AGRICULTURE:

CURRENT CHALLENGES AND SOLUTION SUGGESTS

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PREFACE

Agriculture is critical to the process of socio-economic development, and the importance of agriculture in human development cannot be overstated. Agriculture has numerous problems in order to maximize production while remaining environmentally friendly.

Increasingly difficult global and environmental constraints have put pressure on agricultural systems to improve their resilience capacities. This is particularly important in response to abrupt changes in resource quality, quantity, and availability, particularly during unforeseen environmental circumstances such as inclement weather, pests, and diseases.

The goal of this research was to comprehensively examine future food stability, availability, access, and use, as well as the issues in food and agriculture value chains, in order to show the interwoven nature of their causes and potential remedies.

As a result, this book is intended to contribute to future relevant international consortia in order to cover the highlighted research gaps. A brief literature analysis is undertaken to summarize the primary results on real-world application and current research trends, as well as a critical appraisal of the concept in terms of challenges and opportunities for overall sustainability. As a result, if reversed, would create the highest positive effect on the relevant critical challenges and prioritized the solutions to address these challenges.

CHAPTER 1

PROPERTIES OF BIOCHAR AND ITS USE IN AGRICULTURAL PRODUCTION

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1. INTRODUCTION

Agricultural production plays a critical role in human and animal nutrition around the world (Hussen, 2020). The amount of product taken from the unit cultivation area is significant to meet nutrition and food demands (Soysal and Yılmaz, 2021). However, as a result of various environmental factors and wrong practices, the quality of agricultural soils gradually decreases, organic matter and carbon content decreases, soil fertility is lost and some of the agricultural lands become unusable (Ucar et al., 2021). This situation may cause the problem of not being able to meet the food demand of the production. It is estimated that the world population will reach 9 billion by 2050. Depending on the population growth, food production must increase by 60-100% to meet the food need (Hussen, 2020). Climate changes and the increasing world population necessitate a more professional approach to agriculture (Yılmaz and Soysal 2021). Sustainable agricultural production should be prioritized to meet the increase in agricultural food demand (Tüfenkçi et al., 2022). Biochar is an alternative organic additive for sustainable agriculture, which can partially replace chemical fertilizers that impair soil fertility (Mona et al., 2021; Sönmez and Çığ, 2019).

Biochar is a product containing high organic carbon, obtained by heating environmental, animal, and vegetable wastes in an oxygen-free or very low oxygen environment (via pyrolysis), and applied to the soil to reduce the consumption of chemical fertilizers in plant production, increase product yield, capture and store atmospheric carbon (Namlı et al., 2017). Biochar is well known as a soil regulator (Singh et al., 2022). It can improve the physical, chemical, and biological properties of the soil with its ability to stay in the soil for a long time without deterioration, due to its large surface area, and the nutrients it contains. It is also used as an additive aimed at increasing the efficiency of crop production (Madari et al., 2017; Zhang et al., 2017). The application of biomass in the soil also provides numerous advantages such as climate change mitigation and waste material management (Peiris et al., 2019).

2. PROPERTIES OF BIOCHAR

The properties of biochar depend on the chemical structure of the biomass which contains and the content of organic and inorganic components. Primarily, biochar is a major organic carbon and organic matter source that increases soil productivity and quality, and promotes microbial population and activity, therefore, it induces plant growth, yield and quality (Lehmann and Kleber, 2015; Şahin and Ceritoglu, 2020; Angst et al., 2021). The main raw materials of biomass are nitrogen, oxygen, sulfur, and hydrogen. In addition, it contains such mineral elements as aluminum, silica, calcium, potassium, phosphorus, magnesium, and sodium (El-Naggar et al., 2018a). The properties of biochar vary depending on the type of raw material, the duration of pyrolysis, and temperature. Materials such as straw, corn, pulp, rice husk, wood chips, animal manure, and even wastewater sludge can be used as raw materials for biochar production (Cha et al., 2016). Different types of raw materials create biochar with different characteristics (Weber, et al., 2018). For example, it has been found that herbaceous biochars increase crop yield more than woody biochars due to their high nutrient content (Latini et al. 2019). In addition, wood-based biochar has a greater effect on soil porosity compared to biochar from fertilizers with a higher ash content (Leng et al. 2020). In addition, it has been determined that biochars obtained from raw materials with less C/N ratio such as animal manure increase the P ratio in the soil more (Gao et al., 2019).

Soil type and texture are very important for biochar effects. An example of this is the fact that sandy soils are more sensitive to the effects of biochar than clay soils (Blanco-Canqui, 2017; Kavitha et al., 2018). In a different study, it was determined that biochar increased the crop yield from 9% to 101% in soils with loamy texture (Ajayi and Rainer, 2017). Biochar applied to clay soils showed an increase of 68% in beans and 143% in maize (Zhang et al., 2016). In addition, the effects of biochar application on crop productivity are greater in coarse-textured soils. (Latini et al. 2019). The effect of biochar application on crop yield is higher in tropical regions than in temperate regions (Liu et al., 2019). In a study, biochar application had almost no effect on yield increase in temperate climates. However, in tropical climates, the yield increased by an average of 25%. The reason for the increase in yields in the tropics was explained by the low pH of the soils (pH = 5.7) and the fact that the biomass with a high pH (pH=9.0) is good for the soil (Jeffery et al., 2017).

Pyrolysis temperature and time are other factors that increase biochar efficiency. The important thing in biochar production is to obtain a high-carbon solid product. Biochar pyrolysis time and temperature generally range from 60 to 240 minutes and 300 to 700 ℃, respectively. However, these parameters are determined by the desired properties of the biochar material (Weber et al., 2018). Increasing the pyrolysis time increases the biochar C content and surface area (Mahdi et al., 2017). The most effective pyrolysis temperature in increasing crop productivity is biochar about 400–500 ℃. However, biochar produced at temperatures greater than 600 ℃ has been shown to reduce crop productivity. Biochar produced at high temperatures tightly holds dissolved minerals and water, causing the plant to find fewer minerals and water for growth (Li et al. 2019). With the increase in pyrolysis temperature, higher energy content, porosity, and C content, biochar bulk density with lower O_2 is obtained (Weber et al., 2018). Bordoloi et al. (2016) observed that the biochar yield decreased from 36.0% to 22.4% when the pyrolysis temperature increased from 300°C to 600°C. When the effect of biochar at 300 °C, 500 °C, and 700 °C pyrolysis temperatures was investigated, the highest CH_4 production was obtained from the biochar produced at 300 C and the lowest CH_4 production at 700 °C (Cai et al., 2018). As a result of increasing the biochar pyrolysis temperature from 300 °C to 600 °C, a decrease in the amount of biochar was observed. In the same study, an increase was observed in phosphorus, potassium contents and pH values with the increase in temperature, and a decrease in nitrogen content (Akkurt, 2019). Madari et al. (2017) reported that while the pyrolysis temperature increased from 300 °C to 800 °C, the biochar mass decreased from 67% to 26%, while the carbon ratio increased from 56% to 93%. Different production times, as well as pyrolysis temperature, affect the chemical and physical properties of biochar. Biochar obtained at 500 °C has higher electrical conductivity (EC), total porosity, pH, and cation exchange capacity (CEC) than biochar produced at 300 °C (Méndez et al., 2017).

Biochar increases soil porosity due to its dense porous structure. The porosity of biochar can be affected by different factors such as the pyrolysis temperature and length of time, and the type of raw material (Tomczyk et al., 2020; Leng et al., 2020). Therefore, the negative or positive effect of biochar largely depends on the physio-chemical content (Tian, 2018).

3. USE OF BIOCHAR IN AGRICULTURAL PRODUCTION AND ITS EFFECTS

There are many studies that the use of biochar produced using various methods and raw materials has a positive effect on agricultural production. Among the positive effects of biochar on soil, it can be counted that it increases the carbon holding capacity, water holding capacity and pH value of the soil, prevents the washing of nutrients and increases the biological functions of the soil (Albayrak, 2019; Ucar, 2021). In addition, it provides many benefits with its features such as increasing crop productivity and reducing greenhouse gas emissions (Adams et al., 2020; Ayaz et al., 2021).

3.1. Effects on Soil Properties

Biochar application can improve soil properties in various ways (Kavitha et al., 2018). The main effects of biochar on soil are as follows; i) improves soil structure, ii) increases plant nutrient availability and soil pH, iii) reduces leaching of nutrients, and iv) acts as a liming agent. In addition, it reduces the damage of iron and aluminum to microorganisms living in the soil and plant roots. Biochar application also helps soil airflow (Yu et al., 2019). It reduces greenhouse gas (N_2O and CH_4)

emissions by providing water and air management of the soil (Das, et al., 2020; Batista et al. 2018).

Biochar application improves the physical structure of the soil. It has been proven as a result of studies that it increases the water holding capacity and pore area (Neris et al., 2019). It has been stated that a 3 t da-1 biochar dose is sufficient to improve the chemical, physical and biological properties of the soil (Özenç et al., 2019). It has also been observed that biochar can reduce nutrient losses and helps the accumulation of K^+ and NO_3 ions (Li et al., 2017; Shi et al., 2020). According to Gezahegn et al. (2019), biomass can be used as a liming agent in acidic soils with K, Mg, and Ca content. It has also been noted that biochar prevents P from leaching from sandy soil and acts as a P-scavenger (Glaser et al., 2019; Dharmakeerthi et al., 2019). Zhang et al. (2019) reported that soil enzyme activity increased by 11% due to the contribution of biochar to the P cycle. It was found that the P availability increased 5.1 times as a result of the application of biochar to acidic (pH<6.5) soils, and 2.4 times when it was applied to neutral soils (pH 6.5–7.5). In the same study, it was stated that biochar application did not have a significant effect on alkaline soils (pH> 7.5) (Glaser and Lehr, 2019).

Biochar applications can increase the water holding capacity of the soil (Razzaghi et al. 2020). It has been proven as a result of studies that the water holding capacity of the soil of biochar increases by 11% (Chaudhary et al., 2017). Due to its porosity, soil moisture and water-soluble nutrients are kept higher (El-Naggar et al., 2019). Zhan et al. (2017), stated that biochar increases biomass in soils with low pH values.

It has been reported that it affects phosphatase activity and microbial abundance depending on the change in pH. It also increased the soil water holding capacity, EC and pH value (Günal and Erdem, 2018). It has been reported that the reason for the increase in soil EC is due to the excess ash content of biochar (Sadeghi et al., 2016).

Microorganisms in the soil have various benefits such as nitrogen fixation and nutrient cycling (Ucar and Erman, 2020; Soysal and Erman, 2020). With its properties, biochar helps the activity and growth of microorganisms. Due to its high porosity, biochar creates a habitat for microorganisms and stores water and creates a food source. All this is evidence that biochar improves soil microbial activity (Glaser and Lehr, 2019). It is thought that biomass increases microbial diversity and activity by changing the use of carbon sources (Jaiswal et al., 2017). Biochar also can be used as a carrier material for microbial inoculants. In a study, it was stated that biochar can provide nutrients and drying for the proliferation and survival of microorganisms. In addition, biochar can be used as a carrier and bacterial inoculants. Rhizobial inoculants containing biochar can improve the symbiotic activity of legumes. Thus, the need for N fertilizer is reduced and agricultural sustainability is supported (Egamberdieva et al., 2018; Soysal et al., 2020). Additionally, the use of biochar in combination with the compost pile improves environmental conditions such as humidity, ventilation, and nutrient availability for microbial growth, providing suitable habitat for microorganisms. Rafique et al. (2017) found that biofuel applied together with phosphate-dissolving bacteria increased phosphorus uptake by 61.5% and nitrogen uptake by 23.1% in their studies. Liu et al. (2018), reported that biochar increased the biological nitrogen fixation of legumes grown in acidic soils by an average of 63%. 10 t ha-1 biochar applied to the soil increased the nodule structure by 89% compared to other applications (Azeem et al., 2019).

Biochar triggered microbial interactions and reduced plant pathogenicity. It reduces pathogens in the soil by releasing volatile compounds (Zhu et al., 2017 In addition, biochar can be used in improving saline soils and the most appropriate dose is 20 tons/ha. (Uysal, 2019). Mandal et al. (2017) reported that biochars reduce Cr toxicity in soil and biochar can be used in the remediation of Cr-contaminated soils.

3.2. Effects of Biochar Application on Crop Production and Yield

It provides many benefits such as increasing the high pore volume of biochar and storing the existing water. As the amount of water supplied to the plant increases, root growth improves and thus crop yields increase (Lu and Zong 2018). With the application of biochar, rice yield increased by about 16%, wheat by 17%, corn by 19% and soybean by 22% (Jefery et al., 2017). Likewise, it has been observed to increase yield in corn, soybean, and peanut plants (Liu et al., 2017). Gonzaga et al. (2018) reported that biomass at the rate of 30 t ha^{-1} provided a 90% increase in maize biomass compared to control. Biochar was found to stimulate tomato yield, seed germination, and plant growth (Tripti et al., 2017). With its black color, biochar absorbs sunlight and raises the soil temperature by 0.5 °C in 5 t ha^{-1} (Grunwald et al. 2017). Increasing soil temperature accelerates seed germination (Mumme et al. 2018).

Tablo 1. Effect of biochar treatments on growth, yield and quality of different field crops.

1	Soybean	Wheat straw	20(t /ha^{-1})	7 Increased yield (%)	Liu et al. (2017)
2	Rice	Wheat straw	30 g/kg	34.20 Increased yield (%)	Hu ve ark., (2019)
3	Rice	Rice straw	30 g/kg soil	22.20 Increased yield (%)	Hu ve ark., (2019)
4	Rice	Corn straw	30 g/kg soil	55.20 Increased yield (%)	Hu ve ark., (2019)
5	*Wheat*	Peanut shell		8.46 Increased yield (%)	Du ve ark, (2018)
6	*Triticum aestivum* and *Raphanus sativus*	Papermill biochar	10 t ha^{-1}	Biomass, 250% increased	El-Naggar ve ark., (2018b)
7	Soybean	Corn cob	0-20 t ha^{-1}	It increased seed vigor, shoot length, germination percentage, membrane stability index, and carotenoid and chlorophyll contents.	Hafeez ve ark., (2017)
8	Cotton	Cotton stalk	5 t ha-1	Seed cotton yield, amount of proline accumulated in the leaf, leaf water content (RLWC), and chlorophyll stability index (CSI) increased.	(Kannan et al. 2017)
9	Maize	virgin pine wood	30 t ha^{-1}	Biomass of soil biota groups.	(Pressler et al. 2017)
10	Rice	Wheat straw	30 t·ha^{-1} soil	Increase in total N, pH and plant growth, and total C.	Muhammad et al. (2017)

It was observed that biochar at 20 t ha^{-1} significantly increased seed viability and seed germination percentage (Hafeez et al., 2017). In addition, Palansooriya et al., (2019) reported that biochar increases the growth and yield of highland plants by changing the chemical properties of the soil.

Horel et al. (2019) found that biochar and chemical fertilizers improved yield and growth and increased the K content of different plant parts. Biochar increases the content of K, Al and Na in the shoot and root (Jia et al. 2019). Biochar applied to the soil increased the sucrose content and biomass yield of sugarcane plants. In addition, biochar can increase the production of flavonoids, glucosinolates, and some carbohydrates. At the end of the study, the sugar content, flavonoid and glucosinolate production were increased before the yield of biomass could be negatively cultivated (Song et al., 2020).

Different types of biochar can suppress diseases with different applications (Das et al., 2015). Biochar application reduced *Rhizoctonia solani* disease in cucumber plants. (Roy et al., 2018; Das et al., 2018). Jaiswal et al. (2017) stated that biochar application suppresses tomato root rot and fusarium diseases. In addition, biochar reduced the susceptibility of rice plants to root nematode infections. (Huang et al., 2017 a).

Biochar can improve the negative effects of drought stress (Ali et al., 2017). In addition, it stimulates plant growth by increasing indole-3-acetic acid content and root biomass under salinity stress (Farhangi-Abriz et al., 2018). Çığ et al. (2021) indicated that biochar treatment alleviates drought stress in wheat. Moreover, the combined application of biochar with beneficial bacteria has a more promotive effect on plant growth and mitigation of drought stress. There are studies stating that biochar applications affect metal uptake. Yu et al. (2017) reported that biochar helps to reduce As uptake in As-treated soil. Adding biochar to the soil at depths of 0-15 cm reduced metal uptake (Forján et al., 2017). Similarly, biochar has been reported to reduce the uptake of PAH and cerium oxide nanoparticles (Peng et al., 2017; Servin et al., 2017). As a result of the studies, biochar reduced Zn uptake in soil contaminated with Zn. In the same study, it improved the growth of *Ficus benjamina* plant under metal stress. (Kumar et al., 2018). The application of 5% tobacco stem biochar resulted in a 64.2% reduction in Cd uptake and a 94.9% reduction in Zn uptake (Yang et al., 2017).

3.3. Application of Biochar and Its Effects on Climate Change

Climate change is largely attributed to the concentration of greenhouse gases in the atmosphere. Biochar has the feature of reducing greenhouse gas emissions and can be used for climate change mitigation (Awad et al., 2018; Abdelhafez et al., 2017). The reduction of the global climate change potential of biochar is associated with the long-term bonding of carbon in the atmosphere to the soil (Brüggemann et al., 2018). They stated that the amount of ammonium and nitrate increased depending on the increase in doses of biochar applied in 0-2-4-6-8% doses, while ammonia losses decreased (Bekçi, 2019). It has been proven that even at low doses, biochar can reduce N_2O emissions and sequester excess nitrogen. In addition, when the nitrogen in the soil is insufficient for the plant, the nitrogen retained in the biochar is gradually released into the soil (Li and Chen, 2019). Biochar also helps the efficient use of N, reducing the climate change-causing NO_3 leakage (Borchard et al., 2019). It has been concluded that inorganic and organic fertilizers can be given together with biochar to increase agricultural yield (Ye et al., 2020). This use of fertilizer reduces the demand for chemical fertilizers. This is very important for organic farming and a sustainable environment (Oldfield et al., 2018; Kavitha et al., 2018; El-Naggar et al., 2019). As a result, it has been stated that biochar prevents carbon emissions and is a low-cost and sustainable product (Tunçay, 2019).

3. PROBLEMS ENCOUNTERED IN THE USE OF BIOCHAR

Although most studies show positive effects of biochar applications, some situations limit the use of biochar. Fresh biochar should be added at certain intervals for soil-water status and nutrient cycling in the soil (Kavitha et al., 2018). Elderly biochar adversely affected the growth of earthworms and fungi in the soil, and the root biomass of *Solanum lycopersicum* and *Oryza sativa* (Anyanwu et al. 2018). In the structure of biochar, toxic compounds such as salts and heavy metals can be found. These substances can adversely affect plant growth and germination and the activity of microorganisms (Jfery et al., 2017). In addition, biochar can be late flowering in plants (Hol et al., 2017). The type of material it is made of, the temperature at which it is applied and the rate of application to the soil determine the negative effect of biochar (Abbruzzini et al., 2017). For example, it has been reported that coconut shell biochar increases maize (*Zea mays*) biomass by 90%, while orange pulp biochar at the same doses has no significant effect (Gonzaga et al. 2018). As a result, features such as the structure, amount, applied soil type and product type of biochar have positive or negative effects (Ayaz et al., 2021). Biochar caused an increase in weeds due to its structure. Biochar applied at a rate of 15 t ha^{-1} increased weed growth by 200% during lentil planting (Safaei et al., 2018). Biochar can also react with soil nutrients to act as a competitor rather than providing plant nutrients (Joseph et al., 2018).

Studies have determined that the appropriate dose of biochar is 5-50 t ha^{-1} (Huang et al., 2017b). In addition, rates between 5 and 10 t/ha (0.5–1 kg/m2) in pea mustard, rice, corn, and soybean have beneficial effects on crop yield and soil properties (Kah et al., 2017). However, the appropriate doses are quite high. The biochar market is not yet available and the available doses remain negligible (Campbell et al. 2018). Since they are far from being economically viable doses, they are very difficult to use in agricultural production (Hašková 2017). An increase in production facilities will occur if most organic and agricultural wastes can be processed for the production of biochar. Thus, there will be an increase in the number of raw materials and a decrease in the cost of production (Tüfenkçi et al., 2022).

4. CONCLUSION

There are many benefits of applying biochar to soils in agricultural production. It has many properties such as improving plant growth, increasing yield and water holding capacity, reducing heavy metal adsorption, changing soil structure, agricultural disease, removing pollutants, and reducing greenhouse gases. However, the benefits of biochar applications are limited to certain conditions. The source of biochar raw material, the temperature at which the pyrolysis is made and the speed of application limit the effects of biochar on its economic applicability. Therefore, more research is needed to properly understand the positive and negative effects of biochar applications.

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CHAPTER 2

AN OVERVIEW OF ORGANIC FERTILIZERS CONSUMPTION

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1. INTRODUCTION

Changing climatic conditions around the world reduces the yield values of plants and food safety cannot be achieved (Yilmaz et al., 2022). The amount of product obtained from a unit area is very important to meet the food demands in countries whose economic structure is dependent on agriculture (Soysal and Yılmaz, 2021). With the increasing world population, it has become a necessity to approach agriculture with more professional arguments (Yılmaz and Soysal, 2021). If economically sustainable agriculture is to be achieved, agricultural production and management paradigms must change as soon as possible (Yılmaz et al., 2021). Maintaining high agricultural output and a healthy ecological environment necessitates sophisticated water and fertilization management to increase soil organic carbon accumulation (Yan et al., 2022). Over the last decade, climate change and its associated challenges have been a prominent topic of debate among scientists and scholars. In recent years, researchers have concentrated their efforts on utilizing agricultural wastes to create value-added goods (Dahunsi et al., 2021). One of the most important aspects of organic and sustainable agriculture production is organic fertilizer (Salam et al., 2021). Agriculture's long-term viability is a major global concern. Organic fertilizers can improve crop output and soil qualities while keeping pests and diseases at a barrier. Organic fertilizer can help to shape the microbial composition of the rhizosphere and attract beneficial microorganisms (Lin et al., 2019).

The widespread use of chemical fertilizers and other chemical derivatives has significant side effects such as pollution by damaging beneficial organisms, improved pest resistance, reduced food security, and destruction of the natural balance (Altinok et al., 2019; Ye et al., 2020). Long-term fertilizing degrades soil quality and reduces crop output, impeding current agricultural progress. Organic fertilizer combined with commercial NPK fertilizer should help to minimize soil acidity while also increasing crop yields (Wang et al., 2019).

The decreases in arbuscular mycorrhizal fungus populations and agroecosystem diversity have been confirmed to be mostly related to fertilization-induced nutrient enrichment. Organic fertilization, rather than chemical fertilization, is largely regarded as a viable option for preserving soil biodiversity and a healthy environment (Jiang et al., 2021). Using a combination of organic and inorganic fertilizers to boost crop yields could be a long-term solution. Long-term use of organic fertilizers alters the bacterial community's makeup and functions (Liu et al., 2021).

Developing and maintaining a quality soil structure is among the goals of sustainable agriculture (Ayhan and Kulaz, 2016). Increasing the use of organic fertilizers can help to ensure the long-term viability of soil productivity (Wu et al., 2020). Organic fertilizer can help to improve soil health by lowering nutrient leaching (Martey, 2018). Composting with organic fertilizer and phosphate-solubilizing microorganisms in the soil can improve phosphate availability from rock phosphate (Ditta et al., 2018). Volatilization of ammonia (NH3) from fertilizer applications diminishes efficiency and raises environmental risks (Erwiha et al., 2020). The use of a combination of organic and slow-release fertilizers minimized the potential for global warming (Liang et al., 2022).

In agricultural soils, the transformation mechanisms and destiny of nitrogen (N) in organic fertilizer are very crucial for N supply to crops. Making organic fertilizer into granules is a promising technique to coordinate fertilizer N release with maximum crop absorption, improving N use efficiency and reducing environmental effects (Yang et al., 2020).

