel under a monoxide or metallic form may lead to specific asthma cases and cannular dysfunction. Also, it is known that certain organic nickel compounds like tetra-carbonyl-nickel are highly toxic and carcinogenic (lung cancer).

2.8. Zinc and Its Effects

Zinc (Zn) is a key element in human nourishment (Fu and Xi, 2020). It is available in all organisms and is one of the most important metals for metabolic processes in the human body (Fu and Wang, 2011). It is because zinc is an important component of cells and enzymes attach to it as a cofactor (Mertz, 1981).

Since zinc is resilient to corrosion, its most common area of use is steel coating as a construction material (Vaillant et al., 2005). Also, it is used in casting of compression molding in complex components and as an alloy element in brass due to its lower melting temperature. In addition, zinc oxide (ZnO) which is known as zinc white is used as a dye pigment (Kartal et al., 2004). Other areas of use of zinc are dry cell batteries, ceramics, rubber industry, fertilizers, specific cosmetics and health (Çalışkan, 2005; Çolakfakıoğlu, 2016).

Higher levels of Zn taken through nutrition may lead to serious health issues such as pancreas damage, protein metabolism and arteriosclerosis disorder, poisoning, nausea, vomiting, headache, acute stomach ache, diarrhea, tiredness and fever (Bilandžić et al. 2014). Also, it has an irritating effect for human skin (Saha et al., 2016). Chronic exposure to copper and zinc may lead to Parkinson's disease (Gorell et al., 1997; Yap et al., 2016).

2.9. Selenium and Its Effects

Selenium (Se) is a key element in certain oxidation-reduction processes and is a component of a cellular enzyme which is called as glutathione peroxidase and is responsible for transforming H_2O_2 to H_2O and CO_2 (Sivaperumal et al., 2007).

It is an important element in preventing the mercury toxicity due to a strong attachment affinity between selenium and mercury that preserves the direct involvement of Se and Hg. Additionally, excessive Se intake may lead to a chronic toxicity which results in selenosis characterized by hair and nail loss, fragility, gastrointestinal problems, nervous system anomalies, skin lesions, garlic breath odor and tooth decay (Yang et al., 1983). Clinical symptoms of selenium toxicity also include serious irritations related to the respiratory tract, lung edema, rhinitis and bronchopneumonia (Saha et al., 2016).

CONCLUCSION

Applications which arise from the vital activities of humans and destroy the ecosystem, lead to many environmental problems such as increase of epidemics, decrease of species, extinction of water resources, inability of reaching the fresh air that we need, decrease of the soil productivity, impairment of the soil fauna, losses of biodiversity, decrease of productivity and quality in products, poisoning in living creatures through the food chain, toxic effects as a result of their accumulation and contamination of underground water resources. Due to the increasing industrialization in society and increase in heavy metal exposure worldwide, harmful effects of heavy metal exposure on human health have increased in the past few years.

Heavy metals, which are among environmental pollutants, adsorb and accumulate in the cells of living creatures. Heavy metals are transmitted via ecological cycles and enter the body. Exposure can occur through respiration, nutrition and skin. Heavy metals have highly toxic effects in living creatures. Heavy metal symptoms may be reversible at greater dosages; however, they may also be irreversible and life-threatening. Present studies have been conducted to reveal the mechanisms in which metals induce genotoxicity and carcinogenicity in humans. Most of these studies have not been fully enlightened. They are considered among the causes of most serious diseases, primarily cancer. The removal of heavy metals should be primarily preventing heavy metals from entering the human body. Therefore, no matter why it happens, heavy metal pollutants released in the environment should be prevented from entering the human body, the risks to be caused by their exposure should be reduced and necessary measures should be taken immediately in case of contamination.

In this respect, industrial wastes should be prevented from being released into the soil and water resources without purification. In order to detect the heavy metal pollution in these natural resources and monitor them, heavy metal analyses should be performed regularly. Also, the wastes coming from mines should be stored under appropriate storage conditions and be operated in such a way that they will not harm the nature. Motor vehicles are one of the greatest causes of heavy metal pollution in urban areas. These vehicles should be maintained regularly and their exhaust gas should be monitored. Leaded fuel use in vehicles should be abandoned and fuels with a lower emission value should be encouraged to use. Studies should be conducted to spread the use of renewable energy resources in smaller industrial enterprises and houses. Also, it is necessary to construct advanced-technology landfill areas instead of wild storage methods and control urban solid wastes in urban areas. In agriculture, the use of chemical fertilizers and pesticides should be reduced, awareness should be raised in farmers in this respect and experts should be encouraged to conduct these applications.