2. CHICKEN LITTER

The most environmentally and cheapest technique of disposing of the volume created by the continuously expanding poultry industry worldwide is to apply chicken litter as an organic fertilizer on land. The contamination of chicken litter with diseases such as fungi, bacteria, parasite protozoa, viruses, and helminths, antibiotic-resistant genes, antibiotics, and growth hormones such as heavy metals, meat, egg boosters, and pesticides, are the main safety issues. Animal, human, and environmental health may be harmed by direct land application of chicken litter. For example, Escherichia coli (105-1010 CFU g-1) and counts of pathogenic strains of Coliform bacteria (106-108 CFU g-1) exceeded the maximum permissible limits (MPLs) for land application. In Australia, 100% of tested broiler litter was contaminated with Actinobacillus and reused broiler litter was more contaminated with Salmonella than unused broiler litter. In another similar study in the USA, whole chicken litter (100%) was infected with Escherichia coli containing genes resistant to more than seven antibiotics, particularly tetracycline, amoxicillin, sulfonamide, and ceftiofur. Many antibiotics and heavy metals have been found in chicken litter. There are no particular guidelines for the majority of its known pollutants for chicken litter. Even where standards exist for similar products such as compost, there is a significant difference between nations and organizations charged with establishing guidelines for the safe disposal of organic waste. More thorough research is needed to determine the level of contamination in chicken litter from both layers and broilers, particularly in developing countries where data is scarce; set standards for all contaminants; and standardize these standards across all agencies for safe disposal of chicken litter on land (Kyakuwaire et al., 2019).

3. SEAWEEDS

Seaweeds are valuable marine resources with a wide range of bioactive substances such as lipids, proteins, carbohydrates, amino acids, phytohormones, osmoprotectants, mineral minerals, and antibacterial agents. Since ancient times, they have been an important component in food, feed, and medicine. The potential application of seaweed as an organic/bio-fertilizer in agriculture has been utilized by the recent organic farming trend. Many studies have shown that seaweed can help plants develop faster and more productively. Added to this they are known to be a promising soil conditioner, protect plants under abiotic and biotic stress and increase plant resistance against pests and diseases (Raghunandan et al., 2019).

4. INDUSTRIAL SLUDGE

Industrial sludge is currently produced in massive quantities. All components eliminated from wastewater and any substances added to the chemical and biological operating units throughout the treatment process make up industrial sludge, which is a solid or semi-solid mass. Sludge can have a wide range of chemical compositions. Furthermore, because sludge produced by various sectors has diverse characteristics, multiple treatments and disposal procedures are required. As a result, industrial sludge processing and disposal is a complex and challenging environmental concern. The three most prevalent ways of disposing of industrial sludge are incineration, landfilling, and agricultural land application. Agricultural land application is the most suitable and cost-effective approach for disposing of industrial sludge. On the other hand, industrial sludge poses pathogen risks and can have highly putrescible ingredients. Stabilizing and conditioning the industrial sludge using a pretreatment process is one of the special techniques to ensure that it may be reused on agricultural land. Vermicomposting is one of the pretreatment methods that could be used in this situation. With the addition of earthworms, vermicomposting is an alternative for biologically stabilizing organic wastes. Industrial sewage could be converted into vermicompost or matured organic fertilizer in a shorter time through vermicomposting (Lee et al., 2018; Ceritoglu et al., 2020). Liquid organic fertilizers manufactured from industrial wastes and agricultural residues are becoming increasingly popular (Phibunwatthanawong and Riddech, 2019).

5. MICROBIAL FERTILIZERS

Transitioning to sustainable agriculture and horticulture is a global socioeconomic concern. Fertilization with a low environmental impact can help with this. Given their typical release pattern and production through resource recovery, organic fertilizers can play a significant role.

Microbial fertilizers (MFs) are a new type of organic fertilizer that is made up of dried microbial biomass (Spanoghe et al., 2020).

Functional microorganisms are combined with a suitable substrate in bio-organic fertilizers, which have been found to successfully inhibit soil-borne illnesses and boost plant development (Zhao et al., 2018). Because of their significant good impacts on soil health, bio-organic fertilizers, which are made by inoculating plant growth-promoting rhizobacteria into agro-industrial wastes, are garnering more attention (Bibi et al., 2022). Plant yield and growth are affected by rhizobacteria that promote plant growth through indirect or direct mechanisms (Çakmakçı et al., 2010; Yilmaz and Kulaz, 2019; Çığ et al., 2021). Trichoderma spp. is a diverse collection of soil fungi that, after interacting with plant roots, stimulates plant growth and has promising application prospects in intensive agriculture (Liu et al., 2020). The inability to maintain a high microbial population in commercial products and field soil is one of the primary constraints in the development of microbially-added agricultural products (Stella et al., 2019).

6. ALGAE

Today's farmer uses a lot of synthetic fertilizers and pesticides to meet the global demand for food. While such supplements have aided many developing countries in increasing crop yields, they have also brought a slew of concerns (Baweja et al., 2019). The use of pesticides causes significant losses in terms of diversity in the ecosystem (Kaçar and Koca, 2020). On the other hand, synthetic fertilizers have increased the cost of food production while also lowering soil fertility and degrading local ecosystems due to an increase in soil, water, and air pollutants. As a result, it is necessary to seek out alternatives that can not only aid in the reduction of pollution but also be used to boost crop productivity. Organic fertilizers, also known as biofertilizers, are an alternative that is environmentally benign, cost-effective and improves soil quality without destroying the ecosystem. Organic fertilizers derived from algae are being explored as a potential alternative to conventional synthetic fertilizers since they are high in macronutrients, micronutrients, growth regulators, and other nutrients that directly aid in crop plant growth and yield (Baweja et al., 2019).

7. INSECT FRASS

Nitrogen changes the composition, productivity and some other features of the natural ecosystems it enters (Soysal et al., 2021). The widespread use of nitrogen-based fertilizers has been linked to a number of severe environmental effects, including waterway pollution and eutrophication of estuaries and lakes.

Fig 1. Insect (*Hermetia illucens*) frass fertilizer (Zahn & Quilliam, 2017)

Less environmentally destructive techniques of adding organic matter and nutrients to soils are required to achieve more sustainable food production. As a by-product of insect farming, one promising organic fertilizer has just emerged. The excrement or frass produced by the mass generation of the black soldier fly (*Hermetia illucens* L.) is high in organic matter and includes critical plant nutrients such as nitrogen, phosphorus, and potassium (Borkent and Hodge, 2021).

The Black Soldier Fly, *Hermetia illucens* L., appears to be an opportunity to reuse vegetable by-products because it is easy to reproduce and may be reared in agricultural side streams, permitting the production of both animal feed (the larvae) and soil organic fertilizer (fly frass) (Menino et al., 2021).

8. NEGATIVE EFFECTS OF ORGANIC FERTILIZER UTILIZATION

Organic fertilizer is an important component of agricultural sustainability since it helps to boost soil fertility. When utilized in big quantities, the values of nutrients such as organic matter and nitrogen in organic fertilizers positively promote plant growth while causing environmental difficulties (Guindo et al., 2021). In disturbed soil systems, nitrite oxidation, the second step of nitrification, can be the deciding factor. Partially substituting organic fertilizer for chemical fertilizer as a good fertilizing method to maintain high crop output and soil fertility may cause significant disturbance to soil processes (Liang et al., 2021).

The usage of organic fertilizer may be accompanied by trace metal dangers to soil and humans. Reducing the amount of Cr, Cu, Zn, As, and Cd in organic fertilizer would be extremely beneficial in reducing trace metal damage (Gong et al., 2019). Long-term organic fertilizer use on agricultural soils has been shown to cause Cu and Zn contamination, as well as pH and organic matter changes, which modify soil Cu and Zn availability (Laurent et al., 2020).

Although soil microorganisms play a significant role in agricultural ecosystems, their response to organic fertilizer application has yet to be fully understood. Organic fertilizer application exposed a portion of the soil's functioning or pathogenic bacteria population, and the pace of fertilization was the driving element for bacterial composition change (Wu et al., 2021).

Manure treatment can help with soil quality and long-term food production, but too much of it can spread antibiotics and antibiotic-resistance genes (Xu et al., 2021). Antibiotic resistance genes are common in animal feces, posing a hazard to environmental safety. Organic fertilizers made from animal and poultry dung are applied directly to crops and have the potential to trigger bacterial resistance outbreaks in agricultural settings (Xu et al., 2020).

Organic fertilizer is a good alternative to mineral fertilizer because it increases crop output while still being environmentally friendly. However, because of intricate interactions among the organic fertilizer substitution rate, total nutrient supply, and cropping method utilized, the effects of substitution often differ (Wei et al., 2020).

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CHAPTER 3

RED LENTIL GROWING, ITS STATUS AND PROBLEMS IN SİİRT PROVINCE

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1. INTRODUCTION

Lentil, which is in the legumes family and has an important place, has an increasing position day by day since it has high protein content. Also, lentil, which is suitable for crop rotation in arid regions, provides an important agricultural income to both the producers and the country's economy. With its nutritional aspect, it is among the food products preferred in almost every kitchen in many countries, especially in our country. The stem and pod of the lentil plant contain carbohydrates (50%), protein (4.4%), oil (1.8%), moisture (10.2%), ash (12.2%) and cellulose (21.4%). The dried grains of the lentil plant contain protein rich in amino acids and vitamins A, B, C, K and iron. The high levels of thiamine and niacin amino acids in the grain increase the quality of the protein contained in red lentils (Pekşen et al. 2005).

Lentils are known for their resistance to cold and drought (Bicer and Yılmaz, 2013). Some varieties can adapt to both winter and summer planting. Lentil, which is a one-year plant and has a single-branched body structure, is 15 cm. with 75 cm. show different sorting among them. *Rhizobium* bacteria live in the root of the plant, as in legume varieties. Therefore, it can fix the free nitrogen in the air through symbiosis with suitable *Rhizobium* species and use it throughout lifespan.

In Turkey, it is cultivated in the Southeastern Anatolia Region in winter, and in the Central Anatolia and Aegean regions in winter and summer seasons. Many winter varieties have been developed and expanded. In this direction, some varieties can be grown in winter in all regions of our country, except for very high areas in the Eastern Anatolia Region. In general, yield obtained from winter sowing is approximately 50-100%

higher than summer sowing, winter planting is preferred throughout the country (Sakar ve ark. 1988).

According to TUIK (2021), the 228 thousand tons of red lentils are produced in an area of 2,600.995 decares in Turkey. The province of Siirt is among the top 5 provinces in our country in red lentil production as of 2021, with an area of 127.545 decares and with a production amount of 16.255 tons.

The Southeastern Anatolia Region has a very important potential for legume production due to its favorable climatic conditions, organic matter-rich soil structure, and the number of people living in rural areas in terms of human resources required for legume agriculture. Southeastern Anatolia Region is an important agricultural production center of our country. Wheat, cotton, red lentils and barley are grown mainly in the region, and these products constitute ¾ of the total amount of agricultural production in the region. In the Southeastern Anatolia Region, the cultivation area of legumes has a share of ¼ of the total cultivation area. Red lentil comes to the forefront as the most cultivated product (85%) among legumes (Küsek, 2018). While most of the red lentils grown are used in the country, the rest is exported (Anonymous, 2022a).

According to the production data of 2021 in the Siirt region, cereals and pulses are cultivated in an area of 550 thousand decares within an agricultural area of 953.303 decares (TUIK, 2021). Red Lentil is a strategic product mainly produced in the Southeastern Region of Turkey due to its climatic demands. According to TUIK data, red lentil production, which was around 70 thousand decares in 2019, reached a production area of over 125 thousand decares in 2021. As of 2022, it is aimed to produce more than 25 thousand tons in an area exceeding 150 thousand da. With the arid production year of 2021, the yield is around 100/da, and a yield of around 175/da is expected with the rains and favorable climatic conditions in the spring of this year. Red lentil production area in Siirt has increased by more than 100% in the last 3 years (Siirt TOM, 2021).

In this work, demands and suggestions of the farmers were revealed by investigating the production of red lentils in general terms in the world and Turkey, by determining the production situation and the problems encountered in the province of Siirt.

2. RED LENTIL CULTIVATION IN THE WORLD

According to the data of the Food and Agriculture Organization (FAO) for 2020, world lentil production was realized as 6.54 million tons on 5 million hectares, and the world lentil yield average was obtained as 1,310 kg/ha in the same year. According to FAO (2020), Canada, India and Australia are in the top three in the world production ranking, and our country is ranked 4th in cultivation area and production, and 10th in yield. Canada's exports in the 2020/2021 marketing year amounted to a total of 2.3 million tons, of which 1.5 million tons of red lentils and 800 thousand tons of green lentils, and the drought experienced in the 2021/2022 period was effective. Canadian lentil harvest is expected to decrease despite the increasing area and will be around 1.6 million tons with the update made on 17 December 2021 (FAO, 2020).

The most important countries importing from Canada are India, United Arab Emirates, Bangladesh and Turkey. It is expected that the supply of Canadian-origin products will decrease by 28% as the demand for legumes increases due to the contraction in supply caused by the drought and the pandemic, and the stock contract. The situation in the USA is the same as in Canada. Although the cultivation areas increased by 35% compared to the previous season, the yield is expected to decrease by 31% due to drought. However, 3 shipping companies, which have 80% of the world's container capacity, withdraw empty containers from the USA to Asia, which causes logistics problems for many products. Legislation preparations on this issue have started in the US Congress.

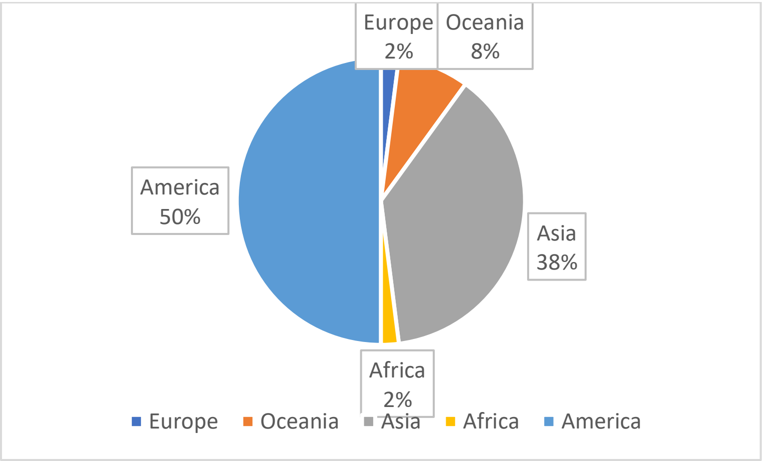
The good condition of the lentil harvest in Australia suppressed the increase in Canadian lentil prices. However, due to the logistic problems, the export is not yet realized in the expected amount. Some of the manufacturers prefer to store their products until the logistical problems are resolved.

In Indian summer plantings, a decrease in both yield and quality is expected with the effect of the first drought and then excessive rainfall. In 2021, India increased the minimum support price of red lentils by 7.8 percent annually. Due to the problems experienced in supply around the world, the Ministry of Commerce and Industry of India extended the import tax reduction until March 31, 2022, and the lentil supply from Russia until June 20, 2022. Despite the decrease in supply, the increase in vegan nutrition leads companies to increase the variety of plant-based protein. An important coffee company worldwide; presented the dairy-free cream made from lentils to its customers for trial purposes. The drought effect will likely be felt in the next production season.

Decreased soil moisture due to drought cannot be supplemented due to insufficient autumn rainfall, chemicals used in the previous production season are still present in the soil, and an increase in the population of diseases and pests is expected due to drought. Especially in North America, an increase in the grasshopper pest population is expected as a result of laying more eggs due to the lack of precipitation (BÜGEM, 2022).

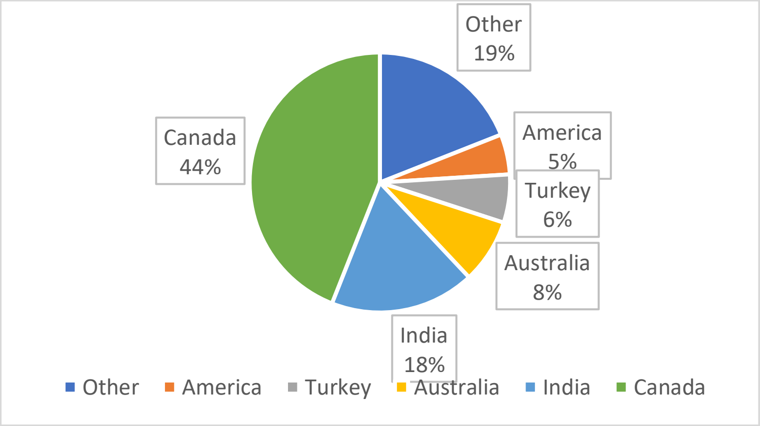
In addition to the problems experienced in production, accumulations in ports that delay the arrival of containers from China, congestion in railway centers, slowdowns in American production facilities, increased prices and delays in inputs and other materials needed by farmers such as machinery, spare parts, and packaging materials. Due to the change in the world's dietary habits and the positive effects of legumes on the environment, legume production and consumption are becoming widespread. International Grains Council has announced that it will add legumes (such as lentils, chickpeas, dried peas and dried beans) to the definition of "grain" to develop cooperation in increasing the global trade of legumes, which play an important role in ensuring food security (BÜGEM, 2022). The distribution of red lentil production in 2020 by continents in the world is given in Figure 1.

Figure 1: Distribution of Red Lentil Production in The World By Continents İn 2020 (FAO, 2020)



The distribution of the countries producing the most red lentils in the world (%) is given in Fıgure 2.

Figure 2: Distribution Of Countries Producing The Most İn Red Lentils İn The World (FAO, 2020)



Looking at the import and export data according to FAO data, lentils in the world in 2020; It has created an import-based trade volume of 3 billion dollars with an import amount of approximately 4.7 million tons.

In the same year, the quantity of exports in the world reached 5 million tons, and the volume of trade based on exports reached 3 billion dollars. Canada made up 57% of the trade volume of lentil exports in 2020, Australia 12% and Turkey 10% (BÜGEM, 2022).

3. RED LENTIL CULTIVATION IN TURKEY

Like many leguminous products, Turkey has experienced a decline in lentils for a while. However, it has started to increase again with the support applications and projects implemented. According to TURKSTAT 2019/2020 marketing year data, the level of proficiency in our country was 71.7% for red lentils and 85.3% for green lentils. While the total consumption of red lentils in Turkey was 381 thousand tons, per capita consumption was 4.6 kg/year, Turkey's consumption of green lentils was 44 thousand tons and per capita consumption was 0.5 kg/year (BUGEM, 2022).

According to TUIK, 2020 data, red lentil production increased by 5.9% compared to the previous year and was 328 thousand tons on an area of 2.5 million decares. The highest production increase based on provinces was in Şırnak province. In addition, in 2021, a transition to lentil products is observed in dry agricultural areas. According to TUIK data, the expected yield is 228 thousand tons for red lentils and 35 thousand tons for green lentils. In December 2021, according to weighted average prices, red kernels were traded at 13,345 TL/ton ($978/ton) and red lentils in the shell at 11,494 TL/ton (842 $/ton) in domestic stock markets. Green lentils were traded at 12,641 TL/ton (926 $/ton). In Mersin Commodity Exchange, on January 21, 2022, the price of red lentils was 16.650 TL/ton, the price of red-shelled lentils was 12.100

TL/ton, and on January 24, 2022, the price of green natural lentils was 16.330 TL/ton. While Canadian small red lentils were traded at $922/ton in foreign exchanges in December 2021, green lentils were traded at $1,243/ton (BÜGEM, 2022).

Turkey Production amount, yield and production area between 2016-2021 Production Years are in Table 1, Cultivation area, yield per decare and the total amount of lentils produced (kg/da) of the 5 provinces with the most red lentil planting in Turkey by provinces. given in 2.

Table 1: Production Amount, Yield and Production Area in Turkey Between 2016-2021 Production Years (TUİK,2021)

	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Sown Area (da)	2.354.743	2.693.181	2.430.652	2.427.761	2.098.215	2.601.995
Yield (Kg/da)	150	149	138	128	157	92
Production Amount (Ton)	345.000	400.000	310.0000	310.000	328.418	228000

Table 2: Planting Area, Yield Per Decare And Total Lentil Amount Produced (Kg/Da) Of 5 Provinces With The Most Red Lentil Planting İn Turkey Between 2016- 2021 Production Years (TUİK,2021).

	Years	**Batman**	**Diyarbakır**	**Gaziantep**	**Mardin**	**Siirt**	**Şanlıurfa**
Sown Area (da)	**2016**	133.900	542.817	72.755	308.290	63.078	1.059.032
	2017	141.031	757.520	72.840	304.490	75.738	1.120.617
	2018	133.250	681.222	75.040	302.176	73.388	929.902
	2019	152.211	632.193	68.140	277.020	69.618	949.719
	2020	142.855	536.544	51.991	175.855	87.532	806.000
	2021	150.145	576.051	46.835	175.997	127.545	1.188.121
Yield (Kg/Da)	**2016**	212	227	47	194	162	94
	2017	183	196	138	168	135	113
	2018	200	184	155	138	132	89
	2019	175	163	137	146	128	96
	2020	196	182	146	178	168	129
	2021	109	86	87	70	127	95
Production (Ton)	**2016**	28.355	123.048	2.334	59.924	10.214	96.086
	2017	25.842	148.253	10.037	51.134	10.251	127.029
	2018	26.625	125.216	11.638	41.712	2.550	72.053
	2019	26.576	102.977	9.358	40.396	8.933	91.287
	2020	28.001	97.461	7.567	31.230	14.725	104.010
	2021	16.313	46.298	4.087	12.277	16.255	105.386

The Red Lentil Production Map, which is the most grown in Turkey according to the provinces, is given in Figure 1.

Figure 1: The Map of Red Lentil Production with The Most Cultivation in Turkey (TUIK, 2021).

Red lentils are cultivated in all regions of Turkey, albeit on a small scale, except for the Black Sea Region. The production map of the provinces where green lentils are grown in Turkey by provinces is given in Figure 2.

Figure 2: Inclusive Production Map of The Provinces Where Green Lentils Are Grown in Turkey (TUİK,2021).

Green lentil cultivation in Turkey is carried out in all regions of our country, except for a very small area of the Southeastern and Anatolian Regions (in Gaziantep 53). Ankara and Konya provinces are the two main provinces that have the potential to produce both red lentils and green lentils.

4. RED LENTIL CULTIVATION IN SİİRT REGION

In the Siirt region, landforms are composed of high mountains and plateaus in terms of the area they cover and spread. Generally known as the Southeast Taurus Mountains, this mountain range extends from east to southeast and merges with the Hakkari Mountains. There is Yazlıca Mountain in the east of the region and Uluçay and Zorava Brook in the west. The land structure, which turned into plots with the decrease in altitude, became suitable for grain and legume agriculture.

Siirt is covered with rich meadows that receive precipitation at all times of the year and is surrounded by plateaus. Continental climate prevails in Siirt, where the four seasons are most clearly experienced. Winters are harsher and rainier in the northern and eastern regions of the region, and warm in the south and southwest regions. The summers are hot and dry (Anonymous, 2022b).

Siirt region, which is among the most suitable regions for red lentil cultivation with its geographical structure and climatic characteristics, is in the top five in Turkey according to TUIK data in red lentil cultivation. Red lentils are grown in all of the Tillo, Pervari, Kurtalan, Şirvan, Baykan and Eruh districts of Siirt. According to TUIK data in 2021, while the production amount of red lentils in Turkey was 228,000 tons, 16,255 tons of red lentils were produced in Siirt, which corresponds to 7.13% of the total production structure (TUIK, 2021). Seasonal Normals of Siirt Province are given in Table 3 (MGM, 2021)

Table 3: Seasonal normals of siirt province (MGM,2021)

SİİRT	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	Measuring period (1939 - 2021)												
Average Temperature (°C)	2.7	4.3	8.4	13.8	19.5	26.0	30.7	30.4	25.5	18.3	10.5	4.8	16.2
Avegare Maximum Temperature (°C)	6.7	8.8	13.4	19.2	25.3	32.3	37.1	37.0	32.3	24.5	15.5	8.8	21.7
Average Lowest Temperature (°C)	-0.5	0.6	4.1	9.0	13.7	19.1	23.5	23.3	18.8	12.8	6.4	1.7	11.0
Average Sunbathing Time (hours)	3.6	4.4	5.4	6.5	9.0	11.6	12.1	11.3	9.9	7.2	5.2	3.6	7.5
Average Number of Rainy Days	9.62	10.23	12.62	10.77	9.62	2.77	0.77	1.15	1.38	6.46	9.31	10.77	85.5
Average Monthly Total Rainfall (mm)	96.4	97.9	112.6	104.4	62.9	9.2	2.7	1.9	6.9	49.9	81.2	94.6	720.6
	Measuring period(1939 - 2021)												
Highest Temperature (°C)	19.7	20.6	28.5	32.9	36.8	40.2	44.4	46.0	40.0	36.6	25.8	24.3	46.0
Lowest Temperature (°C)	-19.3	-16.5	-13.3	-4.1	2.0	8.2	13.1	14.4	8.5	0.3	-6.6	-14.6	-19.3

The production amount, yield and production area based on districts of Siirt Province in 2021 are given in Table 4.