As is seen, one of the greatest causes of environmental pollutions is human activities. Therefore, it is crucial to raise awareness in society to know the negative effects caused by heavy metals, symptoms and ways of removing a part of the contamination we already have in order to reduce the pollution. In addition, it is necessary to determine legal obligations and regulations, implement deterrent punishments and impose and apply legally serious sanctions via regular inspections. A better awareness of pollution sources in society will not only help people protect from this pollution, but also will be effective in reducing the pollution.

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CHAPTER 7

EFFECTS OF DIFFERENT CO-CULTURE ON BOVINE *IN VITRO* EMBRYO PRODUCTION: AN OVERVIEW

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INTRODUCTION

In vitro embryo production (IVEP) is a major biotechnological method that has been widely utilized to spread genetic enhancement and shorten progeny testing and generation cycles by producing large numbers of embryos from animals with high genetic merit. Applications of in vitro fertilization in commercial livestock production include attempts to improve livestock productivity and genetic output, figure out infertility of genetically outstanding livestock individuals, produce sexed embryos, cloned animals, transgenic animals and twin beef cattle. In addition, at the molecular level this process is aimed to better understand the natural process of oocyte maturation, fertilization and developmental process of embryos. Because the in vitro environment does not exactly imitate the natural physiological conditions, embryos result with malformed morphology and gene expression and appear as an inefficient process with 30-40% blastocyst rate (Abd El-Aziz et al., 2016).

In the 1950s, research into the development of mammalian preimplantation in vitro became a possibility and since then, numerous attempts have been made to enhance the development of in vitro embryos, thereby improving implantation and in turn, pregnancy rates. For in vitro embryo development, culture systems advancement is crucial, and for obtaining high quality and quantity of embryos several methods have been devised. Currently the most widely used medium has a chemical composition that includes salts, proteins, calcium lactate, pyruvate, amino acids, and glucose as an energy source (Ascari et al., 2018). Embryos develop in the oviduct and uterus in a dynamic environment, but neither single nor sequential in vitro culture conditions do not have this natural milieu (Hasler, 2014).

Along with greater quality, introduction of distinctive transcriptomic switches, mimicking oviduct-embryo interaction and finally obtaining high quality embryo, somatic cell co-culturing has been greatly applied (Schmaltz-Panneau et al., 2015; Ascari et al., 2018). Using somatic cells as a feeder layer extracts toxin and adds certain growth factors in culture systems such as platelet activating factor, epidermal growth factor, transforming growth factor (TGF)-alpha and TGF-β, insulin-like growth factors-I (IGF) and IGF-II, and vascular endothelial growth factor (Desai, 2000). Co-culture with somatic cells after fertilization has many well documented embryotrophic influences where positive effects are manifested by improved cleavage, blastomeres, post-thaw blastomere survival, blastocyst, hatching and implantation rates and morphological grades of embryos and reduced apoptosis and fragmentation rates (Bongso et al., 1989; Wiemer et al., 1989; Ellington et al., 1990; Smith et al., 1992; Tucker et al., 1995; Marcus and Brinsden, 1996; Wetzels et al., 1998; Xu et al., 2000; Joo et al., 2001). It has also been suggested that co-culture could rescue low quality embryos (Dirnfeld et al., 1997). Despite the fact that most of the research findings support the positive effects of co-culturing, some also indicate negative effects (Ascari et al., 2018).

IVEP involves three main consecutive steps such as oocyte in vitro maturation, in vitro fertilization and in vitro culture of the resulting embryos (Mermillod et al., 2006) and achieving benefit from positive embryotrophic effects, co-culturing is widely used in maturation and culturing processes. Camous et al. (1984) was the first to demonstrate bovine co-culturing, in which live animal embryos were grown in medium containing serum in the presence or absence of trophoblastic vesicles, and it was observed that the co-culture group was better able to overcome the developmental block. From then multiple cell types have been used as a source of somatic cells to increase the embryo production.

We will analyze the effectiveness of several cell types used in co-culturing, with a focus on recent twenty years studies.