Table 4: 2021 Production year Siirt province, district based production amount, yield and production area (TUİK,2021)

Product: Red Lentils	Central District	Baykan	Eruh	Kurtalan	Pervari	Tillo	Şirvan	Siirt(Total)
Sown Area (da)	11.730	5.477	218	110.000	35	30	55	12.7545
Harvested Area (da)	11.730	5.477	218	110.000	35	30	55	12.7545
Yield (Kg/da)	130	90	115	129	86	67	127	127
Production Amount (Ton)	1.525	493	25	14.200	3	2	7	16.255

The red lentil production map of Siirt Province is given in Figure 3.

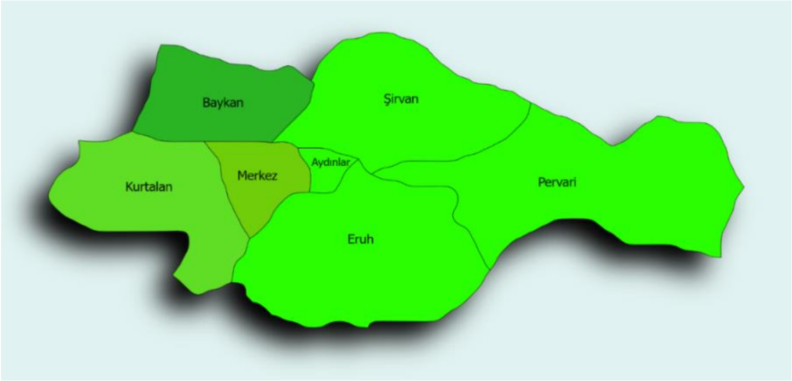


Figure 3: Map of red lentil production by the district of Siirt province (TÜİK, 2021)

4.1. RED LENTIL FARMING IN SİİRT PROVINCE

4.1.1. Climate Request

Red lentil, a plant that likes warm and temperate climates, is easily cultivated in Siirt province, Kurtalan, Baykan, Tillo, Eruh, Pervari and Şirvan districts due to its favorable climatic conditions. Studies have shown that red lentils are the most resistant to extreme cold and extreme temperature weather conditions and drought among legumes. Although the sowing period varies from region to region, winter planting is carried out in hot and dry regions where summer temperatures come very early, and both winter and summer planting is carried out in normal climatic conditions.

The growing period of red lentils, whose germination temperature varies between 8-13 ° C, varies depending on the climatic conditions from the sowing period to the harvest period for a production season but lasts for 6-7 months (Anonymous, 2022a). In the Siirt region, this period is 5-6 months. A producer who plants red lentils in November harvests and threshes in May.

4.1.2. Land Request

Red lentil cultivation can be carried out in many different soil types, from sandy soils to heavy clay soils. Siirt region has well-ventilated, warm, sandy-loamy calcareous soils necessary for a good yield, since it is free of salinity problems in terms of soil characteristics. Although the reaction of the soil, that is, the pH value between 5.5 and 6.5, is the most ideal value in lentil cultivation, the neutral soil reaction desired for the growth of most plant species, the pH between 6.5 and 7.5 is at a level that can be considered sufficient for the usefulness of all plant nutrients (TOB, 2018). Siirt province city center and Kurtalan district have more common red lentil fields compared to other districts in terms of having these rates.

4.1.3. Crop Rotation

In various regions of our country, alternating agricultural practices are carried out in red lentil cultivation, and in some regions, red lentil fields are left fallow. In the Siirt region, a crop rotation system is applied in the Merkez district, Kurtalan and Baykan, but in the districts of Eruh, Tillo, Şirvan and Pervari, red lentils are left fallow after they are harvested.

The increase in the prices of red lentils in the recent past for the producers of red lentils in the Siirt region and the fact that the crops such as barley and wheat, which are planted after lentils, do not experience yield problems, have made the alternation system widespread. This contributed to the increase in the income of the producer.

4.1.4. Lentil Varieties Grown and Can Be Cultivated

Lentils, which are among the indispensables of Turkish cuisine, are preferred and grown according to soil and climatic conditions in the Siirt region; Although the majority of the breeders in the region use the lentil cultivar of Euphrates-87, it is known that some breeders also use the varieties of seyran-96, Cagil, Altıntoprak and local red (Kandemir, 2010).

4.1.5. Soil Preparation

In the red lentil cultivation in the Siirt region, the preparation of the soil for planting is done by different methods. After the grain harvest in red lentils, which will be grown in winter and summer, soil preparation begins with the first ploughing at a depth of 15-20 cm in autumn (November) with a plow. In winter sowing, seedbed is prepared in autumn (November) before sowing by means of a crowbar rake. Especially in winter sowing, the stubble height should not be left during the grain harvest, as the grain stalks cause problems during planting. In summer planting, it is expected after the autumn release until the spring season without any action. When spring comes, the soil is made ready for planting by making the second version with a crowbar rake just before planting (Yüzer, 2020).

If there is no stubble break after the grain harvest, the field is kept untreated until autumn. When the first rains of autumn fall, when the weeds start to sprout and the soil soften, tillage is done with a plow at a depth of 15-20 cm. Then, it is made ready for planting by making second soil cultivation with one of the cultivator + cultivator or gobledisc + cultivator combinations (Küsek,2018). This method is another method used in the region.

When the first rains begin to fall, the earthen pan comes. During this period, weeds begin to germinate. When this time comes, the soil should be processed a second time. The second process can be done using cultivator and scythe, or it can be done using gobledisk and scythe. After these processes, the seed bed will be ready. In the second preparation method, stubble breaking is not done. The soil is kept without any treatment until autumn. When the first rains of autumn begin to fall, it's time to work. After the weeds start to germinate and the soil reaches the pan, 15-20 cm. The soil is plowed deeply with a plow. After this process, the second processing stage is completed with the use of a cultivator and scythe or gobledisk and scythe. The soil will be ready for planting.

4.1.6. Sowing Process

In the Southeast Anatolian Region, winter lentils are planted in November, and in Central Anatolia and Transition Regions in October. Summer lentil planting should be done at the beginning of spring, at the end of February and at the beginning of March. If summer varieties are planted in winter, yield cannot be obtained as they will be damaged by cold. Winter varieties are not affected by winter and cold. In Thrace, summer varieties are usually planted in early March. Delay in sowing causes yield loss. Lentil sowing is usually done with the seeder used for wheat. In both winter and summer lentils, the amount of seeds to be planted per decare varies according to the size of the seed to be planted. If the seed is clean and has high germination power, 250-300 per m2 for winter lentils and 175-225 per m2 for summer lentils should be planted. For coarse-grained lentils, the amount of seeds to be planted per decare varies between 14-15 kg in winter and 10-12 kg in summer. In small grain lentils, this amount is around 8-10 kg in winter and 7-8 kg in summer (Yüzer, 2020).

4.1.7. Fertilization

The plant needs nitrogen and phosphorus in the cultivation of red lentils in the Siirt region. The amount of fertilizer to be used in fertilization depends on the results of soil analysis. For this reason, more than half of the producers who grow red lentils in the Siirt region have soil analysis done before planting and fertilizing. In this process, it receives technical support from the Provincial and District Directorates of Agriculture and Siirt University Faculty of Agriculture.

Lentils fix the free nitrogen in the air to the soil with the tubers formed by the bacteria called Rhizobium in their roots. For this reason, there is no need for extra N in soils where lentils are cultivated and bacteria called Rhizobium are seen in the soil. After planting, 2-2.5 kg nitrogen per decare and 5.5-6.5 kg phosphorus per decare are the ideal fertilizer doses that the plant needs in the first development period. These fertilizer amounts meet the same need as 12-14 kg DAP fertilizer per decare. During planting, fertilizer should be given to the soil with a seeder, if sowing is to be done, it should be sprinkled on the soil surface and mixed with the soil with a crowbar or disc harrow (Yüzer, 2020). In addition, the use of diammonium phosphate fertilizer containing 18% nitrogen and 46% P2O5 in its components is common in the region. Because this fertilizer contains all the necessary substances for planting lentils.

4.1.8. Irrigation

Since red lentil cultivation is a product grown in dry conditions in the Siirt region, irrigation is not done. The most important reason for this factor is that irrigation does not have a very important place in the maintenance processes of red lentils. Red lentil, which is a very resistant plant, also shows this resistance against thirst. Red lentils are grown in dry conditions throughout the Siirt region.

With the first rains, red lentils provide the necessary water from the soil. Even light rains will saturate the lentils because they don't need a very high water level. However, in some regions, the need for irrigation may arise 1-2 times due to excessive drought. However, it should be known that lentils are damaged by excess water. Therefore, irrigation operations should be done very sensitively.

4.1.9. Maintenance Procedure in Lentil Cultivation

Due to the favorable climatic conditions and the soil structure rich in plant nutrients in the Siirt region, the maintenance procedures in red lentil cultivation do not force the producers. Weeds are the leading factor limiting the yield obtained from red lentils. In order to prevent the lentils from being affected by weeds, planting processes should be done at certain periods. The most important factor limiting the planting of winter lentils is weeds. Effective control cannot be made with existing weed killers, which leads to a decrease in yield. In cases where weed control is done well, the yield of winter lentils is 50% higher than summer lentils. It is very useful to take grass once in the lentils grown in the Central Anatolia Region during the summer months. Manual sorting is not economical as the fields are generally wide in the Southeastern Anatolia Region. For this reason, weed control needs to make the first plow with a deep plow and the second plow while the weeds are germinating after the rain (Yüzer, 2020).

After the weeds start to germinate, these weeds should be removed, the soil should be processed and made ready for planting. Lentils do not suffer any damage in the first period when they are planted in weed-free soils. After that, new grass will begin to sprout. Re-germinating weeds can be harvested by hand. However, if it is desired to pluck weeds in very large areas, it will require a high amount of labor. Since labor also means expense, the calculation must be done well.

4.1.10. Disease and Pest Control Procedures

Medicines are used to prevent weeds in lentil cultivation. Weeds should be tackled first during the planting period. Then it is prevented from coming out with weed pesticides and damaging the lentils. Since the pesticides applied to the soil before the weeds emerge are still in the testing phase, they are not very suitable for use. Medicines used after the emergence of herbs will be a very correct move.

Lentil greenworm is one of the most irritating pests. It harms both lentils and chickpeas. The hatched larvae feed by gnawing on leaves and eggshells. The larvae will begin to pierce the lentils in their final stages. During this period, they start to eat the inside of the lentils. Preventive drug applications against worms are preferred. In addition, pests such as lentil seed beetle, apion and lentil weevil are also struggling. The hornworm is also among the pests. They damage lentils in the adult and larval stages. Adult insects can cause great damage in the first development period of the plant. They gnaw the leaves and sometimes completely hollow the leaves. Larvae beetles target the roots of the plant. Plants infested by these insects have poor growth and wilting problems. In some cases, the plant may dry out completely. It is essential to take medicines from reliable addresses while taking medicine measures against all diseases and pests. Otherwise, mistakes can be made that can seriously reduce overall efficiency.

4.1.11. Harvest, Threshing and Storage Operations

At harvest time, the moisture content in the grain should be as low as possible. The best harvest time is when the plant turns yellow but has not completely dried out. Usually, this period coincides with the end of May. However, there are changes according to the region where the planting is made and the type of lentil. In Central Anatolia and Transition Regions, when the lentils turn lemon yellow and the grains are not crushed between two fingers, it means the harvest time has come. Harvesting is done by hand plucking or mowing with a scythe.

The harvested plants are left to dry in the field for 5-6 days in heaps and then threshed in the threshing machine. In the Southeastern Anatolia Region, the lentil scythe is harvested with a mower or combine that moves on the PTO of the tractor. If harvesting will be done with a combine, the lentils should be waited to completely dry. However, if it waits longer than necessary, the grain starts to fall. The best time to harvest is early in the morning.

The grains obtained at the end of the blending are subjected to the selection process and the foreign substances (stone, soil, broken grain, etc.) in it are cleaned. The product should be placed in spraying tanks and disinfected against pests (Yüzer, 2020). If the harvest is delayed, the fruits begin to fall. This directly means the loss of the product. Product losses due to late harvest can reach up to 50% in some cases. Lentils are harvested with a combine harvester, scythe and mower.

The fact that the field is level and stone-free throughout this smart. If the lentil is passed through the lens after planting, the soil will have a flat one. Lentil harvest is done with scythe, mower and combines harvester. The harvested product is then threshed textured, blended, attractive and bagged. 3 rows are combined and dried at harvest with a combine. The plant will be 7-10 days old. Then it reaches the area to be blended and blended. It will then be cleaned and packaged. Bags can be offered for sale. If the sale will not take place immediately, the pulses will have to be prepared and ready for the time.

All of the processes mentioned for red lentil cultivation in the Siirt region are applied perfectly and under normal climatic conditions; 120-150 kg per decare in dry sowing and 200 kg yield in wet sowing.

5. PROBLEMS ENCOUNTERED IN RED LENTIL CULTIVATION IN SİİRT REGION

Producers face significant problems in areas where red lentils are grown in Siirt region. It is possible to separate these problems as abiotic and biotic factors. Frost and drought damage, which are among the main abiotic factors that were most clearly felt in the Siirt region in the 2014 and 2020 production years, caused a loss of approximately 60% in the yield of farmers. Among the abiotic factors, high-temperature differences between day and night appear as factors that directly affect the development of the plant. In the Siirt region, in the regions outside the city center and Kurtalan; the Unevenness of the general land structure, not suitable for mechanized agriculture (harvest) is among the factors that cause red lentil yield not to be obtained at the desired rate. The high salinity and lime content of the soil in agricultural areas in the same regions also cause yield losses. The weed problem is the leading biotic factor in red lentil cultivation. This problem, which is encountered in the whole Siirt region, cannot be adequately struggled with even though the farmers are fighting culturally. Manual weed control is not economical and effective in large lentil fields. In the face of the short plant height of the red lentil in the emergence period and its slow development in the early development period, the rapid growth of weeds prevents the development and growth of the red lentil.

Siirt region is among the gene source centers of the lentil plant. The primary purpose of red lentil cultivation is to increase yield and develop high-yielding varieties. The developed winter lentil varieties have provided some solutions to the yield increase problem, but the weed problem is one of the problems that need to be solved in winter lentil agriculture.

The increase in the prices of herbicides used to combat weeds is another problem faced by the producers of red lentils in the Siirt region. In addition, the same price increases are in question for commercial fertilizers. The increase in input costs negatively affects the red lentil agriculture of the farmers in the region.

6. CONCLUSION AND RECOMMENDATIONS

Lentil cultivation is extremely important in dry farming areas, especially in human and animal nutrition. Our country needs to determine the problems related to red lentil cultivation and production potential, especially due to the importance of rotation in the domestic market, which is applied to reduce fallow areas, and protect and expand soil fertility. Although many varieties developed with appropriate techniques are used, vegetative yield is gradually decreasing in monoculture agricultural areas in the world. In regions where legumes are in rotation, this problem will be solved to a great extent.

It is an important goal to be able to export by obtaining more products from the areas where legumes are cultivated. The sustainability of our genetic resources and the availability of our climatic conditions are the two most important factors that should be evaluated in the dissemination of red lentil cultivation.

Although the per capita consumption in Turkey has not changed much in recent years, it varies between 4.5-5 kg/year for red lentils and 0.5-0.6 kg/year for green lentils. There is a serious decrease in legume cultivation areas in Turkey. While production and exports decreased, there was a rapid increase especially in red lentil imports (Soysal and Erman, 2020). Entering lentils in crop rotation is important in terms of both increasing the yield obtained from the unit area and reducing the fallow areas. Especially in crop rotations in dry agricultural areas, winter lentil is an indispensable plant with its early leaving the field and leaving a suitable soil (TEPGE, 2021).

In recent years, there has been a decrease in production due to the decrease in lentil cultivation areas, especially due to economic reasons. It is thought that the dissemination of crop rotation practice will be effective in increasing production. While the red lentil adequacy ratio, which was 102% in 2011, decreased to 76.7% in 2017, this rate increased to 89.9% in 2018, but this increase in production could not save Turkey from being an importer country. In green lentils; Qualification, which was 61.7% in 2011, decreased to 56.1% in 2018 and became increasingly dependent on foreign sources. Canada, which brought lentils from

Turkey in the 1970s, has become the world's largest lentil exporter today. Turkey; Since it does not meet its consumption with the lentils it produces, it meets almost all of its needs with lentils imported from Canada (SGB, 2019).

Especially in the current pandemic process, the importance of legumes has once again emerged with increasing prices due to demand. Within the scope of the "Enabling the Use of Agricultural Lands Project", which was started to be implemented by the Ministry of Agriculture and Forestry in 2021, studies to increase the production of lentils continued with the projects prepared by the Provincial and District Directorates of Agriculture and Forestry, and the Ministry's contribution is provided by 75% in the supply of seeds. With the positive effect of paying 50% more difference to lentil and chickpea planting in water-limited areas, lentil planting is becoming widespread in Central Anatolia and Aegean Regions. In this way, it is aimed to reduce the impact of lentil harvest from regional and climatic risks. Due to the drought in our country as well as all over the world, there has been a decrease in the yield of 2021 due to drought.

In regions where lentils are produced, winter production should be preferred instead of summer production, and varieties with high winter resistance should be used. Considering the variety characteristics of the products planned to be grown, varieties suitable for regional conditions should be preferred, and climate and soil conditions should be taken into account. In order to minimize the yield loss caused by weed control in winter plantings, weed density should be monitored and weed control should be done twice. Weed control should be done at the appropriate time. It should be taken into account that weed control in the late period will cause yield losses and weed control in the early period is not economical. It should be included in the rotation as an alternate crop and should be encouraged to be planted as a front crop in fallow areas.

It is seen that approximately 50% of the red lentil producers grown in the Siirt region do not have the technical knowledge and sufficient financial infrastructure on weed control, and rotation systems to protect and increase the yield obtained. In this direction, technical support should be obtained from Research Institutions, Provincial and District Directorates of Agriculture and Forestry and Universities. Farmer meetings, demonstrations, and field days should be held and one-on-one meetings should be held with the farmers. It varies depending on the adaptation conditions according to the region in the cultivation of red lentils, whether for family consumption or commercial purposes. Varieties with complete soil preparation and maintenance in the spring and thus obtaining quality products are preferred in the market, they are easily cooked and delicious.

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CHAPTER 4

AGRICULTURAL RELATIONS WITH TURKEY, RUSSIA, AND UKRAINE, THE EFFECTS OF THE WAR ON THE WHEAT CRISIS: TURKEY'S POSITION

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1. INTRODUCTION

The most important issue that has been on the agenda of the world in recent months and that concerns almost the whole world is the ongoing war between Russia and Ukraine. The ongoing impact of the Covid-19 pandemic and the long-term adverse effects of climate change have led to significant increases in food prices. Decreased productivity, increasing global demand, and food supply chain problems, especially in strategic products around the world, led to a decrease in oil seed stocks, especially grains and legumes, and food prices reached the highest levels of the last decade, making access to food difficult and interrupting the supply chain. This war led to the closure of ports, the suspension of oil seed crushing and the introduction of export licenses, and restrictions and bans on certain crops and food products. While the pressure of the problems caused by the pandemic on food supply, supply, and prices continued to decrease, the war between Russia and Ukraine started on February 24, 2022. The Russian Federation and Ukraine are the leading countries in global food and agricultural trade.

Russia and Ukraine, which are the global suppliers of many basic foodstuffs, are among the agricultural powerhouse countries that make up the most important share of wheat, corn, oil seed and fertilizer exports. This war, which threatens world agriculture and therefore food security, has adversely affected all aspects of agriculture in Ukraine and has significantly slowed down exports from Russia. During this critical period, a grain corridor was opened in the Black Sea against the food crisis with the initiatives of Turkey and this process is being operated successfully. While the world countries were following the war, the vital importance of the grain corridor opened in the Black Sea in the fight against the food crisis emerged. While the grain corridor gave hope to humanity in the grip of the food crisis triggered by the war, it played a key role in solving the problem that concerns the whole world. In the war that started between Russia and Ukraine, which started in February 2022, Turkey, as the only country that can negotiate and hold contact with both countries, pioneered the opening of the grain corridor and thus the resolution of the food crisis. Following the signing of the "Safe Shipment of Grain and Foodstuffs from Ukrainian Ports Initiative Document" between Turkey, The Russian Federation, Ukraine and the United Nations (UN) on July 22 in Istanbul, the safe route began to operate and the food products began to arrive at the ports.

With the Ukraine-Russia war, the strategic importance of Turkey and the Black Sea was once again seen. Thus, in the food crisis that will affect almost all humanity, the grain corridor gave the world a breather. As a result of the effect of the corridor created in the Black Sea region, which was opened with the outstanding efforts of Turkey, in the fight against the food crisis, while the grain prices decreased, the way to access food products was opened. The steps taken by Turkey against the wheat crisis in the Black Sea were welcomed both in developing countries and all over the world. The products produced in Russia and Ukraine would remain in the domestic market and cause an oversupply due to the lack of grain shipment and thus the cessation of trade.

Due to this probable stagnation, the prices of grain and basic food products would tend to increase due to the excess demand in consumer countries. African countries and some Asian countries meet a significant portion of the need for basic food products, especially grains, through imports. As aItin an extremely important position for low-income and underdeveloped countries and developing countries. With the cooperation of Turkey, Russia, and Ukraine, studies are, carried out sensitively for the continuation of the success of the grain corridor in the Black Sea. Today, wheat has strategic importance because it is the raw material of the most basic foods such as pasta, bulgur, and bakery products, which have an important place in our diet both in the world and in Turkey (Çığ et al., 2021). With this aspect, wheat has a more important position than other agricultural products. The need for durable dry foods such as pasta and bulgur, especially in the world, who cannot leave their homes due to the COVID-19 pandemic, has also increased the demand for wheat. For this reason, wheat remains at very high prices as a result of the extraordinary demand for wheat and wheat-based products.

Wheat, which has an important cultivation area in Turkey, has a self-sufficiency degree of over 100% in the country and may decrease to 89% in some years due to reasons such as reduction in cultivation areas, yield losses, or climate change. Total domestic wheat use varies between 18-20 million tons, and wheat imports are made to meet the export of wheat-based products. Considering the reductions in planting areas and the yield losses due to climate change, the use of certified seeds will increase the yield It is of great importance in terms of ensuring the supply and thus meeting the total demand (TEPGE, 2021).

This study aims to prevent a possible wheat crisis by being aware of the agricultural relations between Turkey, Russia and Ukraine countries the effects of the Russian-Ukrainian war on the wheat crisis, the duties and responsibilities of Turkey based on its strategic position, and the possible exposure of the world to the danger of starvation. In this study, the negative consequences of the war and Turkey's mediator identity in the war were revealed.

2. AGRICULTURAL STRUCTURE OF UKRAINE AND AGRICULTURAL RELATIONS BETWEEN TURKEY AND UKRAINE

Ukraine remained between the European Union and Russia, and experienced demographic differentiation as well as the ethnic and religious differences it already has; As a result, they faced many obstacles in the construction of the modern Ukrainian nation, which is seen as their own identity (Bingöl, 2014; Brzezinski, 2005).

Ukraine, which gained its independence with the collapse of the USSR, has been one of the countries that felt the tightness between the European Union (EU) and Russia most intensely in terms of economic, political, cultural, and security aspects of the post-communist period (Özkural Köroğlu, 2015). Relations between Turkey and Ukraine started with the "Trade and Economic Cooperation Agreement" signed in 1992 and entered into force in 1994 (Middle Black Sea Development Agency, 2011; Özdal and Demydova, 2011).