Stem cells

Some of the advantages of stem cells, such as their capability of releasing plethora of molecules such as growth factors, cytokines and microRNAs able to influence microenvironments led to the decision to begin co-culturing with stem cells (Katsuda et al., 2013). Stem cell-conditioned medium can promote tissue repair and evidence from wound repair studies suggests that the exempt of soluble substances that regulate native cellular feedbacks to dermal damage may be liable for the majority of the therapeutic effects of mesenchymal stem cells that have been transplanted (Hocking and Gibran, 2010).

Human umbilical cord mesenchymal cells co-culturing with embryos could rescue cellular damage of mouse embryos in the same manner as antioxidants (Moshkdanian et al., 2011). The addition of a 10% human adipose tissue-derived mesenchymal stem cells derived bioactive materials treatment beginning at 4 days increased in vitro fertilized pig embryo development and total cell number (Park et al., 2013). Mesenchymal stem cells (MSCs) can develop into numerous cell lines and secrete various growth and immunomodulatory substances (Uccelli et al., 2008; Caplan, 2009). From the best of our knowledge first stem cell co-culturing in bovine was accomplished by Lange-Consiglio et al. (2012) where they found that co-culture with horse amniotic epithelial stem cells resulted in a considerably greater percentage of bovine blastocysts when compared to control and horse bone marrow mesenchymal stem cell feeders in an attempt to standardize a horse embryo culture procedure.

Higher mouse oocyte maturation rates conditioned at 48 h bone marrow derived MSCs and 10% human embryonic stem cell derived bioactive material in cattle showed efficiency in keeping quantity and quality of embryos (Ling et al., 2008; Kim et al., 2011). Miranda et al. (2016) used adult adipose tissue-derived mesenchymal stem cells (b-ATMSC) co-culturing in in vitro produced cattle embryos with two concentrations (b-ATMSCs; 10^3 and 10^4 cells/mL) and b-ATMSC preconditioned medium, and finally compared co-culture with 10^4 b-ATMSCs/ with traditional granulosa cell co-culture system. Their results showed beneficial effects of stem cell co-culture by higher cleavage and blastocyst rate compared to granulosa cells. The relative expression of the pluripotency gene POU class 5 homeobox 1 and glucose metabolism gene glucose-6-phosphate dehydrogenase were increased with unaltered expression of the heat stress marker heat shock protein 70. Altogether, these results support an increase in embryo quality resulting from co-culture with stem cells.

Murine embryonic fibroblasts (MEF) are commonly utilized as feeder layers in the cultivation of embryonic stem cells because they promote proliferation and allow these cells to remain undifferentiated in co-culture (Villa-Diaz et al., 2009). Co-culture with MEF or murine mesenchymal stem cells (MSC) improves early embryonic development and quality of mouse embryos was reported by Jasmin et al. (2016). Ascari et al. (2018) conducted (research group consisting of aforementioned researchers) research in cattle based on this earlier success in mice, hypothesizing that MSC and MEF can act as a feeder layer to improve the efficiency and quality of bovine oocytes and preimplantation embryos. Co-culturing with MSC or MEF was done in IVM firstly and after fertilization, co-culturing was again applied after four days of embryo culture. Accessing on day 7 and 8 cleavage, blastocyst and hatching rates did not show any positive results in contrast treatment with MSC in both maturation and cultivation steps affected embryo hatching negatively, suggesting that anticipating embryo data to various species should be done with caution.

Bovine oviduct epithelial cells (BOECs) improve freezability of bovine embryos (Shirazi et al., 2009) but BOECs culture is slow growing, increasing the risk of microbial contamination and variable results and thus stem cells may be superior due to functional durability in successive subcultures (Lange-Consiglio et al., 2012; Miranda et al., 2016). Nejat-Dehkordi et al. (2020) evaluated the effect of bovine amniotic membrane stem cells (bAMSCs) co-culturing on in vitro development and cryo-survival of embryos. In vitro matured and fertilized presumptive zygotes allowed bAMSCs, BOECs co-culturing up to blastocyst stage and compared with cell-free control systems. Blastocyst and cleavage rate did not differ in co-cultured groups but significantly improved blastocyst morphology after vitrification. And improved hatched blastocyst in prolonged culturing after vitrification indicated that bAMSCs could boost the cryo-survivability of embryos and are preferable to BOECs because of subculturing easiness. In the above discussion positive effects were observed where co-culturing was done in only embryo culture and in one case negative results were observed while co-culturing was in both in vitro maturation and embryo culture. It is difficult to reach a conclusion with this few research but at least we can conclude that stem cells co-culturing show promise.