With the first agreements, opportunities that may arise in the tourism and construction sectors and the diversity of Ukraine's resources for tourism were seen (Middle Black Sea Development Agency, 2011). Ukraine is one of the countries with favorable climatic conditions and rich in organic. In this respect, it is one of the countries with the highest production potential in the world. Approximately 15% of the total working population in the country operates in the agricultural sector. Most of the agricultural enterprises in Ukraine are state enterprises larger than 3,000 hectares. In addition to state enterprises larger than 8,000 hectares, there are also small family businesses in the country. 90% of fresh fruit and vegetable production is made on this small farm (TOB, 2016).

Approximately 71% (42.8 million hectares) of the country's total land assets are arable lands, and the total amount of agricultural land is 32.5 million hectares. About 1/3 of Europe's arable land is located in Ukraine. About 2/3 of this land is agriculturally very rich black soil. The climate of the country is suitable for growing both summer and spring crops. Annual precipitation in Ukraine is approximately 600 mm/m² and 350 millimeters of this falls on the soil between April and October when the plant is most developed (Anonymous, 2016a).

Wheat is one of the most important agricultural products in Ukraproductscultivated throughout the country, especially in Central and Southern Ukraine. Although it is preferred throughout the country, about 95% of winter wheat is planted in autumn and harvested in July and August. About 80% of the harvested wheat is processed into flour and the remaining part is processed as by-products (TOB, 2016). Barley has become one of the most important forage crops, exceeding wheat production in the last ten (10) years. Summer barley, planted in April and harvested in August, accounts for 90% of the total barley cultivation and is mainly cultivated in eastern Ukraine. Winter barley is cultivated only in the lands in the south of the country. The increased production amount and the decrease in the demand for grain in the country have led to an increase in export potential. A significant part of the wheat and barley sold to the foreign market is exported to Europe, North Africa, and the Middle East (Anonymous, 2016a).

Corn plant, one of the industrial plants, is the third most important forage crop in Ukraine. The amount of agricultural land is increasing despite the fact that equipment cannot keep up with our age and meet the needs and additional input costs. Corn is cultivated mainly in the Eastern and Southern Ukraine regions. The product sown in the last week of April or the beginning of May is harvested in the last has December or the beginning of October. Approximately 25-50% of the corn agriculture in the country is used as a grain and the remaining part is silage. The production of corn, which is mostly used in the poultry and pig sectors, has increased due to the increase in investments in the poultry sector in the 2000s. Russia and Belarus are the biggest suppliers of Ukraine in corn imports (Anonymous, 2016a).

Sunflower is the main oil seed crop of Ukraine and its production is concentrated in the southern and eastern regions of the country. Due to its low production cost, high price, and high demand, sunflower seeds are preferred by farmers in the country.

Among the most important problems faced by the Ukrainian agricultural sector are the loss of productivity and labor due to the low number of modern agricultural machinery, the lack of storage facilities for the harvest, the difficulties experienced in the privatization of state enterprises, and the high debt burden of the farmer to the banks (TOB, 2016).

3. AGRICULTURAL STRUCTURE OF RUSSIA AGRICULTURAL RELATIONS BETWEEN TURKEY AND RUSSIA

About half of the land area of Russia, which is the largest country in the world in terms of area, consists of forest areas. The lands used for agricultural purposes within the total land assets of the country constitute 13% of the total land assets and the existing agricultural land assets correspond to approximately 1/3 of the world agricultural land average (World Bank & FAO 2020).

It is seen that the rainfall is not sufficient in approximately 80% of the existing agricultural land assets in Russia. In Russia, it is seen that the share of irrigable lands in the total agricultural land was around 2% in 2008, and this rate increased to 8% within the scope of the soil renewal and development programs implemented in the 2010-2020 period. Considering all the enterprises that carry out their agricultural activities throughout the country, the average enterprise size of 269 hectares reaches up to an average of 12 thousand hectares in large agricultural enterprises (Ministry of Commerce, 2021).

The 2000s were a turning point for the agricultural sector in Russia. Showing an unstable performance before 2000, Russia has succeeded in rapidly increasing its level of integration with the global agricultural markets since 2000.

According to the data of the Federal State Statistics Service (Rosstat) in Russia, where the potential of the agricultural sector in the economy is more limited than in Turkey, those living in rural areas within the country constitute approximately ¼ of the total population. The agricultural sector in Russia has a share of 4.1% of the national office, with an added value of approximately $60 billion (Turkey: $47.3 billion) in 2020. On the other hand, Turkey has a 6.6% share of the national product with an added value of 47.3 billion dollars. In Russia, whose real economy contracted by 3.1% in 2020, when the COVID-19 pandemic occurred, the agricultural economy, which is very sensitive to grain production, maintained its 2019 level in real terms with the effect of the second highest grain yield achieved (Ministry of Commerce, 2021).

In the agricultural sector, which has a share of 5.8% of the total employment in Russia throughout the country, employment opportunities have been provided to approximately 4.2 million people. In Turkey, this rate is 16.7% and 4.5 million people have been employed (Ministry of Trade, 2021).

Russia, which is among the top five countries in terms of grain yield in the world, achieves a grain yield of proximately 130 million tons. The country ranks first in oat, buckwheat, and barley production, and ranks third in the world in rye and wheat production according to the data of the Unitedions Foodfmmmnd Agriculture Organization (FAO).

The total grain production in the country in 2020 is approximately 133 million tons, which is among the highest yield levels. In 2020, a total of 85.9 million tons of wheat, 20.9 million tons of barley, 13.9 million tons of corn, 4.1 million tons of oats, 2.4 million tons of rye, and 892 thousand dries of buckwheat were produced (T.C. Ministry of Trade, 2021).

In Russia, which is the leading country with sugar beet production of 54.4 million tons in 2019, beet production decreased by approximately 40% in 2020 to 32.4 million tons. Sugar production, which was obtained in a very large amount of 7.3 million tons in the 2019 production year, fell to 5.8 million tons in the 2020 production year, remaining below the annual consumption need. In the last 10 years, the production areas of sunflower seeds increased by 20% to 8.6 million hectares, and the production in 2019 reached a record level of 15.4 million tons, leaving Ukraine behind to become the leading country in production. However, due to adverse climatic conditions, total production decreased to 13.3 million tons in 2020. The increasing trend in sunflower oil production, which increased by 15% in 2019 to 5.4 million tons, continued in 2020 and reached 5.9 million tons (Ministry of Trade, 2021). Considering world production; Russia, which is in second place in dry peas and third in potatoes, is among the top four countries in the world in carrot and cauliflower, where field vegetable production is intense. Russia, which is the leading country in terms of production amount in sour cherry and raspberry cultivation, is also among the main producer countries in pine nut cultivation (Ministry of Trade, 2021).

In addition to field production, Russia has taken its place among the top 3 countries after Turkey on a global scale, especially in cucumber products, with its increasing greenhouse production potential. In the last five years, Russia continues its development in greenhouse vegetable cultivation, which has increased its total greenhouse areas by approximately 40% to more than 2,800 hectares (about 1,500 hectares with high technology) and increased its production in this area by 78%

(Ministry of Trade, 2021). Russia, which has approximately 1.5 million tons of product obtained from greenhouse production in 2020, achieved 600 thousand tons in tomato production and 850 thousand tons in cucumber production (Ministry of Trade, 2021).

In the winter period, the self-sufficiency rate can reach 50% in tomatoes and 85% in cucumbers and tomatoes addition, the total per capita consumption of tomatoes and cucumbers in the winter period has increased by nearly 20% and exceeded 12 kg in recent years. In Russia, where approximately 40 thousand tons of other greenhouse products are produced, the Ministry of Agriculture aims to increase greenhouse production to a total of 1.6 million tons by 2025 (Ministry of Trade, 2021).

According to the data of the Turkish Statistical Institute (TUIK); Our agricultural imports of approximately 3.1 billion dollars from Russia in 2020 mainly consist of processed agricultural products such as wheat, raw sunflower oil and corn products, and wheat bran, sunflower seeds and meal.Our food industry, which processes the raw materials supplied by Turkish entrepreneurs at international prices and markets them to third countries through export, has preferred Russian origin raw materials the most (by taking into account the factors such as deadline and price quality) in the cultural products since 2012 (Ministry of Trade, 2021).

4. WHEAT TRADE INDICATORS OF TURKEY, RUSSIA, AND UKRAINE AND THE WORLD, WHEAT PRODUCTION POTENTIAL

Domestic use of wheat in Turkey is 20 million tons as of the 2019/20 production period, and this amount is consumed in the food sector (80%), feed industry, (11%) and seed (6%). According to TUIK data, although the degree of proficiency changes according to years, it is at the level of 89% in the 2019/20 production season. Venezuela, Yemen, Somalia and Iraq are among, the countries to which Turkey exports wheat and wheat products. The country from which Turkey imports more wheat is Russia. The rate of Wheat imported from Russia constitutes 64.6% of the total imports from Turkey. As of the thfrom2019/20 production period of Turkey, the share of imports in the total wheat supply is 37%. In the first four months of 2021, wheat exports decreased by 9% compared to the same months of the previous year and decreased to 1.35 million tons, while imports decreased by 24% to 3.01 million tons in the same period (TEPGE, 2021). World wheat production and important producer countries are given in Table1.

Table 1: World Wheat Production and Major Producer Countries (million tons) IGC Arpil 2021 (*) GueApril TUİK (**)

Countries	**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**	**2019-2020**	**2020-2021**
EU	118,6	122,5	123,7	128,3	132,6	133,3	134,3	131,4	133,6	134,3
India	138,1	132,6	143,2	156,1	159,6	144,2	151,4	137,7	154,9	124,5
Russia	86,9	94,9	93,5	95,9	86,5	86,0	98,5	99,7	103,6	107,9
USA	54,2	61,3	58,1	55,1	56,1	62,8	47,4	51,3	52,6	49,7
Canada	25,3	27,2	37,6	29,4	27,6	32,1	30,0	32,2	32,3	35,2
Austuralia	29,9	22,9	25,3	23,7	22,3	31,8	21,2	17,3	15,2	33,3
Ukraine	22,3	15,8	22,3	24,7	27,3	26,8	27,0	25,1	29,2	25,5
Pakistan	24,2	23,3	24,2	26,0	25,5	25,6	26,6	25,5	24,4	25,2
Türkiye**	21,8	20,1	22,1	19,0	22,6	20,6	21,5	20,0	19,0	20,5
Argentina	14,5	8,0	9,2	13,9	11,3	18,4	18,5	19,5	19,8	17,6
Kazakhstan	22,7	9,8	13,9	13,0	11,3	18,4	18,5	195,5	19,8	17,6
Other	86,3	82,9	92,8	87,8	92,9	87,9	86,7	86,9	92,3	100,9
Wolrd Total	701,0	659,0	718,0	732,0	739,0	757,0	763,0	732,2	762,0	774,3

Wheat production increased in China, India, Russia, Ukraine, Canada, Australia and Kazakhstan in, 2020/21 compared to the previous period; decreased in the EU, USA, Ukraine and Argentina due, to adverse weather conditions. World wheat production and import and export data are given in Table 2.

Table 2. World wheat production and import and export data-thousand tons (USDA, 2021)

Years	**2017-2018**	**2018-2019**	**2018-2019 -1**	**2019-2020 -2**	**2020-2021 -3**
Area(thousand ha)	218.475	215.439	216.654	221.848	223.790
Yield (ton/ha)	3,49	3,40	3,53	3,50	3,53
Production	762.557	731.552	764.156	776.097	788.978
Consumption	740.499	733.179	741.805	774.267	785.297
Year-End Stocks	287.816	284.084	299.439	294.667	294.962
Imports	184.046	174.053	187.880	294.046	199.036
Export	185.427	176.158	194.876	199.648	202.422
Export Price (Dollars/ton)	211	241	219	239	284

In the 2020/21 period, global wheat trade was 189 million tons with an increase of 5 million tons compared to the previous year, supported by the imports made especially by China and Pakistan. Pakistan's imports increased to 3 million tons and China's imports for the 2020/21 period increased to 10 million tons. In the 2020/21 production period, world wheat stocks increased by 11 million tons to 289 million tons, and the highest closing stock of recent years was recorded. The increasing stocks of the EU and the US were somewhat offset by the decrease in China. There has been a slight decrease in China's stocks due to increased feed use, and while wheat production in China, India, Russia, Ukraine, Canada, Australia and Kazakhstan increased, in the 2020/21 production period compared to the previous period; decreased in EU, USA, Ukraine and Argentina due to adverse weather conditions (TMO, 2022).

According to USDA's June 2021/22 production season indicators, total grain production in the world was 2.8 billion tons and wheat was among the most important grain products with a rate of 28% in this harvest. In the same production season, a total of 464 million tons of grain was exported in the world, and wheat had an important place in this export volume with a rate of 41%. As of the 2021/22 production period, Russia, China, EU, USA, and India account the d for 54.8% of the world wheat cultivation area, while these countries had a share of 65.1% of world wheat production of the world wheat cultivation area, which was 222 million hectares in the 2020/21 production period, is expected to increase by 0.9% to 224 million hectares in the 2021/22 production period. Depending on the forecast of an increase in the world when its cultivation area compared to the previous season, it is predicted that world wheat production, which was 776 million tons in the 2020/21 production season, will increase by 1,7% in the 2021/22 production season and will reach 789 million tons. World wheat yield is predicted to increase by 0.9% in 2021/22 production areas on. In line with the forecast of an increase in world wan heat production, it is predicted that world wheat ending stocks will increase by 0.1% compared to the previous season and reach 295 million tons in the 2021/22 production season (IGC, 2021).

The export amounts of Russia, Turkey, Australia, Canada, USA and European Union countries, which are the main wheat exporting countries in the world, are given in Figure 1 in percentile.

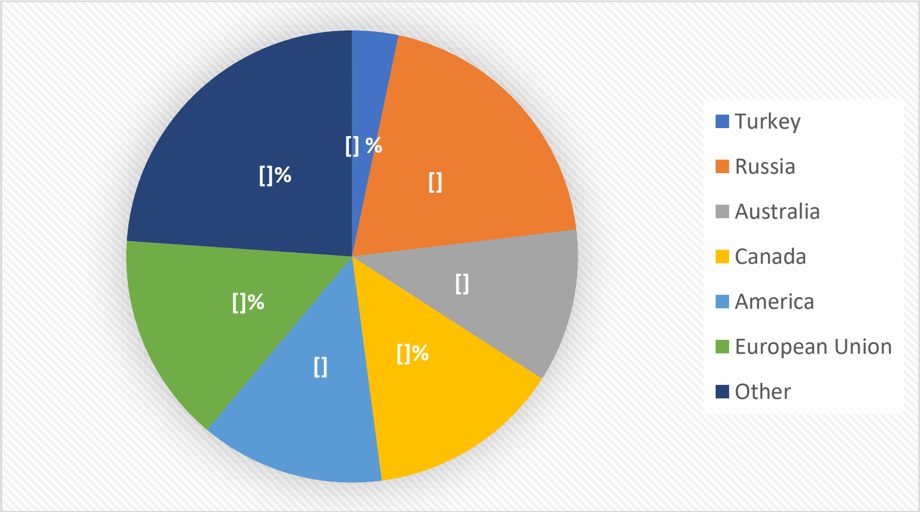
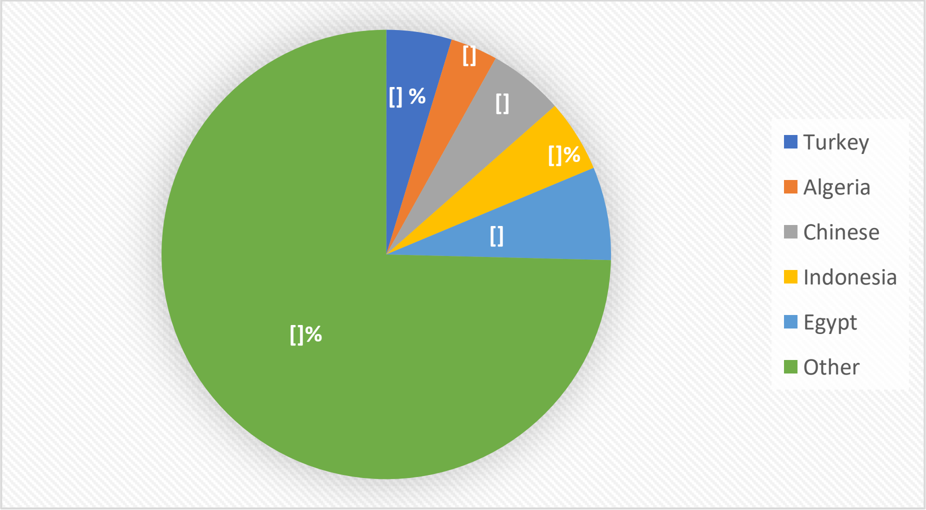


Figure 1: Share Of Major Countries İn World Wheat Export By Country (TEPGE, 2020/2021)

The export amounts of Egypt, China, Algeria, Indonesia and Turkey, which are the main wheat importing countries in the world, are given in Figüre 2 in percentiles.



Figüre 2: Share Of Major Countries İn World Wheat Import By Country (TEPGE, 2020/2021)

Russia, Ukraine, the USA and EU countries, which are the leading producers of wheat export in the world, are in the first place. Then, Canada, Australia and Turkey are, shown among the important wheat exporting countries. According to the data of the US Department of Agriculture (USDA), in the 2020/2021 production season, Turkey ranks 9th in the world ranking with its wheat export of 6.6 million tons. In the 2021/22 production season, world wheat exports are expected to increase by 1,4% to 202 million tons due to the rise in the main exporting countries. World wheat import, which was 193 million tons in the 2020/21 production season, is expected to increase by 3.1% to 199 million tons in the 2021/22 production season (TEPGE, 2021).

Although there was an increase in production in 2020, world wheat export prices (HRW) increased by 9.2% compared to the previous season to $239/ton as the demand for wheat products increased too much due to the COVID-19 outbreak. According to the averages for the first four months of 2021, this increase continues and increased by 18.9% compared to 2020 and reached $284/ton (TEPGE, 2021).

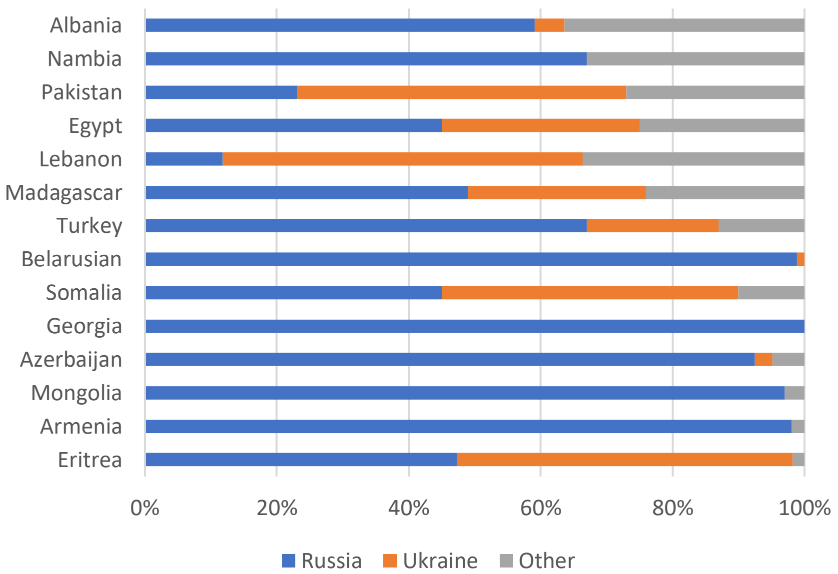
Over the past 30 years, the Black Sea region has been an important global supplier of cereals and the most basic food products. After the collapse of the Soviet Union, the region was a net importer of grain in the early 1990s, while today Russia and Ukraine's exports account for about 12% of the total calories traded in the world. The two countries are among the top five global exporters of many important grains and oil seed crops such as wheat (34.1%), barley (26.8%), sunflower (23.99%) and corn (1,7.4%). Ukraine is also an important source of sunflower seed oil, providing approximately 49.6 percent of the global market (Anonymous, 2016b). When we add Russia to this figure, this share rises to 72.7 percent. The country, which is in the position of many importers, is dependent on these agricultural products from Russia and Ukraine. The Middle East and North Africa regions import more than half of their grain needs and most of the wheat and barley from Ukraine and Russia. Ukraine is an important supplier for many North African markets, including Egypt and Libya, as well as the EU and China. On the other hand, in terms of agricultural inputs, Russia, which is the focus of the war, and Belarus, which supports it, are among the very important supplier countries.

Ukraine as of 2015; In terms of agricultural products, our country is in the 28th rank (share 0.9%) in the ranking of the countries to which it exports, but it is in the 2nd rank (8.1%) in the ranking of the countries that our country imports. When we look at the composition of the imports of agricultural products, the majority of the imports consist of soybean, wheat bran and sunflower meal, which are used as feed raw materials and whose production is insufficient in our country, and bread wheat and raw sunflower oil, all within the scope of the Internal Processing Regime (DIR). As an important development in relations with our country, additional taxation on walnut imports from Ukraine was terminated on 18.11.2015 (TOB, 2016).

When Turkey's foreign market potential is analyzed, it is seen that Turkey exports mostly fresh fruit and vegetable products to Ukraine, especially ready-made foods and confectionery products, white meat, vegetable oils, eggs, dairy products, tobacco products, and aquatic products. It has important export potential in vegetable seeds. Turkey's share in Ukraine's citrus imports in the last five years is approximately 36%, and it is observed that this rate may increase (TOB, 2016).

Percentage rates of the countries to which Ukraine and Russia export wheat in 2021 are given in Figüre 3.

Figure 3: Percentage Ratios of Wheat Exporting Countries by Ukraine and Russia in 2021 (FAO,2021)



Wheat export and import amounts (tons) and income from exports (thousand dollars) of Russia and Ukraine countries between 2016-2020 are given in Table 3.

Table 3: Wheat Export And İmport Amounts (Ton) And İncome From Exports (Thousand Dollars) Of Russia And Ukraine Between 2016-2020 (FAO,2021)

Russia	**2016**	**2017**	**2018**	**2019**	**2020**
Export Amount (tons)	25.326.784	33.025.971	43.965.626	31.873.170	37.2670.14
Export Value (Thousand Dollars)	4.215,80	57.910,13	84.324,93	64.030,11	79.182,94
Import Amount (tons)	579.923	269.028	344.248	191.578	190.042
Import Value (Thousand Dollars)	89.011	39.709	60.466	48.620	64.839
Ukraine	**2016**	**2017**	**2018**	**2019**	**2020**
Export Amount (tons)	17.920.945	17.314.278	16.373.389	13.901.207	18.055.673
Export Value (Thousand Dollars)	2.717.474	2.759.757	3.004.359	3.224.194	3.594.217
Import Amount (tons)	2.507	3.755	4.040	35.869	10.940
Import Value (Thousand Dollars)	2.100	3.032	2.806	10.706	3.645

The critical role played by Russia and Ukraine in global wheat farming is more evident in terms of international trade. Both countries are net wheat exporters. It plays a leading role in the supply of wheat products to global markets.

5. THE IMPACT AND RISKS OF THE RUSSIA-UKRAINE WAR ON THE WORLD AND TURKEY

The war, in particular, caused a decrease in the amount of agricultural production in the region, problems in the food supply chain and logistics disruptions, as well as risks that were reflected all over the world and negatively affected global food security. Millions of people in Ukraine were forced to relocate and migrate within the country.

It is clear that the outcome of the war was massive, and the deterioration of agricultural growth, food security and livelihoods negatively impacted global food security and the supply chain, especially in Ukraine. Before the Russia-Ukraine war, international food prices reached their highest levels. This was mostly due to market conditions, but also to high energy, fertilizer and all other prices. Grain agriculture in Ukraine, Russia and Kazakhstan, which are located in the region called the Black Sea Region, has an extremely important place in terms of production and export volume.

Considering the share of the two countries in some products, it will be seen that they have the power to change the balance in world trade. 90 percent of exports from Ukraine are carried out through ports. In this context, with the start of the war, there was a risk of loss of more than 15 million tons of different commodities that Ukrainian farmers were planning to export. Considering that the capacity of the Western Ukraine border and the railway connection is around 300 thousand tons per month, Ukraine's trade logistics, which exported about 4-5 million tons of goods in the spring months, were at great risk (Anonymous, 2022).

These risks are at the forefront of the issues that need to be focused on, both at the global level, in terms of Ukraine and Russia, and in terms of Turkey, which imports advanced agricultural products and inputs from these countries. The war had caused the closure of oil seed processing facilities, especially ports, and strategically important commercial and agricultural facilities. Due to the sudden and sharp decline in the shipments made by both countries, the countries importing wheat from Russia and Ukraine would have to seek alternative sources and have to procure products at higher costs, and there would be a risk that the countries would face supply shortages.

Considering that the world wheat export is 200 million tons on average, 60 million tons, which corresponds to about 30 percent of this export, is carried out by Russia and Ukraine. Russia and Ukraine carry out 1 million 250 thousand tons, which corresponds to 32 percent of sunflower seed exports, 38 million tons, which is 19 percent of corn exports, and 10 million 500 thousand tons, which constitutes 31 percent of barley exports. War also threatens the next production period. It is a worrying situation for the future periods that the Ukrainian farmers and those living in rural areas remain uncertain whether they can continue their lives, make a living and continue agricultural production in the war environment. Production sustainability was adversely affected by the Russia-Ukraine war.

Damages to agricultural lands and processing/operation facilities, production logistics problems and labor supply difficulties can be shown among important production risks. To ensure the continuation of agricultural activities, there was an energy risk in agricultural activities supported by fuel, pesticides, commercial fertilizers and many inputs. In this respect, agricultural production is dependent on energy. Risks such as production, energy and labor supply in rural areas concern the whole world in the war zone (UHK, 2022).

Again, in our country, except for the extreme years, wheat production generally meets domestic consumption, but a certain amount of wheat is imported every year to process the wheat within the scope of the inward processing regime and export it as a finished product. Our country maintains its effectiveness as the first country in the world in flour and bulgur export and the second country in pasta export. In dry years, a certain amount of wheat import is required for domestic consumption, as in the previous year.

The direction of this import is mainly from Russia and Ukraine due to reasons such as geographical location, logistical conveniences, reasonable prices and high quality. Therefore, the war between Russia and Ukraine, which started after the epidemic, directly affected the wheat sector of our country, both on the product and the inputs. In this process, with the support of our state, TMO revised and republished its purchase prices twice in 2022 and continued to support Turkish farmers. Revised Grain Purchase Prices for the 2022 Period of Turkish Grain Board (TMO) are given in Table 4.

Table 4: Revised Grain Purchase Prices Of Turkish Grain Board For The Period Of 2022 (TMO,2022)

TYPE		PURCHASING KODE	PURCHASING CODE (TL/TON)
ROLLER WHEAT	Durum Wheat	1121	7.000
		1122	6.900
		1123	6.875
	Low-Quality Durum Wheat	1141	6.600
BREAD WHEA	White and Red Hard Wheat	1211-1221	6.550
		1212-1222	6.450
		1213-1223	6.425
	Other White and Red Wheat	1311-1321	6.450
		1312-1322	6.425
		1313-1323	6.400
	Low-Quality Bread Wheat	1611-1621	6.375
NON-STANDARD WHEAT		1690	6.000
BARLEY-RYE-OAT-TRITIKALE		2111-2211-2221-2311	5.800
		2112-2212-2222-2312	5.700
NON-STANDARD BARLEY		2190	5.450

As can be seen from the Revised Cereal Purchase prices of the Turkish Grain Board for 2022 (TMO), the continuity of production was encouraged by giving a purchase guarantee to the farmers engaged in wheat farming.

6. CONCLUSION AND RECOMMENDATIONS

The Russian-Ukrainian war will cause problems in the maintenance and harvesting of the cultivated products in the 2022 production season in Ukraine, as well as the expectation that it will continue to affect the products to be planted and in the following production seasons. There are problems in the food supply chain, especially in logistics, and the closure of ports and critical commercial enterprises.

The increase in agricultural commodity prices due to the ongoing problems between Ukraine and Russia, which are among the world's largest countries with grain export potential, increased the concerns about food security risks, especially in import-dependent countries in Near East Asia and Africa. In addition, grain prices increased due to the ongoing uncertainties in the grain trade in the Black Sea region and the global demand supply.

Since Russia and Ukraine have a very important place in the world in terms of the production and export of basic agricultural products such as wheat, sunflower and corn, Turkey has taken initiatives to end the war as soon as possible by fulfilling its responsibility in the region.

In case of failure to comply with the 'Safe Shipment of Grain and Foodstuffs from Ukrainian Ports Initiative Document' agreement, the trade risks brought by the war and the food supply chain will be adversely affected in the countries that were adversely affected by the war, which will expose these countries to downsizing policies, increase the threat of famine in the world, and create food insecure masses. will face starvation deaths.

Turkey should act by taking all necessary measures by engaging in international diplomatic activities on the subject to reduce all the effects and risks that arise, even if it is not possible to eliminate them even when the war continues and even if it ends.

It is the common wish of the world to end the war between Russia and Ukraine as soon as possible due to both humanitarian and economic reasons. However, similar problems and crises between countries have opened alternative ways for countries in the recent past.

With the increase in soybean prices, which is an important feed input, the export quota of the USA to Brazil in 1973 made Brazil an important soybean producer in the world; After the invasion of Afghanistan, the export quota of the USA to Russia in 1980 made Russia an important wheat producer in the world. Like the countries that import from these countries, Turkey will have to open doors that are not very dependent on foreign countries in terms of the products and inputs in question (Anonymous, 2022)

Projects to bring water from external basins to basins with insufficient water should be reviewed, and the ongoing dam and pond projects should be completed quickly.

Agricultural products, food, and fertilizer trade should continue unhindered under the leadership of Turkey. Every year, 3.5 million hectares of fallow agricultural lands in our country should be planted less frequently in the fallow year, and the cultivation of cool climate cereals, winter legume forage crops, grain legumes such as chickpeas and lentils, oil crops such as sunflower and safflower should be encouraged.

Social projects that will prevent the emptying of rural areas should be put into practice urgently. Efficient use of precipitation and water resources should be ensured in agriculture. In the fields of field crops grown in irrigated conditions, a four-year crop rotation practice should be applied and this practice should be supported by an incentive system. By operating the inspection mechanism throughout Turkey, producers should be encouraged to invest in renewable energy and the cost of agricultural energy should be reduced by coming together in cooperatives and unions.

Especially in wheat, agricultural insurance should be made compulsory, TARSİM support rates should be increased and necessary inspections should be provided. It is thought that the agriculture and food sector will be the most affected sector due to the grain crisis. Due to the recent COVID-19 epidemic, the foreign trade volume has decreased significantly and there have been signs of deterioration in the foreign trade balance due to logistics problems.

With the addition of the war, the concern of a global crisis in the agriculture and food sector is experienced by many countries. As a natural consequence of war and pandemic; The slowdown in logistics, the strict sanitary measures applied in sea and land transportation, and the restriction or preparation of restrictions on the export of agricultural products by more than thirty countries (including countries with strong relations in the supply of raw materials such as Russia, Ukraine, Kazakhstan) have revealed the trend of rising food prices around the world. Although it is known that world wheat production will increase and the stocks will reach a record level, a national mobilization should be declared and measures should be taken in this direction in line with the predictions of an increase in wheat prices due to the reasons listed above.

The important findings that will reveal the relationship of this war with food and grains in particular are as follows; Russia and Ukraine are the global suppliers of many basic foodstuffs; As a matter of fact, these two countries provide 12% of the total calories traded in the world. These countries account for 25-30% of global sunflower exports, 27-30% of barley exports, 30-34% of wheat exports, 17-20% of corn exports (UHK, 2022).

The expectation is that the war will cause problems in the maintenance and harvesting of agricultural products grown in the 2022 production season, especially in Ukraine, and that it will continue to affect the crops to be planted and in the following production seasons. Even in this production season, it is estimated that there may be decreases of over 5 million tons in wheat production and over 10 million tons in corn production (UHK, 2022).

Russia's natural gas exports account for 20% of global trade (much more in EU countries). Russia's natural gas potential causes extraordinary increases in energy prices, and there is a direct relationship between energy and agricultural activities and significant production cost increases over energy-intensive inputs (such as fertilizers, and pesticides) trigger food prices. Russia has a global export share of approximately 15% in nitrogen and potassium fertilizers, and Belarus, which is a party to the war, has a global export share of approximately 15% in potassium fertilizers. The restriction of their trade has also lifted global fertilizer prices to the top. Adding the following issues to all these makes the food problem even more intractable. There is an increasing trend in the conversion of energy crops, led by oil crops and grains, into bio-fuels, which is associated with the exponential increase in fossil fuel prices, and this causes a contraction in the food supply, which will result in countries turning to stockpiling in crisis environments, reducing exports or banning them. should be foreseen.

It should be foreseen that important problems may arise in access to food as a result of individuals' tendency to individual stocking in basic products as a result of food supply insecurity due to the epidemic period habit and panic and that significant increases in global food prices will occur, and inflation pressure will occur even in countries that have not met inflation before. measures should be taken to correct the problems. FAO announced that the February Global Food Price Index has reached an all-time high. Moreover, there was war pressure on only two days of February, so the index continued to increase in March as well. It is estimated that the amount of world wheat production will increase slightly compared to the previous production season and will be at the level of 780 million tons. It is predicted that the rise and fluctuations in prices will continue due to the covid-19 pandemic and the problems caused by the war.

In the first year of the epidemic period, again in the UHK May 2020 report, The fact that there is no food problem in Turkey, while the market shelves are empty even in many developed countries during the pandemic period, indicates the high agricultural-food potential of our country. However, while the world was affected by the epidemic, the ongoing war that started right next to us was added to this. In terms of wheat, a more difficult process emerged when the production declined as a result of the agricultural drought in 2021 combined with the effect of the epidemic and war.

Turkey; The war between Russia and Ukraine has assumed a historical responsibility and has saved the whole world from mass grievances against possible food crises and supply chain disruption.

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CHAPTER 5

BOILING STONE: USAGE OF ZEOLITE IN AGRİCULTURAL PRACTICES

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1. INTRODUCTION

For the sustainability of agricultural activities, it is necessary to ensure that fertile soils are always needed and the future uses of the soil remain at an optimum level (Doran et al., 1996). The soil should have high biological activity and organic matter, good aggregate stability, allow plant roots to move freely, and easily infiltrate water into soil (Lewandowski and Zumwinkle, 1999). Organic and some inorganic materials accelerate the development of microorganisms in the soil and increase aggregation (Demiralay, 1993; Ucar et al., 2021).

Zeolite is a crystalline, easy and abundant aluminum silicate containing alkaline earth cations. Natural zeolite, which is a good soil conditioner, is called the "boiling stone" and was discovered in 1756 by the Swedish mineralogist Fredrich Cronstdet. The structural unit of zeolite is AlO_4 or SiO_4 quartet (Mumpton, 1978). Zeolites are aqueous amino-silicates containing alkali and alkaline earth cations (K^+, Na^+, Ca^{+2} and Mg^{+2}) and have a three-dimensional structure in the form of crystals (Yalçın et al., 1987; Balevi et al., 1999). Eight of the zeolites are of commercial importance in the world. These are Clinoptilolite, Chabasite, Analcime, Erionite, Ferrierite, Hoylandite, Laumontite, Mordenite, and Fillipsite. Clinoptilolite is one of the most important mineral groups of natural zeolites with features such as being widespread in the world, wide application area, economic operability and homogeneity

The most important feature of zeolite minerals is that they act as a sieve due to the liquid and gas molecules that can easily enter and displace the cavities within. It is stated that the zeolite contains numerous water molecules and exchangeable metallic ions in its lattice structure, the water held by the zeolite becomes free in dry times, and more water is not accepted by keeping it in the water body in rainy times (Köksaldı, 1999).

Zeolite keeps the nutrients in the root zone of the plants and allows them to be used when necessary. In this way, nitrogen and potassium fertilizers are used more effectively. Zeolite increases nutrient uptake by increasing the availability of phosphorus from phosphorus sources in the soil, promoting the use of NH_4-N and NO_3-N nitrogen, and reducing leaching losses of exchangeable cations, especially K (Barbarick et al., 1990; Bernardi et al., 2008). Another benefit of zeolite application is that unlike other soil additives (gypsum and lime), it does not dissolve over time, instead, it remains in the soil to help retain nutrients. The use of natural zeolites in agricultural areas is mainly the preparation of fertilizer-soil mixtures, agricultural struggle and soil pollution control. The high adsorption and ion exchange capacities of clinoptilolite and mordenite, especially the selectivity of clinoptilolite towards ammonium ions, enable such zeolites to be used in soil preparation, as additives in N-based fertilizers or as direct fertilizer.

Zeolite tuffs have been used for many years to remove the foul smell of fertilizers, control their content and increase the pH of acid volcanic soils. In addition, by using clinoptilolite as a carrier in fertilizer preparation due to its high ammonium selectivity, more efficient use of ammonium by plants and fertilizer savings are provided. Natural zeolites are also used as drug carriers in agricultural production due to their high ion exchange and absorption capacity (Anonymous, 2001). The cation selection and exchange properties of natural zeolites can be utilized not only in the transfer of nutrient ions to the plant but also in the retention of harmful heavy metal cations in the nutrition chains. Natural zeolites are used effectively in cleaning the pollution caused by biological residues in lakes and ponds. In addition, natural zeolites are also used to provide the oxygen-rich airflow needed in live fish transportation and aquaculture environments. The usability of natural zeolite, especially in sapling production, in poor sandy soils and afforestation areas in arid/semi-arid areas, has been examined to increase the success of plantation and its possible contributions to the forestry sector have been trying to be examined. Due to the known properties of zeolite, it is stated that as a result of its addition to the soil, it improves the water regime and prevents the washing of plant nutrients.

One of the important problems in agricultural production is the removal of nitrogen fertilizers from the soil in the form of nitrates without the use of plants. It is known that nitrogen fertilizer in the soil is lost as NH_3 gas and NO_3 as a result of washing. The use of zeolite reduces nitrogen fertilizer leaching due to its high selectivity to ammonia and ammonium exchange capacity. It can be ensured that NH_4^+, which is given to the soil as fertilizer, is washed with water and taken from the soil and kept in the soil by preventing it from being transported to other places.

2. TURKEY'S POTENTIAL FOR NATURAL ZEOLITES

Natural zeolites have not yet taken their place in the world market. The main reason for this is that although synthetic zeolites, which can be produced in desired purity and desired pore diameters, are more widely used in industry, the usage areas of natural zeolites are more limited than synthetic zeolites. However, it is not a remote possibility that natural zeolites will shortly gain superiority over synthetic zeolites and they will be used more intensively. It is stated that Turkey is a rich country in terms of natural zeolite resources (Altan et al., 1998). It has been determined that the existing zeolite reserves are in large volumes such as 45.8 billion tons (Anonymous, 2001; Kocakuşak et al., 2001; Köksaldı, 1999). Clinoptilolite is also important in Turkey with its reserves, formation, homogeneity and high mineral quality. Zeolite, which is widely available in Turkey, finds wide use in livestock feed additives, animal bedding, growing media in plant production, as a fertilizer additive, as well as in the containment of toxic wastes, waste and utility water treatment. Analcime formations were detected for the first time in our country in 1971 in the vicinity of Gölpazarı-Göynük. Later, Analsim and Clinoptilolite deposits were found in the west of Ankara. Manisa-Gördes and Balıkesir-Bigadiç are expressed as the most important zeolite deposits of Turkey and the zeolites here are easily exploitable.

In our country, there are zeolite deposits in Göynük, Polatlı, Oğlakçı, Ayaş, Nallıhan, Çayırhan, Beypazarı, Mihalıççık, Kalecik, Çandır, Balıkesir-Bigadiç, Emet-Yukarı Yoncaağaç, Gediz, Gördes, regions (Anonymous, 2001; Kocakuşak et al., 2001). As a result of the studies carried out in the field only in Balıkesir-Bigadiç and Manisa-Kululuk, it has been determined that there is an easily exploitable potential of approximately 500 million tons. In our country, which has a significant reserve potential in terms of zeolite, the usage areas and technological properties of zeolite need to be investigated extensively. In the agricultural field, the application of zeolite applications on soils of different regions has a positive or negative effect on soil properties and how it affects the uptake of different plant nutrients and their use by plants. Thus, besides the contribution of our natural zeolite potential to the country's economy, it will provide great benefits in order to prevent agriculture and animal husbandry in our country and environmental pollution that seriously threatens humanity.

3. ZEOLITE PRACTICES IN AGRICULTURE

It is stated that agricultural soils in Turkey are insufficient in terms of organic matter and especially nitrogen (Ertiftik, 1998). It is estimated that the use of zeolite in seedling production systems based on field and external feeding, which are sandy or devoid of organic matter, will provide significant fertilizer savings, especially in production systems where an intensive fertilization regime is applied. It is stated that in Japan, farmers try to prevent the leaching of nitrogen from the soil by adding natural zeolite to nitrogen fertilizers (Mumpton and Ormsby, 1978). With the use of zeolite in nurseries with sand-based soils, besides water and fertilizer economy, the harmful effects of pesticides used in cultures against beneficial microorganisms in the soil and the creatures in the aquatic-terrestrial environment around the nursery will be reduced.

It was carried out by the Soil Laboratory Directorate of the Ministry of Environment and Forestry. The effect of clinoptilolite on the cultivation of red pine (*Pinus brutia*) saplings was investigated by applying different doses. Better results were obtained in 5% and 10% of applications of clinoptilolite compared to 30% of the application. As a result of the study, it was determined that the morphological characteristics and nutritional status of the seedlings produced by mixing clinoptilolite into a sandy loam textured soil in the cultivation of red pine seedlings in pillows were superior to the control group (Kılıcı et al., 2003). Zeolites are also used as drug carriers in agricultural struggles. Natural zeolites with high ion exchange capacity can also act as an effective carriers for herbicides, fungicides and pesticides. It has been observed that the use of clinoptilolite, one of the natural zeolites, as a carrier material in the control of weeds in paddy fields is twice as effective as the use of other commercial products.

Uher (2004) conducted a pot study to reveal the effects of zeolite application at different doses on the yield and growth of pepper plants in Slovakia. In the three-year research, the product yield in zeolite application increased from 29.78 tons/ha in the first year to 55.93 tons/ha in the third year. As a result of the study, it was reported that as zeolite application doses increased, pepper yield increased statistically and zeolite increased the physical properties of the soil and water percolation capacity.

Azapour et al. (2011) investigated the effect of zeolite on yield and nitrogen fertilization at different doses in cowpea plants. In their study, they applied 0 and 5 tons/ha zeolite doses to the soil. Nitrogen was applied in 6 different doses in their studies. In the results of the study, it was reported that zeolite application provided a significant increase of 1% in seed weight, plant weight and 100-seed weight. Among the zeolite applications, the highest seed yield was obtained from 835.8 kg/ha and 5 t/ha zeolite applications. Among the nitrogen doses, the highest grain yield was obtained from the N3 application (N: 60 kg/ha), while the highest seed yield from Z2N3 applications was 1224 kg/ha. Zeolite increases the nutrient use efficiency by increasing the availability of phosphorus from phosphorus sources in the soil, improving the efficiency of the use of NH_4-N and NO_3-N nitrogen, and reducing the leaching losses of exchangeable cations such as K (Barbarick et al., 1990; Bernardi et al., 2008).

Kavoosi (2007) carried out a study in which 8, 16 and 24 tons/ha of zeolite and 0 and 60 kg/ha of N were applied to the soil to investigate the yield and nitrogen use efficiency of rice. According to the results of the research, it was reported that zeolite applications together with nitrogen application caused an increase in grain yield compared to control conditions, and zeolite applications increased the efficiency of N use compared to control conditions.

Kütük et al., (1996), tried different doses of zeolite in the development of the bean plant. They reported that there was a statistical increase in the fresh and dry weights of the bean plant with the application of zeolite.

Baikova and Semekhina (1996) investigated the effects of zeolite on cucumber cultivation in the greenhouse for four years. In the research, zeolite and soil zeolite mixtures were used as the growing medium. As a result of the research, it was observed that there were zeolite substrates whose pH level decreased by 2 units and decreased salt concentrations, but they determined that the change in the amount of exchangeable potassium, calcium and magnesium was not significant, there was a decrease in the amount of sodium and the salinization was low. It has been determined that the nitrate ratio is lower in the fruits of plants grown with zeolite applications.

Işıldar (1997) conducted a study on the leaching of nitrate nitrogen in 5 soils taken from Isparta-Atabey region. In the study, zeolite was mixed in the soil in the form of 0, 12.5 - 25.0 - 50.0 g/kg. Ammonium sulfate solution was applied to the soils at the equivalent of 250 mg/lt N. Soils were then brought to field capacity at 5 different levels and NO_3–N formation in the soil was examined. The accumulation of NO_3–N decreased due to the increase in zeolite doses added to the soil.

Loboda (1999), in a study examining the effect of zeolite use on pepper cultivation in the greenhouse, reported that zeolite showed more positive results in organic soil conditions, reduced fertilizer use by half, reduced nitrate concentration, and improved pepper yield and quality.

Ataşlar et al. (1999) investigated the effects of zeolite on the germination, seedling growth and development of cucumber (*Cucumis Sativus*) and wheat (*Triticum aestivum*). Natural zeolite treated with commercial fertilizers and manure. As a result, they stated that zeolite can be used as a nitrate carrier in the preparation of fertilizers, ammonium can be used more effectively by plants with this method and more savings from fertilizers will be achieved

Leggo (2000) conducted a study on the ammonium retention of zeolite. In their studies, it was reported that there was a 19% increase in the dry weight of the wheat plant when ammonium was given to the zeolite medium.

Gevrek et al., (2004) investigated the use of zeolite in rice farming. In this context, it provided the development of the plant by applying zeolite to the paddy pans. According to the results of the first year of the project, the researchers determined that the zeolite applications increased the plant yield, the number of siblings in the plant and the number of grains statistically.

Polat et al. (2005), investigated the effects of zeolite on quality and yield in lettuce cultivation, and compared different doses of zeolite (0, 40, 60, 80 kg/da) with the control group (zeolite and fertilizer were not applied). It has been determined that the use of zeolite together with fertilization has a positive effect on plant growth and yield in lettuce cultivation, and when controlled irrigation is used, zeolite applications increase the yield by about 15% in 80 kg/da application.

Gül et al. (2005) investigated the effects of perlite and zeolite applications on plant growth and nutrient uptake in soilless growing media in head salad cultivation. As a result, they stated that the zeolite added to the growing medium significantly increased the K level taken up by the plants, while the K level decreased by washing from the medium.

Nooria et al. (2006) investigated harmful salts in the soil and the effects of natural zeolite on salinity in radish (*Raphanus sativus* L.). In the research, 6 soil media, control, Na2SO4, NaCl, natural zeolite, NaCl + natural zeolite and Na_2SO_4 + natural zeolite were used. The number of leaves, whole leaf area, total dry weight, dry root weight, fresh root weight of the plant were examined. As a result, they stated that the use of zeolite improves the soil structure and increases the yield, controls the harmful salt levels and prevents it from passing to the plant roots.

Baninasab (2009) used Cerry Belle variety as a material in his study to determine the effect of natural Iranian zeolite on vegetative growth and nutrient uptake in radish plant. Different doses of zeolite (0, 20,40, 60, 80 and 100 g/kg) were applied to the soil. It was determined that zeolite increased the fresh shoot weight, number and area of leaves, edible diameter and root weight and harvest index.

Eprikashvili et al. (2010), in their study, investigated the effect on grape yield by adding zeolite to the soil in the vineyard. They stated that the yield increased 1.8-2.9 times per vine, the acidity of the juice decreased, and the pH level increased from 3.75 to 4.53.

Er (2011) researched to determine the effect on the development and mineral content of maize by adding zeolite and diatomite to the acidic soils taken from 6 different regions in the Rize region. He harvested two corn varieties after 8 weeks of development and took the stems and leaves of the plants. The dry weights of the stems and leaves of the plant were determined, and after grinding, macro and microelement analyzes were made. As a result of the dry matter analysis of the diatom-treated plants, the contents of S, Mg, Fe, Cu, N, P, K, Na, Ca, Mn, B and Zn increased depending on the applications.

Azam et al. (2012) investigated the effects of zeolite administration from the soil on the generative growth and plant growth of Solanum melongena. It has been stated that zeolite applications increase potassium and nitrogen productivity with plant growth, regulate infiltration by holding water, retain nutrients for long-term use by plants, increase the quality of the soil and the number of products, decrease the loss of nutrients in the soil, and help the absorption of harmful metals. They stated that zeolites could be effective in investigating the use of plant protection. It has been determined that Zeolites and Kaolin are applied as particulate films to diseases and pests, they can be used for coating leaves with CO2 absorption, porous structure and heat stress reduction, water absorption and small size of the particles have effects against fungal insect damage and diseases (Spanogheve et al., 2015).