Oviductal cells

Based on the current literature it appears as oviductal cells remain ahead of the co-culturing race. Oviduct is one of the important reproductive parts in the cow reproduction system and final oocyte maturation and early embryo development takes place here (Avilés et al., 2015). Reactive oxygen species (ROS) are known to be a primary cause of in vitro embryonic arrest (Johnson and Nasresfahani, 1994), and BOECs has the ability to assist embryo development by producing antioxidant enzymes like glutathione peroxidase, superoxide dismutase, and catalases, which fight ROS (Harvey et al., 1995). Along with the ability of modifying the culture's metabolites to meet the needs of the embryo (Edwards et al., 1997), BOECs are thought to produce growth and embryotrophic substances into the medium (Tse et al., 2008). Many researchers have tried co-culturing of oviductal epithelial cells to enhance the efficiency of IVEP so far (Kattal et al., 2008; Mugnier et al., 2009). Özdaş et al. (2012) reported that the addition of oviductal cell co-culture in the in vitro culture increases the rate of transferable embryos. The effect of BOECs on the rate and quality of bovine in vitro produced embryo development was confirmed by Cordova et al. (2014), and it was revealed that the presence of BOECs during the first four days of the eight-day development is sufficient to produce these effects. Results also showed that the presence of BOECs at early stages of development induced modification of transcription profile in the blastocyst, four days later, suggesting an epigenetic regulation initiated by BOECs in developing embryos. The first four days correspond to the embryos' presence in the oviduct in vivo, emphasizing the physiological importance of this in vitro co-culture paradigm. Fertilized embryos were co-cultured with cumulus and oviduct cells, and 192h of culturing resulted in significant blastocyst development in somatic cell co-culturing (Soto-Martínez et al., 2019). Recently for methodological complexity, bio sanitary risk, lack of reproducibility of primary oviductal cells, frozen oviductal cells are used as an alternative (Lopera-Vásquez et al., 2016). When the final 6 hours maturation is carried out in the presence of a frozen–thawed ampullary monolayer, one research group found improved blastocyst yield and quality (Asaadi et al., 2019).

This improvement suggests that oocyte maturation with bovine oviductal epithelial cells (BOECs) co-culture provides the required conditions for oocyte maturation and embryo growth. Schmaltz-Panneau et al. (2014) reported that in the presence of developing embryos, oviductal cells would change their transcription. BOECs responsiveness by early embryos during their development is supported by differential gene expression. Hamdi et al. (2019) also confirmed that the early embryo affects the gene expression of BOECs. Especially frozen-thawed ampullary cells co-culturing for in vitro maturation of bovine oocytes yields significantly higher oocytes maturation and fertilization rates. Growth differentiation factor 9 (GDF9) gene expression was increased in co-cultured groups, which is linked to cumulus cell expansion, future cumulus oocyte complex formation, and preventing cumulus cell apoptosis. The increased expression of steroidogenic acute regulatory mRNA suggests that co-culturing with ampullary cells may influence oocyte maturation and development through steroidogenesis assistance (Azari et al., 2021).

Theca cells (TCs)

Theca cells need for oocyte development, support follicular structure and supply androgen (Hillier et al., 1994). TC-secreted growth factors bone morphogenic proteins (BMP) control follicular production (Young and McNeilly, 2010). In in vitro maturation cultures, adding BMP-4 to the culture medium suppressed granulosa cell luteinization while maintaining oocyte survival (Yang et al., 2016). Yang et al. (2020) conducted co-culturing with TCs at the maturation level as a source of androstenedione and compared this with and without steroid supplemented medium. Findings revealed that oocytes survived equally well in TCs co-culture and androstenedione supplemented culture. Also, co-cultured maturation showed improved oocyte diameter, normal oocytes formation, maturation and development. Oocyte's viability and subsequent developmental competence were comparable to oocytes derived from traditional in vitro maturation with sex hormone supplementation. Results figure out that the primary advantage of introducing TCs into the maturation medium is the provision of an androgen source.

Luteal cells

During early pregnancy, progesterone released by luteal cells has an embryotrophic effect (Lonergan and Forde, 2015). To investigate the development of progesterone, bovine luteal cells (BLCs) were co-cultured with in vivo produced bovine blastocyst or trophoblastic vesicles (Thibodeaux et al., 1994). A long-term embryo-luteal cell co-culture was published to test steroidogenic and prostanoid interactions (Torres et al., 2013). Recently a study by Maruri et al. (2018) looked at the impact of a short-term co-culture method of early bovine embryos and BLCs on embryo production and in vitro growth. As a result, the blastocyst rate, cell proliferation rate, day 2 embryo ROS level, and apoptosis rate, all improved when bovine luteal cells were co-cultured. Short-term embryo co-culture with bovine luteal cells could be an alternative to improve IVEP, given the potential negative long-term effects of co-culture.

Vero cells

Vero cells, which come from the kidney of an African green monkey (*Cercopithecus aethiops*), share an embryonic origin (mesoderm) with cells from the genital tract (Duszewska et al., 2000). Furthermore, vero cells are common, readily available cells that have a positive influence on in vitro embryo culture, making them commonly used to promote embryo viability and development (Pegoraro et al., 1998; Duszewska et al., 2000). By considering the positive effects in embryo culture, vero cells were also used in in vitro maturation of bovine oocytes, which resulted in improved cleaved zygotes, total cell quantity, and inner cell mass and trophectoderm ratio, indicating superior quality of generated embryos (Moulavi et al., 2006).

CONCLUSION

Formerly commencing a new co-culture system to optimize IVEP more research is required to use luteal cells, theca cells or stem cells co-culturing as these cells showed notable improvement. To better evaluate the use of co-culture and determine the methods of application, large, prospective studies are needed as existing literatures are not homogenous. We suggested that to support more in vivo-like embryonic growth, establishing a sequential culture system of more than one type of cell co-culturing could improve the efficiency not only quantitatively, but also qualitatively.

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CHAPTER 8

TRENDS IN LAST DECADE ON OILSEED CROPS

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INTRODUCTION

Some plants are biofactories of oils. These oil producing plants may also be a source of high amounts of protein, animal feeds, industrial fatty acids, biofules, chemicals and medicinal bioactive compounds. Soybean, canola, sunflower and sesame are frequent subjects in studies conducted on oilseeds in last decade but efforts to find on efficient alternative crops also enlarge the candidate list with species like castor oil, moringa, *Medicago truncatula*, *Fagus sylvatica* and *Fraxinus excelsior* etc. Last part of this review is including novel and emerging techniques in oil extraction process which is important to increase quality and quantity of vegetal oil production.

The seeds of some plants are valuable biofactories capable of transforming photosynthetically produced sugars into storage compounds like oils which are the most energy-dense plant derived nutritional source. Oils are the source of much of the calories and essential fatty acids in human diet. Vegetal oils are also increasingly getting utilized as biofuels. This properties turn oils into a highly valuable agricultural commodity and the demand for oils is rapidly increasing. This situation is forcing scientists to develop breeding and metabolic engineering programs for the improvement of oilseed crop (Baud, 2018). As vegetable oils are important feedstocks for biofuels, industry needs novel and underexploited oilseed crops to feed the world oil demand (Omilakin et al., 2020). Plant oils can also be useful chemical feedstocks as a source of epoxy fatty acids (Li et al., 2012).

Oleosin is the main protein in the oil bodies of seeds of plants which has a role in regulating oil body formation and lipid accumulation (Liu & Liu, 2013). Oil bodies can be found in cells in oilseeds as small organelles and they show a potential technology platform for food industry as stable antioxidant-enriched lipid-delivery systems (Fisk et al., 2011). Oil bodies are emulsions, can be extracted from seeds and stable after spray drying (Fisk et al., 2013).

Oil Seeds Species

Seeds of some legumes such as soybean (*Glycine max* L.) and *Medicago truncatula* store high amounts of oil together with protein in cotyledons. Legumes also fix atmospheric nitrogen and increase the sustainability of agricultural production worldwide. Also storage strategies of legume are variable and has opportunities to detailed understanding of carbon partitioning into diversified storage products (Song et al., 2017). Oil of soybean include 20% oleic acid and 63% polyunsaturated fatty acids, which has poor oxidative stability. This is limiting its usage in food and industrial applications. Increasing oleic content of soybean oils will improve oxidative stability and its benefits to human health (Yang et al., 2018).