Budak (2017) studied under laboratory conditions to determine the effects of zeolite applications (0%, 1%, 3%, 5%) on the aggregation and some physical properties of different soils' textures (loam, sandy loam). While it was determined that there was a decrease in aggregates with more sand content, it was higher in aggregates of >12.7 mm. In terms of values, the mean weighted diameter decreased from 9.25 mm to 5.04 mm in soil 1, average weighted diameter decreased from 5.15 mm to 4.14 mm in soil 2 and 1, while soil 3.

4. CONCLUSION

The use of zeolite in agriculture is an increasing practice. Zeolite increases the effectiveness of inorganic fertilizers, especially nitrogen and phosphorus. Zeolite has positive effects on the regulation of some physical properties in soils, the retention of heavy metals (Cd, Pb, Cr, Zn), the increase of water holding capacity, especially the fixation of gaseous compounds. Thanks to these properties, the use of zeolite stands out as an important material for sustainable agriculture.

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CHAPTER 6

SEED COATING TECHNOLOGY WITH PLANT GROWTH PROMOTING BACTERIA IN AGRICULTURAL PRODUCTION

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1. INTRODUCTION

The yield and quality of crops depend on various genetically, environmentally and agronomically practices. Viability, vigor and quality of seed have a pivotal role in the early and mature performance of crops in agricultural production. Thus, improving practices, in particular, based on beneficial microorganisms, i.e., plant growth promoting bacteria (PGPB), arbuscular mycorrhizal fungi (AMF), rhizobia, to seeds are commonly used and have been an increasing phenomenon in recent years (Glick, 2020; Bice Ataklı et al., 2022; Yang et al., 2022). The seed pre-treatments viz., pelleting, priming and coating, etc. are locally and commercially practiced as a means to enhance the quality of the seed to improve productivity under optimum and stress conditions (Afzal et al., 2016; Özyazıcı and Acikbas, 2021; Matlok et al., 2022). Among them, seed coating provides a chance to bundle compelling amounts of materials with the end target that can impact the micro-environment of each seed to enhance seed quality by protecting various soil, air and seed-induce diseases (Javed et al., 2022). Seed coating technology, which also has a major role in the economical agriculture industry on over the world, can be applied by using various techniques that depend on using a goal. Moreover, seed coating technology can be applied by both various techniques and also chemical or biological tools such as plant growth promoting bacteria (PGPR), arbuscular mycorrhiza and rhizobia (Bennet et al., 2009). There are studies indicating that PGPB bio-materials, which can be applied with different methods, show beneficial results depending on their use with seed coating technology (Ma, 2019; Rocha et al., 2019,2020). This review is aimed to point out the use of seed coating technology with PGPB in the seed industry, discuss its effects of it on agricultural production and comprise its advantages and disadvantages.

2. PLANT GROWTH PROMOTING BACTERIAS AS A VERSATILE BIOLOGICAL TOOL IN AGRICULTURE

Plant growth promoting bacteria can be described as bacterial strains increasing water and nutrient uptake, gaining nitrogen and phosphorus to plants by biological nitrogen fixation and phosphate mineralization and promoting plant growth (Bashan, 1998; Gamalero and Glick, 2011; Glick, 2020). PGPB may be used as biofertilizers, rhizoremediators, phytostimulators, biomodifiers, stress bioalleviators, or control agents/biopesticides (Ma et al., 2016). PGPB is isolated and characterized even though they are found in the natural flora, because of the selection and development of strains that exhibit superior characteristics in terms of different characters from among many isolates. Bacterial strains that are used as biological fertilizer commonly belong to genera including Acetobacter, Achromobacter, Acinetobacter, Aereobacter, Alcaligenes, Agrobacterium, Artrobacter, Azotobacter, Azospirillum, Bacillus, Clostridium, Burkholderia, Enterobacter, Flavobacterium, Erwinia, Klebsiella, Pseudomonas, Microccocus and Pseudomonas (Burr et al., 1984; Çakmakçı, 2005; Etesami and Adl, 2020). PGPBs have direct and indirect mechanisms involving plant growth and protection via various biochamical and molecular pathways (Hayat et al., 2010; Vejan et al., 2016; Glick, 2020). Direct mechanisms of PGPB contain the facilitation of nutrient acquisition, synthesis of phytohormones, and production of ammonia, organic acids, and ACC deaminase activity while the indirect mechanisms are relevant to plant protection against phytopathogens, mainly through the synthesis of allelo-chemicals and lytic enzymes, as well as the activation of induced systemic resistance (Rocha et al., 2019).

PGPB strains commonly used as a beneficial biological fertilizer in agricultural lands for many years (Çakmakçı et al., 2010; Gupta et al., 2015; Ceritoglu et al., 2021; Çığ et al., 2021). Nitrogen fixation (Kuan et al., 2016), phosphorus and potassium solubilizing (Yazdani et al., 2009; Masood and Bano, 2016) and gaining micronutrients (Rana et al., 2012) have been reported by various researchers under controlled and field conditions. Atmospheric nitrogen (N2) is converted into utilizable forms (ammonia) by nitrogen-fixing PGPB strains or diazotroph rhizobia species by complex and special enzyme system, i.e., nitrogenase (Gaby and Buckley, 2012). Phosphorus solubilizing mechanism of PGPB strains based on solubilizing insoluble Pi compounds including hydroxyapatite, tricalcium phosphate, dicalcium phosphate, rock phosphate, and mineralized organic phosphate sources to useful forms (i.e. H2PO4- and HPO4-2) in rhizosphere soil (Zaidi et al., 2009; Wang et al., 2021). Potassium solubilizing PGPB strains can assist the solubilization of potassium in addition to the physical and chemical weathering of potassium minerals. PGPB converts insoluble forms of potassium to soluble forms via acidification, chelation and exchange processes (Masood and Bano, 2016). PGPB strains produce plant promoting compounds and play a significant role in the cycling of micronutrients by modifying the root system architecture, therefore, it induces micronutrient uptake from rhizosphere soil (Saravankumar et al., 2008).

PGPB enhances stress tolerance by mechanisms including secretion of various growth regulators, vitamins and phytohormones, restriction of ethylene synthesis with ACC deaminase activity, and reducing pathogen damage via fungicidal and antibiotic compounds (Glick, 2020; Chowdhury, 2022). PGPB strain should have some criterias such as high colonization in the rhizosphere, eco-friendly, an exhibition with a wide spectrum of action, promotion of plant growth, tolerant to biotic and abiotic stress factors, and high competition with other bacterias (Basu et al., 2021). Thus, using PGPB with various techniques such as inoculation to seed or soil, seed priming and seed coating provides a major role in both biological fertilizer and also stress management under extreme conditions.

3. SEED COATING TECHNOLOGY: ITS TARGET AND ROLE IN AGRICULTURAL SYSTEMS

Although seed coating is an actual technology used in the seed market it dates back to nearly 2000 years ago by Chinese used mud for coating rice seeds (Vanangamudi, 2006). Seed coating is described as the practice of applying exogenous materials such as solids, liquids, or dispersions to the external surface of the seed, thereby, resulting in the formation of a layer (Pedrini et al., 2017). The annually global market for seed coating is expected to reach 1.63 billion USD in developing countries in 2020 (Pedrini et al., 2017).

Seed coating technology is based on mainly four styles including seed size, weight and shape. Coating of seeds by plant nutrients, biostimulants, or any other suitable materials enhances germination characteristics, promotes seedling growth and protects the plant from the adverse effect of biotic and abiotic stress factors (Piri et al., 2019; Bıçakçı et al., 2020; Qiu et al., 2020). Seed coating improves the physical properties of seed and delivery of active ingredients. The physical improvement of seeds aims to enhance seed handling by standardization of seed size and weight (Zinmeister et al., 2020). Besides, where the aim is to decrease friction and enhance flowability, the alteration of seed morphology is minimal, but for small, morphologically uneven, or expensive seeds, a thicker coverage is often applied. The artificial external surface is frequently used as a carrier for a difference in active ingredients (Pedrini et al., 2017).

The primary target of seed coating is to provide the homogeneous stand establishment of sown seeds since heterogeneity causes some critical problems in particular field crops. Therefore, seed coating modifies the physical characteristic of the seed, and accelerates and facilitates the germination processes, resulting in homogeneous stand establishment (Godinez-Garrido et al., 2022). Similarly, seed coating facilitates the production of hybrid seeds via synchronizing of flowering time of parental lines and enables early sowing in no-tillage systems (Gesch et al., 2012). The effectiveness of seed coating directly depends on coating technique and used equipment as well as seed properties. Common seed coating techniques are film coating, pelleting, dry powder coating and seed encrusting. Film coating technique is based on covering seeds with a thin layer of artificial slurry forms such as polymers, pigments, plasticizers, and solvents, using a rotating drum machine. Film coating does not noteworthy change the shape and size of seeds, but, it improves the germination characteristics of seeds and eliminates product dust-off (Accinelli et al., 2019). In recent years, film coating has an increasing demand in the seed industry to enhance the productivity and homogeneity of many valuable crops such as maize (Priyadharshini et al., 2022), anise (Dumanoğlu et al., 2020), cotton (Mahantesh et al., 2017) and sugar beet (Duan and Burris, 1997). Pelleting is a technique that is based on coating the seeds with inert materials to enable metering and improve plantability by modifying the shape weight and size of seeds (Ma, 2019). Pelleting is used especially in amorphous and very small-sized seeds, and wrapping the outer surface of the seed as a powder layer resulting in an increment of its size and weight. Thus, it is aimed to prevent emergence heterogeneity and seed losses in such crops onion, tobacco, cotton, alfalfa, lettuce and rice (Tabil et al., 1997; Rathinavel et al., 2000; Taylor et al., 2001; Bonfim et al., 2010; Carvalho et al., 2018; Shin et al., 2020). Encrusting is a seed coating technique of covering seeds with a small amount of adhesive material to empower seed metering sensibility in which the weight of the seed increases by 8-500% whereas the shape of it is affected less or not (Ma, 2019; Javed et al., 2022). Thus, the pelleting technique enables to creation more uniform shape and smoother seed surface, resulting increment in sowing accessibility and homogeneous stand establishment under field conditions (Szemruch and Ferrari, 2013). Dry powder treatment is a coating of seeds with dust materials and it is almost used for the application of bacterial or fungal agents followed by drying, however, it causes a shorter shelf-life compared with seeds that are exposed to other coating techniques (Taylor and Harman, 2003). Encrusting increases more weight of seeds more than film coating however than pelleting, therefore, it is a more economical method compared to pelleting. The encrusting process is successfully used by various materials in different crops and promotive impacts of them were reported by researchers in Allium cepa (Patil et al., 2019), Oryza sativa (Nazari et al., 2019) and grass species (Pedrini et al., 2021).

The other major factor affecting the choice of seed coating technique is application goals such as stimulation of plant growth (biostimulants), plant nutrient (nutrient coating), stress management, plant protection and others (Afzal et al., 2020).

4. SEED COATING WITH PLANT GROWTH PROMOTING BACTERIA: PRACTICES IN DIFFERENT CROPS, ADVANTAGES AND DISADVANTAGES

Beneficial microorganisms, in particular PGPB, have been commonly used as biofertilizers and stress management tools in agriculture. In terms of PGPB coating, bacteria cells might be directly entrapped in the polyelectrolyte complex of changing charges existing of a basic and acidic component by ionic interactions since their cell membrane is negatively charged, or they might be entrapped into inorganic porous carriers that increase the shelf-life of bacterias in the prepared formulation (Gerasimenko et al., 2004; Rubner et al., 2012; Wojcieszynska et al., 2012). Different researchers have been studying promotive new methods to increase the success of seed coating by PGPB. In a general perspective, carrier material, which aids to deliver a suitable amount of PGPB, has a pivotal role in the seed coating process. So, carrier materials are generally categorized as nutritional functions or fillers (Weber et al., 1997; Madsen et al., 2014; Padhi et al., 2018; Krishnamoorthy and Rajiv, 2018). Safety, cost, availability environment and benign are the pivotal factors affecting the choice of the carrier in the microbial coating. The most critical properties that should involve in carrier material are: i) Easly adhere to seed surface and inoculation materials, ii) Provide and/or promote seed germination and seedling growth, iii) Assure of microbial material on the seed surface as well as possible shelf-life (Ma, 2019).

O'Callaghan et al. (2006) investigated the effects of seed coating with a beneficial bacteria strain, Pseudomonas fluorescens, on biocontrol capacity against pathogenic fungus, i.e., Pythium ultimum. The experiment also focussed on the effective formulation type and shelf-life of microbial-coated seeds. According to the results, storage conditions of coated seeds were a key factor affecting the success and 4 °C-stored seeds had more bacterial populations compared with 20 °C-stored seeds. Moreover, Bacteria formulation (NF 600) had greater survival up to 79% in foil bags compared with gas transferable bags after storage for 1 month and an improvement in bacterial survival by 59% was seen in NF 602-coated seeds in foil bags. Ryu et al. (2006) indicated that pelleting with Paenibacillus polymyxa E681 strain may be a sustainable and biological strategy against various fungal pathogenics in sesame. Moreover, pelleting technique increased the effectiveness of beneficial bacteria compared with inoculation of it. Sandhya et al. (2009) coated the sunflower seeds with a talc-based formulation of Pseudomonas sp. GAP-

P45 (108 CFU) used 1% carboxy methyl cellulose as an adhesive and tried to alleviate the adverse effect of drought stress. Results denoted that exopolysaccharides producing bacteria-induced plant biomass, root colonization and reduced drought stress in sunflower seeds. Young et al. (2006) encapsulated the lettuce seeds with PGPB and enriched them with humic acid. They revealed that encapsulating technique protected the PGPB population and increased their activity in the rhizosphere. Also, humic acid promoted PGPB population growth and increased the effectiveness of seed coating. Zhou et al. (2017) indicated that molybdate used in rhizobial seed coating improves nodulation and yield. Also, treatment of 0.2% of ammonium molybdate induced the performance of PGPB coated on the seed, root nodulation and nitrogen fixation capacity in alfalfa plants.

Contrary to its many beneficial properties, the most important factor affecting the quality and sectoral use of the PGPB-coating technique is the shelf life of the commercial formulation. Thus, new research mostly goal to increase the shelf-life of formulations. So, factors that extend the shelf-life of bacterial formulations created for seed coating should be well known. In general, five main factors have a pivotal role in the shelf-life and marketing of products including characteristics of PGPB strain, coating carrier, coating type, drying process and storage conditions (Ma, 2019). Enhancing shelf-life depends on some critical phenomena such as reduction of the moisture level of used carrier, formation of completely dry formulation to enable long-term storage, lower storage temperatures than room temperature, reduction of moisture level in the storage room and curing duration after formulation at room temperature. Moreover, desiccation has a pivotal role in the survival of the bacterial population and the optimum condition for microbial survival is a balance among intercellular and extracellular water status. Low relative humidity of storage conditions is more suitable for the survival of freeze-dried microbial cells, whereas fully hydrated cells decreased the survival of cells under low relative humidity (Deaker et al., 2007). Besides, Deaker et al. (2007) indicated that polymer adhesives can increase cell survival by diminishing the effect of fluctuations in relative humidity throughout the mediation of moisture sorption and desorption. The other restricting factor in the effectiveness of seed coating with bacteria is contamination that might decrease microbial survival and colonization in the rhizosphere and plant tissues after the germination stage (Deaker et al., 2012). Finally, the lack of accessible tools for fast determining microbial survival after treatment or stand establishment is a major problem. Thus, low effective coated materials might be used resulting in low effectiveness of microbial coating (Junges et al., 2013).

5. CONCLUSION

Seed coating with PGPB is an effective and innovative technology for sustainable agriculture. Seed coating technology is seen to have superior properties in many ways when compared to similar techniques, i.e., seed or soil inoculation and bio-priming. However, it is understood that some scientific and technological deficiencies limit the shelf-life of the product by ensuring bacterial viability on the seed surface. Therefore, there is a need for new approaches to extend the shelf-life and develop seed coating technology, where effective microbial viability can be achieved.

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CHAPTER 7

ORGANIC AGRICULTURE, ITS POTENTIAL, AND ORGANIC WHEAT CULTIVATION FROM PAST TO PRESENT

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1. INTRODUCTION

Organic farming activities started in the United States (USA) and Europe in the history of the world and then spread to other countries. The increase in concerns about human health and nature pollution has increased demand and interest in organic farming activities. As the demand for products obtained by organic farming increased, the number of farmers engaged in organic farming naturally increased. The growth of this demand has also enhanced international business activities. Although there is no demand and domestic market for organic agricultural products in many countries, they have started the production of organic products, which are demanded in European countries, and exported these products (Demiryürek, K., 2016).

Organic agriculture is an agricultural model that has principles and special principles and aims to meet the needs of future generations, from the cultivation of organic products to the marketing of these products. Primarily, this agriculture model, which aims to reduce hunger and poverty and protect water resources, has important duties related to ensuring biological diversity and the ecosystem. This study has been compiled and revealed in light of statistical data to rate organic agriculture from past to present, the process of organic wheat cultivation, and the strengths of its potential.

2. ORGANIC AGRICULTURE

From the field to the kitchen, from the kitchen to the table, which includes a production system that is friendly to humans, the environment, and nature, which does not harm nature, the environment and human health, prohibits chemicals and components, ensures continuity in soil fertility by controlling diseases and pests with biological and cultural control methods. It is an agricultural production model in which the products obtained are certified at the same time (BÜGEM, 2022). A production model that aims to protect the natural balance and preserves important natural resources such as air and water, which is seen as a vital cause, where every stage of production is planned and programmed, and where both the production amount and product quality are aimed, is defined as organic agriculture.

2.1. History of Organic Agriculture

In light of the findings that emerged in 1924 within the scope of the bio-dynamic Agriculture Method study published in 1910 with the title of Agricultural Testament, farmers and consumers sensitive to organic agriculture in many European countries started organic agriculture studies by acting together. People began to detect the harmful effects of synthetic chemicals and fertilizers on themselves and their environment. As people began to detect the negative effects of chemical pesticides and commercial fertilizers on themselves, their surroundings and nature, this damage that was felt at the beginning of the 1970s, many of the world's countries conducted independent studies on organic agriculture. (Er, 2009; Yurudur et al., 2010; Ceritoglu and Erman, 2019; Tıraşçı et al.,2020).

From the 1970s to the 2000s, the development process of organic agriculture in the world has been quite stable. During this period, the establishment of the International Federation of Organic Agriculture Movements (IFOAM) (1972) and the establishment of the Organic

Agriculture Research Institute (FIBL) (1973) are considered to be the two most important developments. Especially since the 1980s, the increase in the demand for organic agriculture and the growth of the market brought the first legal regulation in France in 1985. Agricultural policies compatible with nature and the environment were developed and supported in European Union countries. The entry into force of the EU Council Regulation 2092/91 (1991) and the inclusion of livestock in the regulation (1999) appear as important developments in the history of organic agriculture. Following the publication of the regulations for the products to be exported, the publication of standards (JAS and NOP) involving organic agriculture, especially in Japan and the USA, accelerated the development process since 2000. These developments in the world The Council Regulation No 834/2007 on Organic Production and Labeling and the Implementation of the Council Regulation No 889/2008 in the European Union are among the most important developments in the history of organic agriculture (Anonymous, 2014).

2.2. The Development Process of Organic Agriculture in Turkey

The establishment of the Ecological Agriculture Organization Association in Turkey in 1992 is accepted as the first official organic farming activity. Then, in 2000, 2004 and 2005, respectively, the Regulation on the Principles and Implementation of Organic Agriculture, the Draft Law on the Cultivation, Consumption and Inspection of Organic Agricultural Products, and the regulation on the Principles and Implementation of Organic Agriculture within this draft law was published and entered into force. The National Organic Agriculture Legislation was harmonized with the European Union Legislation and republished in 2010 as a result of the European Union Accession Negotiations.

Producers who want to make organic agricultural products can obtain an organic product certificate for their products produced per organic agriculture legislation under the supervision and control of an international certification company. This process, called Organic Agriculture in our country, has been carried out by the Republic of Turkey within the framework of Organic Agriculture Law No. 5262 and the relevant regulation. It is carried out under the control and supervision of the Ministry of Agriculture and Forestry.

2.3. Organic Farming Principles

- Conservation of soil fertility with correct tillage, organic (green) fertilization and appropriate rotation.
- Minimizing the use of all chemical agricultural inputs that pose a significant threat to humans, the environment and nature.
- The varieties used are resistant to diseases and pests.
- Selection of suitable plant species and seed varieties with the ability to adapt to the climatic conditions of the region where organic farming will be carried out.
- Ensuring the use of methods such as pheromone traps, early warning systems in plant protection cultural control methods by using cultural and biological control methods.

- The provision of soil with natural substances in order to ensure self-sufficiency of the natural food cycle between humans, plants and animals.
- Avoiding the use of pesticides and fertilizers, synthetic chemical fertilizers, hormones and chemical growth regulators that have direct effects on product yield and quality in organic agriculture.
- Inputs such as pesticides and fertilizers to be used in organic agriculture must comply with regulations and legislation. (Suzer,2022)

2.4. Why Organic Agriculture

The main purposes of organic agriculture are to protect the living resources, to increase the amount of products, to obtain quality and durable products, to protect future generations by avoiding chemical additives and to produce quality food by making use of predators and parasites, to consume more delicious products, to ensure the continuity of biodiversity, etc. . can be displayed.

2.5. Advantages of Organic Agriculture

- Since most farmers use very little or no synthetic chemicals, the transition to organic farming is easy.
- Farmer income increases depending on the amount of organic products. • Savings are made on chemical fertilizer and pesticide inputs, which have high prices.

- The purchase of organic products is guaranteed with the Contracted Production Model, which is preferred by the producers in recent years.
- The export price of organic agricultural products is 10-20% higher than the products obtained in traditional agriculture.
- The high interest of foreign tourists in organic agricultural products, especially in Mediterranean countries, due to the tourism potential.
- A new sector will be formed with the chance of creating a domestic market in Turkey and the entry of large companies into organic agriculture. • The organic farming model, which requires technical equipment and special skills and knowledge, creates new employment areas.

2.6. Disadvantages of Organic Farming

- Lack of documentation and information about organic agriculture in our country; farmers do not have the habit of recording all their practices during their agricultural activities from past years to the present and not enough academic and scientific studies have been done.
- Due to the small and fragmented agricultural lands, the risk of contamination from the environment and nature is high, and the economic income level of the farmer is low.
- Due to the decrease in yield and product quality in the face of increasing demand for organic agricultural products, it is

difficult for organic agriculture to develop and become widespread in a short time.

- Due to the newness of Organic Agriculture, the lack of sufficient agricultural technical information and qualified labor force negatively affects the development of organic agriculture.

- Being innovative and uncertain, especially for the domestic market may create unexpected difficulties in the sale, market and promotion of products grown with organic farming principles and practices.

- Significant fluctuations can be seen in the amount of agricultural products. Due to the increase in the human population, the continuous increase in the variety and amount of consumption, and the fluctuation of the organic production amount of the world countries demanding agricultural products (decrease in yield), it may take time and extraordinary effort to develop in a short time.

2. ORGANIC AGRICULTURE IN THE WORLD

According to the organic agriculture statistics published by FIBL and IFOAM in the 2020 production year, Australia is the country that allocates the most land with 35,687,799 ha in terms of organic agricultural areas in the world. Turkey ranks 22nd in this ranking after Austria, Sweden, the Czech Republic and Greece. According to the 2020 data of FIBL and IFOAM, 3.4 million producers worldwide are engaged in organic cultivation on 74.9 million hectares of land. According to the 2020 production year indicators worldwide, 1.6% of the total agricultural area is organic farming. In EU countries, organic agriculture is carried out in 3.4% of the total agricultural area with a production of 17.6 million tons. (Anonymous, 2022a).

The USA and European countries have an important position in the organic agriculture and food products market in the world. Denmark, Switzerland and Luxembourg are the countries that consume the most organic products per capita. Grains (wheat), tea, meat, sugar, oil seeds, fruit (lemon, pear, orange and apple), vegetables (beans, garlic and onions), soy, coffee, banana and corn products are the leading organic products produced.