Fig.1. Legume *Medicago truncatula (*May & Dixon, 2004)

Canola (*Brassica napus* L.) seeds are important sources of vegetable oils worldwide (Gaber et al., 2018). During last few decades, researches focused on canola seed oil content and composition (Elahi et al., 2016). Canola breeding history began after the discovery of low erucic acid containing germplasms in seeds of a spring type forage cultivar in 1950's (Cao et al., 2010). Conditioning rapeseed (canola) may increase the bioactive compounds content of its oil but keeping conditioning temperatures too high can result with unwanted side effects like sensory defects and darker color. Moderate temperatures produce high quality rapeseed oil with radical scavenging activity (Kraljic et al., 2013).

Castor oil (*Ricinus communis* L.) seed is an agricultural product which has high amounts of proteins and lipids which be useful in industry of food and energy (Perea-Flores et al., 2012). Castor oil plant is known globally for its quality seed oil but have issues related to pathogens which may affect its seed quality (de Araujo et al., 2019). Castor oil plant seed is rich in protein and oil and has a good potential as a source for animal feed and biodiesel production (Perea-Flores et al., 2011).

Fig. 2. Castor oil plant (*Ricinus communis* L.). Upper left: Shoot of the plant; Upper right: Flowers; Lower left: Fruit (capsules); Lower right: Seeds (Khan Marwat et al., 2017)

Sesame (*Sesamum indicum* L.) as oilseed has high nutritional quality and economic value (Sarkis et al., 2015). Seeds and oil of sesame contain sesamin and sesamolin lignans and lignan glycosides (Rangkadilok et al., 2010). Popularity of consumption of camelina

(*Camelina sativa* L.) oil is increasing everyday but contains erucic acid as an unwanted fatty acid in its oil. Different genotypes contains different amounts of eriuc acid (Kurasiak-Popowska et al., 2020). Speedy and non-destructive methods to determine seed composition of camelina may be effective to evaluate germplasms for important traits (Anderson et al., 2019).

As opposed to other oilseeds, developing sunflower (*Helianthus annuus* L.) seeds do not accumulate starch initially. They rely on the sucrose that comes from the mother plant to synthesise lipid precursors. Glycolysis is the principal source of carbon skeletons and reducing power for lipid biosynthesis (Troncoso-Ponce et al., 2010).

Moringa (Moringa oleifera) is cultivated worldwide as an edible and medicinal plant whose seeds contains high levels of oil and proteins (Chen et al., 2019).

Figure 3. *Moringa oleifera* leaves (left) and pods (right)

Seeds of common beech (Fagus sylvatica L.) plant may be an unconventional oilseeds crops due to relatively high content of fat (27%) whose oil is classified as oleic-linoleic (more than 76%) (Siger et al., 2017).

Common ash (*Fraxinus excelsior* L.) seed oil is at level of 18% with mainly containing fatty acid of linoleic acid followed by oleic acid and palmitic acid. The main phytosterol and tocopherol of the oil was β-sitosterol and α-tocopherol, respectively (Naderi et al., 2020).

Oil Extraction

Oil extraction from seeds is conventionally conducted by mechanical extraction machines (Kumar et al., 2018). The extract oil bodies are used for diverse applications, but different pH values of extraction result with oil bodies with different properties (Zhao et al., 2016). Canola oil get industrially extracted from seeds by expeller-pressing of heat-preconditioned flaked seeds. Solvent extraction by hexane is a common method to recover residual oil remained in press cake but hexane extraction has adverse impacts on safety and environment compared to alternatives (Gaber et al., 2018). Microwave pre-treatment for canola seeds is a good alternative to the conventional thermal steam pre-treatment (Gaber et al., 2021). Ultrasound is a novel and emerging technique in oil extraction process (Senrayan & Venkatachalam, 2020).

The long extraction times in oil processing industry is responsible for large losses of organic solvent to the atmosphere (Castejon et al., 2018). Synthetic flocculants and coagulants used industrially in oil mill effluent treatment poses environmental and health risks. There is a high demand for natural flocculants and coagulants (Kim et al., 2020).

CONCLUSIONS

Diversification of cultivated oilseed crop types is an efficient method to get more benefits from these valuable plant species due to wide spectrum of metabolic byproducts. Especially nitrogen fixing and drought tolerant species will be more prefered in the age of global warming. Efficient trait scannig programmes for breeders and detailed oil extraction method updates for industry will help to compensate the oil production gaps of nations.

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