The situation of total organic farming production areas in the world by continents is given in Figure and 2 comparatively.

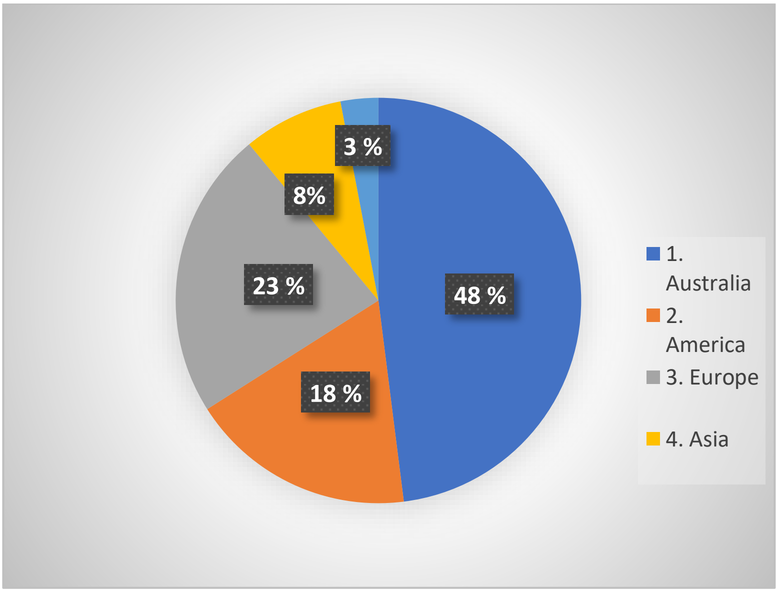

Figure 1: Distribution Of Organic Farming Areas İn The World By Continents (Anonymous, 2022a)

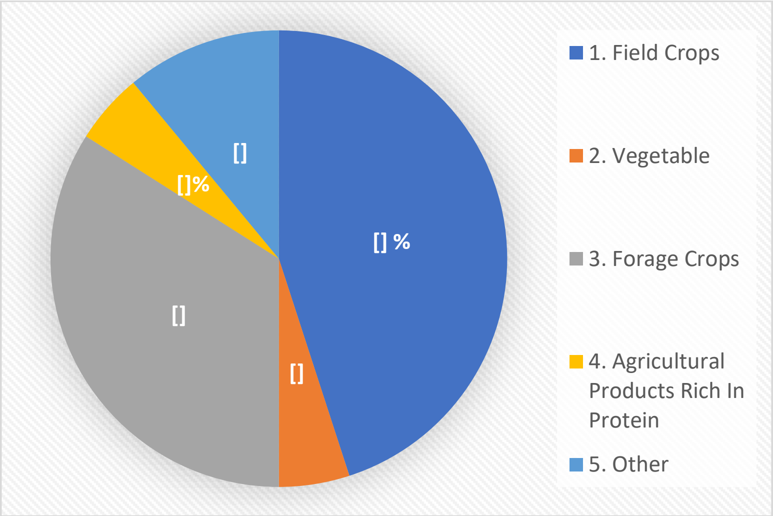

Figure 2: The Use Of Organic Agricultural Products İn The World According To Their Cultivation (Anonymous, 2022a)

Organic agriculture production areas in the world by years are given in Figure 3.

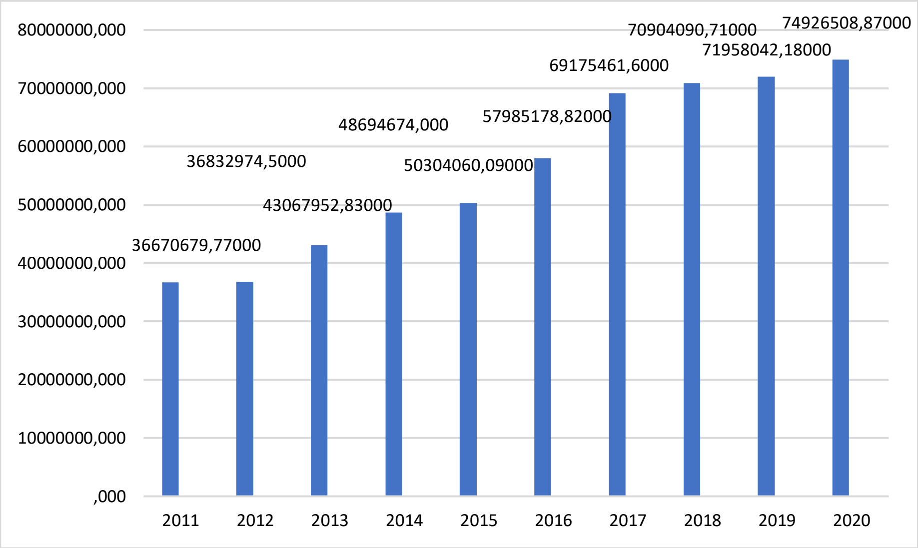

Figure 3: Organic Agriculture Production Areas (Da) İn The World By Year (Anonymous, 2022b)

The values of 22 countries with the highest number of organic agriculture production areas in the world and their situation against each other are given in Figure 4.

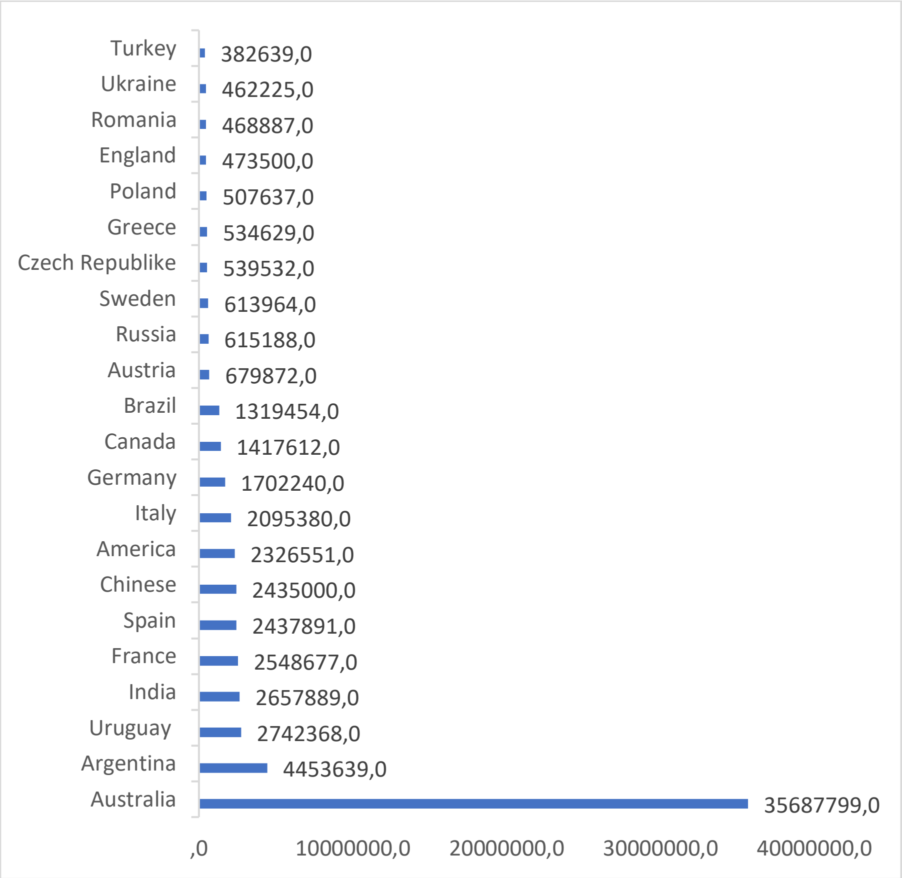

Figure 4: As of 2020, 22 countries with the most organic farming areas in the world (Anonymous, 2022b)

The values of the 10 countries and areas with the most organic farming areas in Europe are given in Figure 5.

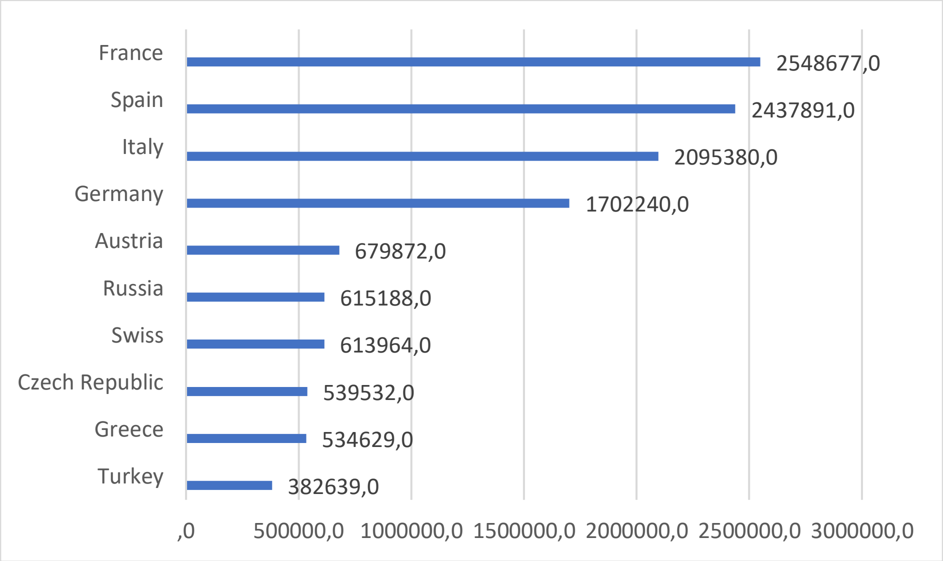

Figure 5: 10 countries with the largest organic farming area in the European continent (Anonymous, 2022b)

4. ORGANIC AGRICULTURE IN TURKEY

In recent years, Turkey has had the potential for organic production from dried fruits (apples, hazelnuts, pistachios, dried figs and grapes), fresh vegetables and fruits, medicinal and aromatic plants, primarily various field crops (such as cereals and legumes and industrial plants). Demiryürek, K., 2016).

Although the production amount, the number of products and the number of farmers, and the production area values according to the organic plant production indicators according to the years in organic agriculture in Turkey decreased in some years compared to the previous year, there was an increase in the total projection over the years.

When the data for 2002 and 2020 are compared in the quarter of the last century in Turkey, significant increases were observed in the number of farmers (499%), the number of organic products (42%), the amount of production (554%) and the production area (507%) in 2020. Although there have been fluctuations in organic production areas and the number of farmers over the years, there has been an increase in the total production potential. Although the amount of organic production in our country has increased over the years, there has been a decrease in organic trade volume and per capita consumption of organic products. According to the indicators of 2020 in our country, the income obtained from retail sales in organic agriculture is 46 million €, and the amount of organic product consumption per person is 1 €. The area where organic farming is carried out within the total agricultural area in Turkey; According to the data of 2020, it has a share of 1.0% (FIBL, 2022).

In our country, the number of crops and farmers by years, breeding and natural collection areas, total production are,a and production amount are given in Table 1.

Table 1: Turkey organic agriculture production data (BÜGEM, 2020)

Years	Number of products	Number of manufacturers	Cultivated area (Ha)	Natural collection area (Ha)	Total Production area (Ha)	Produce amount (Ton)
2015	197	69.967	486.069	29.199	515.268	1.829.291
2016	225	67.878	489.671	34.106	523.778	2.473.600
2017	214	75.067	520.885	22.148	543.033	2.406.606
2018	213	79.563	540.000	86.885	626.885	2.371.612
2019	213	74.545	505.140	33.283	545.870	2.030.465
2020	248	52.590	352.395	28.882	381.277	1.630.252

The main reasons for the variability in the potential of producers engaged in organic farming are that companies engaged in organic farming activities guarantee high prices to farmers, technical suppor,t and cash assistance to producers, and the prices of traditional agricultural products are 10-15% more economical than the sales price of organic agricultural products and the sales price of traditional agricultural products. Factors such as the fact that farmers encounter problems in sales and marketing are shown. (Turan et al., 2009; Öztürk and İslam, 2014).

Organic farming activities started in our country in 1984-1985 with the demands of European companies for organic agricultural products from our country. (Özbilge, 2007) Our first organic production started with the export of raisins and dried figs in the Aegean region. While only 8 types of products were produced for export in 1985, production was made in line with the increasing demands, and 248 types of products were produced in 2020. (Ataseven and Aksoy, 2000)

In our country, especially dried fruits such as raisins, dried figs, dried apricots, cereals (wheat), legumes, pistachios, medicinal aromatic plants, walnuts, hazelnuts, cotton, berry-like fruits, and fresh fruits and vegetables are produced following organic farming methods.

Considering comparatively in terms of regions in Turkey, the production amount, the number of farmers, and the area of organic farming in our Aegean Region are quite advanced compared to other regions. In recent years, the Aegean region has produced 751,900 tons of production on an area of 136,961 hectares with an average (2018-2020) of 23,943 farmers (TÜİK, 2019).

The values of the 10 (ten) cities with the highest organic production in Turkey and their production amounts are given in Figure 6.

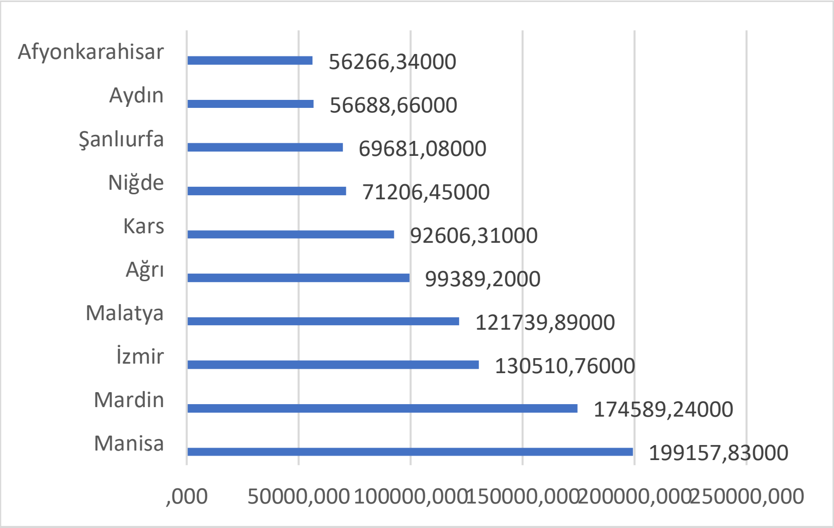

Figure 6: Top 10 Organic Production Cities in Turkey (TUIK, 2019)

The values of the 10 (ten) cities with the least organic production in Turkey and their production amounts are given in Figure 7.

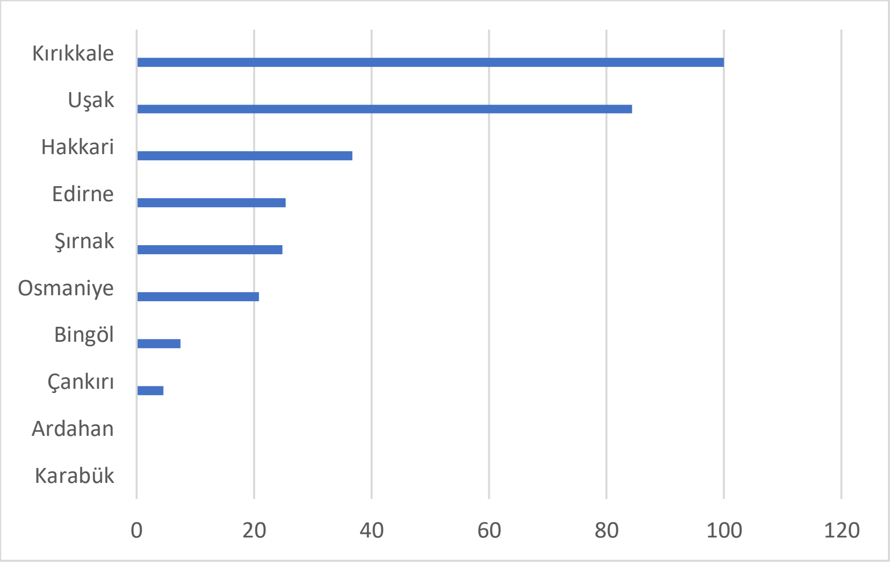

Figure 7: 10 Cities with the least organic production in Turkey (TUIK, 2019)

- The total amount of organic vegetable production in Turkey in 2018 is 48,787 tons (TUIK, 2019). Among this production amount, Manisa (12,885 tons), İzmir (5,575 tons) and Ankara (4,876 tons) are the main provinces in terms of organic production potential. Among organic vegetables, tomato (16,594 tons) is the main production vegetable (TÜİK, 2019).

- The amount of organic fruits (including wild organic fruits) collected from nature in the 2018 production year in Turkey is 214,106 tons (TUIK, 2019). Among the most organic fruits collected from nature, apples come with 73,503 tons. (TUIK, 2019)

- The amount of organic field crops production in Turkey in 2018 production is 684,539 tons (TUIK, 2019). Van (128.242 tons) and Erzurum (108.680 tons) are the provinces with the highest amount of field crops in terms of production potential. Among the field crops, wheat (195,131 tons), alfalfa (133,377 tons) are the main crops produced. (TUIK, 2019)

4.1. Import and Export Data

Wheat and its by-products constitute a significant part of the export amount in Turkey. The most exported countries from our country are Italy (26 thousand tons), Germany (18 thousand tons) and the Netherlands (16 thousand tons) (Anonymous, 2022).

Looking at Turkey's import data, soybean (non-seed) is the most imported product. Depending on the international market demand, it belongs to dry and dried herbal products in our country's organic herbal product cultivation. Therefore, the domestic market in organic fresh fruit and vegetable cultivation is developing slowly (TUIK, 2019).

The most imported organic products in the 2019 production year are given in Table 2.

Table 2: Organic products with the most ımport potential in Turkey (BÜGEM, 2020)

Name of the product	**Quantity (Ton)**	**Country of Import**
Dates (dry, molasses, crushed)	598,0	USA, Germany, Algeria, France, Netherlands, England, Iran, Israel, Pakistan, Saudi Arabia, Tunisia
Apple (dried)	137,0	Kyrgyzstan
Flaxseed	276,0	Kazakhstan
Licorice Root	716	Georgia, Kazakhstan
Soybeans (Non-Seed)	1.518	Ethiopia
Sesame Seed (Raw)	112	Uganda
The Overall Total	3.357	

The most exported organic products in 2019 are given in Table 3.

Table 3: Organic Products Most Exported In Our Country (BÜGEM, 2020)

Name of the product	**Quantity (Ton)**	**Price ($)**	**Quantity (%)**	**Price (%)**
Wheat and Wheat Products	31.194,53	11.913.987,26	41,1	5,86
Fruit and Fruit Products	16.733,92	65.242.625,00	22,05	32,12
Grapes and Grape Products	9.536,31	27.895.275,66	12,56	13,73
Figs and Fig Products	6.895,86	40.306.275,00	9,08	19,84
Hazelnut and Hazelnut Products	4.440,76	31.964.563,27	5,85	15,74
Apricot and Apricot Products	3.744,10	14.727.473,00	4,93	7,25
Vegetables and Vegetable Products	1.146,61	1.694.270,52	1,51	0,83
The Overall Total	73.692,09	193.744.469,7	97,53	95,37

4.2. Principles of Starting Organic Farming

Documents Required for Organic Agriculture Application

- Identity information and documents including the farmer's personal information, contact and tax number

- Deed of the agricultural land on which organic farming will be carried out if it belongs to itself or rental information and documents if it is rented,
- Land registry in the areas where the cadastral work has been completed, and the sketch of the land in the areas that have not been completed,
- The address and location of the Agricultural Enterprise, • If it is a food processing workplace, "Work Permit and Food Registry Certificate"

4.3. Organic Agriculture Supports in Turkey

As in the world, agricultural incentives and supports are provitor to ensure that organic agriculture is adopted by farmers in our country. In addition, Ziraat Bankası A.Ş. and Agricultural Credit Cooperatives, low-interest agricultural loans are given to couples engaged in agricultural production.

5. WHEAT GROWING

Wheat is one of the agricultural products with wide adaptation ability among cultivated plants. Wheat, which is the leader in the world and Turkey in terms of production amount and cultivation area, is a strategic product that is the most basic food of many countries. While the contribution of wheat to the world population among the total calories obtained from plant products is approximately 20%, this rate is stated as approximately 53% in Turkey.

In the growing and developing world, the daily consumption of cereals, especially in human nutrition, is increasingly being used in animal nutrition and industry day by day. Grain farming and its usage areas, and nutrition-related problems have taken their place among the most important economic issues today. Many institutions and organizations continue to work on the relationship between the rapid increase in the human population and the rate of increase in grain production, to realize the production to meet the increasing consumption amount and related to the problems related to nutrition arising from the increasing human population.

Wheat, which is an annual plant, is grown in many regions of the world and is the most planted in terms of cultivation area and production amount in the world and in Turkey, since it has many species that can be grown in various climatic conditions and do not vary in terms of soil demand. It has a leading position in agricultural products (FAO, 2020).

The rapid increase in the human population and the development and improvement of the living standards of many countries in the world cause the increasing supply in agricultural areas to not meet. For this reason, soil fertility is gaining importance day by day and becomes a strategic element. There are different reasons why the amount of wheat cultivation areas is widespread in almost all regions of the world. Wheat, with its wide ecotype, vari,ety and species richness, is a plant group that includes many agricultural product species. Therefore, wheat finds areas with wider adaptation ability than other crop plants. In addition to the wheat species that grow in soils rich in organic matter and high in moisture, there are also wheat species and varieties that grow in soils that are poor in organic matter. In addition, it is known that wheat cultivation requires a small amount of labor, and being suitable for easy transportation, storage, and preservation conditions are important factors in its spread over a wide area in the world (Toprak, Çığ and Ark, 2016). Wheat, which ranks first in the world and Turkey in terms of cultivation areas among cultivated plants, is a strategic agricultural product in our region and the Siirt region in terms of its rich protein content and being a basic energy source, and its use in human nutrition and animal nutrition.

Wheat, which has been one of the most important food sources of our Turkish people for generations, has a great cultural, historical and social value as well as being a product that has been respected throughout history in our society. Turkey, which hosted 28 wild wheat species until 2016, had 205 bread and 67 durum wheat varieties (Özberk and Ark, 2016). Today, more than 400 improved wheat varieties meet our lands in Anatolia, which is known as the "granary" (Anonymous, 2022c).

Wheat cultivation areas and production are gradually decreasing due to important natural events that have adversely affected agricultural areas such as drought, global warming and climate change in the recent past. In addition, the rapid increase in the human population will soon lead to the fact that our main food sources will not be able to meet the needs, and therefore, malnutrition problems of people will increase. Increasing the use of chemical fertilizers and pesticides while growing day by day brings health risks besides balanced nutrition. Nutrition should be healthy as well as adequate. For this reason, organic farming methods are one of the important issues that should be emphasized in wheat, which is one of our basic food sources, which is increasing in importance day by day in the world in and Turkey. Turkey's general wheat data are given in Table 4.

Table 4: Turkey 2020-2021 Wheat Data (TUİK,2020)

Product	**Market Year**	**Production (Tons)**	**Sown Area (Hectares)**	**Import (Ton)**	**Export (Ton)**	**Consumption Per Capita (Kg)**	**Degree Of Proficiency (%)**
Durum Wheat (total)	2020/2021	20.500.000	6.922.237	8.237.981	7.583.765	176,8	102,3
Durum Wheat (total)	2019/2020	19.000.000	6.846.327	10.793.317	7.530.767	192,8	89,5

Amount of wheat planted area in the world by country World wheat production, consumption and stock amounts are given in Figure 8.

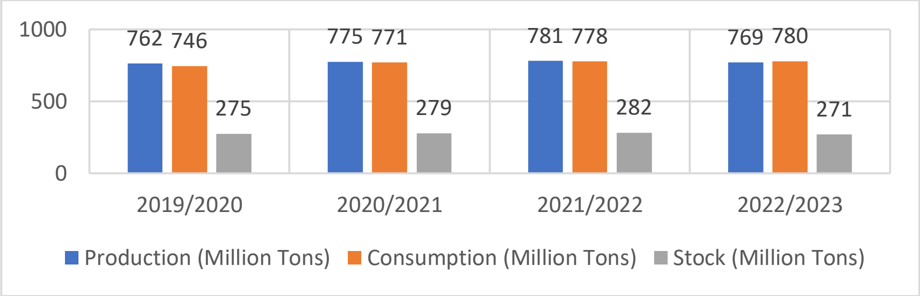

Figure 8: Wheat Production, Consumption and Stock Amount in the World (TUIK, 2022)

Turkey wheat production amount data are given in Figure 9.

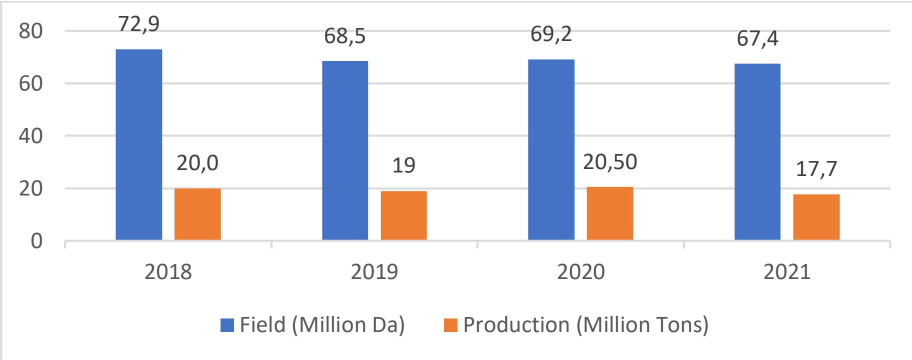

Figure 9: Turkey Wheat Production Amount (TUIK, 2022)

Wheat provides a very attractive and abundant source for diseases and pests due to the large area of the production areas and is mostly produced in the form of a uniform product in hectares of land. Product loss in wheat caused by diseases, pests and weeds in the world is about 35%, and the rate of damage caused by insects, rodents, birds and microorganisms after harvest is about 10-20%.

5.1. Wheat Farming in Siirt Province

Siirt Province General Wheat Data are given in Table 5.

Table 5: Siirt province wheat production data (TUIK, 2022)

Wheat Type	**Sown Area (Da)**	**Yield(Kg)**	**Production Amount (Ton)**	**Production Amount (Da)**	**Harvested Area (Da)**
Bread Wheat	132.571	167	22.127	132.571	132.571
Durum Wheat	185.621	248	25.685	185.621	185.619

6. ORGANIC WHEAT

In the world and Turkey, the cultivated wheat areas and the production amount of organic wheat are very low. One of the deterrents for producers in the transition from conventional agriculture to organic agriculture is the low yield in organic wheat farming. However, over the years, the yield in conventional wheat farming is decreasing. Thus, the yield difference between organic wheat farming and conventional wheat farming also decreases.

Most of the wheat growers in Turkey get very little yields in traditional wheat cultivation because they have small and fragmented lands and use fewer additional inputs. In addition, today, production costs in traditional wheat cultivation are increasing and wheat/input parity is decreasing. Local wheat genotypes selected in the process where chemical pesticides and commercial fertilizers are not used are very important genetic resources in terms of suitability and suitability for organic farming (Akkaya, 2018).

It is possible to say that organic wheat cultivation, which is made by choosing local varieties, can be an important option in regions where the climatic conditions are favorable and wheat yields are well below the country average, and in agricultural enterprises that use small and fragmented and few additional inputs.

There are various debates about whether traditional wheat cultivation will be replaced by organic wheat cultivation. In particular, the main subject of the discussions is whether the production of wheat in the amount that can meet the current nutritional need in the face of the increase in the human population will be provided by organic wheat farming.

Although organic agriculture has advantages in various aspects, the share of organic wheat in the total wheat cultivation area and production amount of our country is still very low. Although there are various difficulties in the transition from traditional agriculture to organic agriculture, it is predicted that wheat, which is extremely important for Turkey, will be produced with organic principles and practices, and that local varieties will be preferred while producing, and it will become the main economic power of our country in this field in the coming years.

T.R. According to the data for 2020 published by the Ministry of Agriculture and Forestry, the production ama ount, number of producers and production area of Turkey Organic Wheat are given in Table 6.

Table 6: Turkey organic wheat production data (BÜGEM, 2020)

Number of Farmers	Production Area (Ha)	Total Area (Ha)	Production Amount (Ton)
20.763	156.680	159.796	655.930

When the harmful effects of agricultural inputs such as chemical pesticides and fertilizers, herbicides, and pesticides on human health, nature and the environment are seen, the interest and demand for organic agriculture is increasing day by day. The opinion that organic agricultural products are more reliable and healthier is becoming widespread. Organic plant products have a positive effect on nature, where nitrate accumulation is low in the edible parts of the plant, organic agriculture increases biodiversity, soil fertility and earthworm species, increases fulvic acid fraction, microbial biome and organic carbon, improves soil organic matter content, soil fertility and biodiversity and has a positive effect on nature (Herencia et al., 2011).

6.1. Yield Difference in Organic Wheat

The yield obtained in organic wheat farming is generally low. For this reason, there is a concern about whether organic wheat cultivation can be an alternative to traditional wheat cultivation. It is a concern that the production amount will not be able to meet the consumption due to the increasing population due to the low yield obtained if organic wheat farming becomes widespread. In a 21-year study conducted in Central Europe, it was observed that the grain yield of organic wheat plants decreased by 20% (Mader et al., 2002).

In a study containing 66 data sets collected from trial fields and farmer fields in various countries in the world, it was determined that the yield in organic wheat cultivation decreased by an average of 27% depending on factors such as climatic conditions and cultivation techniques. As a result of the study, it was determined that the yield difference with organic wheat farming decreased due to the decrease in yield in conventional wheat farming (Ponti et al., 2012). Similar to these indicators in various countries, some studies conducted under the climatic conditions of Konya have also found that the grain yield in organic farming decreases by up to 30% compared to traditional farming (Aydın et al., 2010).

In wheat in Turkey, according to the production indicators for the year 2015, the grain yield of durum wheat is 247 kg per decare in dry conditions, 466 kg per decare in irrigated conditions, 244 kg per hectare in dry conditions for bread wheat, and 412 kg per decare in irrigated conditions in traditional wheat cultivation. Wheat cultivation is carried out in many marginal agricultural lands and small-scale lands in Turkey.

Currently, in some regions, the average wheat yield falls far below the country average due to unfavorable climatic conditions and the use of small amounts of inputs (Anonymous, 2017). The provincial average wheat yield in Erzurum is 135 kg per decare in dry sowing, 232 kg per decare in irrigated plantings, 95 kg per decare in Tekman district, 91 kg per decare in dry plantings in Karayazı district, and 170 kg per decare in irrigated plantings. The provincial average grain yield of wheat yield in Konya is 286 kg/decare in durum wheat under dry conditions, 496 kg/decare in irrigated conditions, 261 kg/decare in bread wheat under dry conditions and 535 kg/decare in irrigated conditions. In Sarayönü district, the yield of bread wheat decreases to 127 kg per decare and 83 kg per decare in Taşkent district. (Anonymous, 2017). In Şanlıurfa, the average yield of durum wheat in irrigated conditions is 485 kg per decare, 181 kg per decare in dry conditions, and 64 kg per decare in Ceylanpınar. As can be understood from the data obtained from the samples obtained, wheat yield in some regions of Turkey is half of the country's average, and in some regions, it is less than half.

Although traditional wheat is grown in regions where the yield is low, soil and climate characteristics are limited and there is less input use due to economic conditions, organic wheat farming can be preferred instead to traditional wheat farming in regions where the yield is well below the country's average. If the transition to organic wheat farming is made due to the decrease in yield in traditional wheat farming, there will not be significant losses in terms of yield, and it will also bring benefits such as economic and healthy life (Ponti et al., 2012).

6.2. Cost of Organic Wheat

From the past to the present, the amount, variety, and prices of additional inputs used in wheat farming vary significantly in an increasing direction. In the past, producers who were self-sufficient and used fewer additional inputs in terms of amount and ratio and were self-sufficient today have been exposed to more than one additional cost. The farm size of wheat producers in EU countries is 174 decares on average, and 61 decares in Turkey. The most important inputs in conventional wheat farming are chemicals and fertilizers. In Turkey, fertilizer (18%) and pesticides (7%) constitute a significant part of total costs. (Anonymous, 2005).

This rate has increased even more today. Especially in small-scale enterprises, wheat farmers are more affected by the additional costs such as increasing pesticides and fertilizers and are experiencing financial difficulties (Anonymous, 2008). In our country, if organic wheat farming is carried out rather than traditional wheat farming in agricultural enterprises of this scale, even if there are losses in the obtained yield, depending on factors such as the reduction of additional costs and the high price of the product, it can be ensured that the growers make more profit economically. Although there is a 20% decrease in the yield obtained in organic wheat farming, it is seen that there are decreases in energy and fertilizer input costs (34-54%) and the use of pesticides (97%) (Mader et al., 2002).

Today, modern agricultural tools and equipment, agricultural machinery, chemical fertilizers and pesticides, high-yield newly certified seeds, fuel and energy have become the indispensable basic additional inputs of agricultural production. For this reason, wheat producers aim to provide these additional orders to continue agricultural production rather than making a profit. Looking at the 2015 and TUIK 2017 additional input and price, projections in wheat cultivation, wheat/ammonium nitrate, wheat/urea, wheat/(20-20-0) and wheat/diesel prices in 2002 are among the wheat price/input cost rat, ios. When the values are taken as 100, these price values decreased to 65, 68, 80 and 75, respectively. TOB,2015-TUİK,2017. According to these indicators, wheat prices remain below the additional input costs and wheat producers face economic difficulties.

In the face of this negative situation, with the support of our State, Grain Purchase prices for 2022 were revised and wheat growers were supported. Grain Purchase prices of the Turkish Grain Board for 2022 are given in Table 7.

Table 7: Revised Grain Purchase Prices Of Turkish Grain Board For 2022 (TMO,2022)

TYPE		**PURCHASING KODE**	**PURCHASING CODE (TL/TON)**
ROLLER WHEAT	Durum Wheat	1121	7.000
		1122	6.900
		1123	6.875
	Low-Quality Durum Wheat	1141	6.600
BREAD WHEAT	White and Red Hard Wheat	1211-1221	6.550
		1212-1222	6.450
		1213-1223	6.425
	Other White and Red Wheat	1311-1321	6.450
		1312-1322	6.425
		1313-1323	6.400
	Low-Quality Bread Wheat	1611-1621	6.375
NON-STANDARD WHEAT		1690	6.000
BARLEY-RYE-OAT-TRITIKALE		2111-2211-2221-2311	5.800
		2112-2212-2222-2312	5.700
NON-STANDARD BARLEY		2190	5.450

6.3. Local Variety Preference in Organic Wheat

High-cost new breeding varieties selected in traditional wheat farming are not sufficiently adapted to organic farming conditions (Murphy et al., 2007; Wolfe et al., 2008). It is stated that the old wheat genotypes are more active in their mycorrhizal relationships and can use more nitrogen than the new wheat genotypes in low-yielding conditions (Foulkes et al., 1998).

The development of genotypes suitable for organic farming depends on the selection of genotypes with special adaptation abilities, based on local adaptation suitable for the region. (Banziger and Cooper, 2001; Ghaouti and Link, 2009 In organic wheat cultivation, the density and variety of weeds increase, and yield losses of up to 40% are experienced. When wheat genotypes are compared, there are significant differences in terms of competition with weeds. Although there has been a significant increase in wheat yield over the past 150 years, there has been a slight decrease in the yield of newly developed varieties in terms of competition with weeds (Gosme et al., 2012).

It has been observed that early development, more tillering, and tall genotypes are more effective against the ability to compete more against weeds (Mason et al., 2007). In addition, wheat genotypes containing many allelopathic compounds show differences in terms of allelopathic relationships (Lammerts van Bueren et al., 2011). Developing varieties that are resistant to diseases and pests is very important in organic agriculture as in traditional agriculture. Tall and old genotypes are used to develop disease-resistant varieties such as weeds and tillage, rust, and smut, which are the main problems of organic agriculture.' (Murphy et al., 2007; Lammerts van Bueren et al., 2011).

Although a significant increase in wheat yield has been achieved in the past 120 years, the content of zinc, copper, phosphorus, manganese, iron, selenium, and magnesium in the grain, apart from calcium, decreased in newly used varieties, and the relevant elements were found in the ratios needed in terms of nutrition in old varieties. In this respect, in terms of suitability for organic wheat cultivation, adaptability according to the regions, being tall and high tillering for competitiveness with weeds, allelopathic (chemical interaction) and mycorrhizal (fungal) characteristics, resistance to diseases and pests, water use efficiency and high nitrogen content. properties such as having a balanced nutritional element content are sought (Akkaya, 2018).

The current needs of our local wheat genotypes, which are rich in vitamins and minerals, have never been genetically modified, which have never been genetically modified, which have been selected under organic farming conditions and have been used in Anatolia for thousands of years, where the use of chemical chemicals and commercial fertilizers is out of the question. potential is very high. In addition, products obtained from our local wheat varieties are in high demand today, depending on the dietary habits from the past. For this reason, organic wheat farming can be preferred because the planting and production of our local varieties are preferred by the producers and the consumers' interest and trust in organic farming.

7. CONCLUSION AND RECOMMENDATIONS

- Our local wheat genotypes can be defined as an important treasure in terms of being suitable for organic farming. In light of this information, the transition to organic wheat farming is easy in the regions where the yield amount is far below the Turkey average, in small-scale enterprises that use less input.

- Input costs in wheat, which is traditionally grown in our country, are increasing. • Farmers engaged in wheat cultivation in some regions of our country obtain low yields.

- As the yield decreases in traditional wheat farming, the yield difference between organic wheat farming and conventional wheat farming decreases.

- Organic wheat farming should be promoted, and infrastructure, especially marketing opportunities, should be prepared for those who will do organic wheat farming.

- Evaluation units should be established quickly among the wastes in cities suitable for organic agriculture as an additional resource to provide fertilizer for organic agriculture.

- The number of studies on alternative organic control options to these preservatives should be increased instead of using chemical drugs and pesticides. • It should find sufficient interest in all Agricultural Research Institutions, studies should be planned by establishing field days and demonstrations, and information should be exchanged between institutions.

- Engaging in organic farming is easier in eastern Turkey than in industrialized regions. Therefore, Turkey will be able to isolate itself from the environmental problems faced by many developed and developing countries due to the intensive use of chemicals.

- It can contribute to rural development and employment by increasing the cultivation of agricultural products with high trade volume and high added value, in organic principles and practices. • Organic residues potentially found in the Black Sea Region must be evaluated by composting method. Among these, rice husk, hazelnut slag, tobacco residues, tea residues, and plant residues such as broccoli and cauliflower left in the field after harvest should be made suitable for returning to the soil.

- The lack of communication and cooperation between the public, private sector, and non-governmental organizations and the insufficient development of the information-sharing network appear as critical problems.

- The number and adequacy of farmer cooperatives and unions formed by organic farmers coming together are limited. Farmers should be strengthened economically with incentives and support by being subject to control.

- Farmer training and extension studies should be carried out to increase the cash support for organic agriculture and to encourage the transition process. • To increase consumers' interest in organic agriculture, it will increase the potential of organic agriculture and the food domestic market in our country in cooperation with the private sector and non-governmental organizations.

- Compared to other countries, the trade volume of the organic agriculture domestic market in our country ($ 14 million) is at the lower limit values. The scarcity of incentive activities, lack of documentation and technical infrastructure, low consumer awareness rate, and relatively high prices cause the annual organic agriculture development rate to be low.

- For the multi-faceted development of organic agriculture, the development of the domestic market, as well as the foreign market, should be encouraged.

- To deliver the obtained product to the agricultural-based industrial zones in a short time and safely, the road networks forming the village, district, and province connections should be given importance and these roads should be established in areas that may be within a distance of all villages.

- It should create a database of local wheat genotypes and obtain information about the plants previously grown in various parts of our country.

- Plant growth and yield models should be established in wheat that can be applied in every region of our country. • Care should be taken with a higher value than standard products, from sowing and planting to harvesting, packaging, preservation, and even sales/marketing of organic products. • Every stage of control and certification processes should be controlled and audited by the Ministry.

- Cheap and alternative inputs should be provided. (PCPR, PCPF, Fungi)
- A generation with environmental awareness and love for plants/animals/nature should be raised. • Burning of stubble should be prevented.
- Certification institutions should not be private, they should be state-sponsored. For this, especially Provincial Directorates of Agriculture and Forestry should be assigned, certificates should be given free of charge and some financial support should be provided for incentives.

Compared to industrialized countries, the rate of chemical input usage per unit area in Turkey's agricultural lands is very low. Since our agricultural lands are rich in organic matter and there is no intense chemical pollution, the development and dissemination of organic agriculture should be ensured. For the organic farming model, which is nature and environment-friendly, to be established as a sustainable farming system, farmers should be introduced to this system and encouraged to transition to these organic farming practices.

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CHAPTER 8

EFFECTS OF SILICON APPLICATIONS ON PLANT GROWTH AND NUTRIENT UPTAKE IN LEAD POLLUTION

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1. INTRODUCTION

With the rapid increase in the human population, environmental pollution is also increasing. Major soil polluting heavy metals are Cd, Cr, Hg, Pb, Cu and Zn. Among these pollutants, lead is especially prominent. Because lead is spread around as tetra ethyl lead compound, which is formed because of the combustion of gasoline used in motor vehicles (Çağlarırmak and Hepçimen, 2010). In addition, lead paints, water installations, cosmetics, as a result of gold refining processes, tin can lid, lead-tin alloy containers, ceramic glazes, pesticides, batteries, etc. It is used extensively in areas (Kahvecioğlu et al., 2016) and constitutes an important source of environmental pollution. Lead negatively affects cell turgor and cell wall stability in the plant (Sharma and Dubey, 2005), regression in chlorophyll biosynthesis (Fargasova, 1994; Doğan et al., 2009) and an increase in the amount of non-protein SH groups and proline (Öztürk et al., 2003; Doğan and Çolak, 2009). Today, a significant number of heavy metals reach the soil through industrial activities, motor vehicle exhausts, mineral deposits and operations, the use of urban wastes as fertilizer, chemical fertilizer and pesticide applications, irrigation with wastewater and treatment sludge applications (Asri and Sönmez, 2006). These substances not only accumulate in organisms, but also travel through food chains and stay in ecosystems for a long time at dangerous concentrations (Okcu et al., 2009). The rapid industrialization of our country and its exposure to increasing traffic density increase the number of heavy metals in the environment along with many other pollutants. This situation causes many negativities, especially product loss, especially in plants (Munzuroğlu and Gür, 2000; Erman et al., 2022).

Although silicon is not an absolute essential nutrient (Epstein, 1994), in some plants it can be as high as phosphorus, sulfur, calcium, and magnesium in equal amounts and in some cases as high as nitrogen and potassium (Casey et al., 2003). Silicon is the second most abundant element in soils, in proportions ranging from 50 to 400 g kg^{-1} (Kovda, 1973). Silicon application at high concentrations increases plant growth, reduces water loss, increases resistance to fungal diseases and insect damage (Ma et al., 2001), helps plants to stay upright and provides more resistance to lodging (Ma et al., 1992; Takahashi et al. et al., 1990), it increases the resistance of plants against some heavy metal toxicity (Horst and Marschner, 1978; Horiguchi, 1988; Barcelo et al., 1993), increases the resistance against salt stress by reducing the use of Na (Miyake, 1993; Liang et al. , 1996; Tsuda et al., 2000; Ali et al., 2013), that is, it has been reported by studies that it increases the resistance of the plant against many abiotic stresses (Ahmed et al., 2013). It has been reported that external silicon applications improve plant-water relations and internal ionic balances, provide tolerance to oxidative stress, and reduce heavy metal-induced phytotoxicity in plants by limiting the accumulation of toxic metal ions in regions with heavy metal problems in plant cultivation (Huan et al., 2019; Khan et al., 2020).

In this review, the effect of silicon applications on some morphological properties of barley grown in lead-contaminated environments was investigated.

2. MATERIAL AND METHOD

This study was carried out in the climate room of Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition. In the experiment, Tokak 157/37 variety of barley (Hordeum vulgare L.) and 2 kg soil pots were used. In the experiment, which was carried out in three replications according to the factorial experimental design in random plots, 0, 75, 150 and 300 mg kg^{-1} Pb, $PbNO_3$ and 0, 3, and 6 mM Si kg^{-1}, as $SiO_2.H_2O$ were applied. As basic fertilization, 300 mg kg^{-1} N, 80 mg kg^{-1} P_2O_5 and 180 mg kg^{-1} K_2O were applied to each pot with ammonium sulfate, triple superphosphate, and potassium sulfate. 10 seeds were planted in pots. After the emergence, the thinning process was carried out to leave 5 plants in each pot. The experiment was carried out in the climate room at 21 ± 1^0C, 14 hours during the day, 10 hours at night and at 800 lux light intensity. During the experiment, the plants were grown by irrigating with distilled water. The experiment was continued for about 8 weeks, and at the end of the experiment, development criteria such as plant number, plant height, number of siblings, emergence rate, emergence speed, fresh root fresh weight, root dry weight, root fresh weight and root dry weight were determined. After the plant samples harvested at the end of the experiment were washed with distilled water, they were dried in the drying cabinet at 65 ^{o}C until they reached a constant weight. The dried samples were ground with a plant grinding mill and made ready for analysis. Plant samples were extracted for elemental analysis as reported by Kacar and İnal (2008), and Fe, Mn, Zn, Cu and Pb readings were made in the ICP-OES instrument.

Some physical and chemical properties of the trial soil are given in Table 1.

Table 1. Some Physical and Chemical Properties of the Experimental Soil

Texture	pH	Salinity	Lime	O.M.	Total N	Available P	Extractable			Available			
							Ca	K	Mg	Fe	Mn	Zn	Cu
		%				mg kg^{-1}	%			mg kg^{-1}			
Loamy	8.16	0.02	15.4	1.19	0.08	6.28	0.48	382	121	5.3	4.2	1.1	2.6

It has been determined that the experimental soil has loamy texture, alkaline reaction, no salt, insufficient organic matter, calcareous, nitrogen and phosphorus contents at medium level, and potassium, calcium, magnesium, iron, manganese, zinc, and copper contents at sufficient level (Aydeniz, 1985).

3. RESULT AND DISCUSSION

3.1 Effects of Applications on Development Criteria

The variance analysis results regarding the effects of different doses of lead and silicon applications on the morphological characteristics of the barley plant are given in Tables 2 and 3. It was determined that lead applications had a significant effect of 5% on plant height, 1% on root fresh weight and 0.1% on root dry weight. On the other hand, silicon applications had a significant effect on the emergence rate and dry weight on the root at the level of 5%, on the fresh weight on the root at the level of 0.1% and on the root fresh weight at the level of 1%. SixPb interaction affected plant height and root fresh weight by 5%, root length and root dry weight by 0.1% (Table 2, 3).

Table 2. Variance Analysis Results of he Effects of Silicon and Lead Applications on Some Morphological Features

Source	Df	Plant no.		Plant heigth		Root length		Tillering		Exit rate	
		MS	F	MS	F	MS	F	MS	F	MS	F
Pb	3	0.518	0.52 ns	32.33	4.15 *	0.083	0.07 ns	1.17	2.70 ns	77.78	0.45 ns
Si	2	2.527	2.53 ns	6.97	0.89 ns	0.250	0.20 ns	0.95	2.20 ns	858.33	4.98 *
Pb x Si	6	0.824	0.82 ns	20.27	2.60 *	9.333	7.47 **	0.67	1.55 ns	269.44	1.56 ns
Error	24	1.000		7.78		1.250		0.43		172.22	

**, %0.01; *, % 0.05; ns, non-significant

Table 3. Variance Analysis Results of the Effects of Silicon and Lead Applications on Some Morphological Features

Source	Df	OS		FWP		DWP		FWR		DWR	
		MS	F	MS	F	MS	F	MS	F	MS	F
Pb	3	0.479	1.77ns	0.181	0.34ns	0.01	0.12 ns	1.78	5.89**	0.07	12.16**
Si	2	0.740	2.73ns	6.412	11.86**	0.23	3.85 *	1.91	6.32**	0.01	2.63 ns
PbxSi	6	0.297	1.10ns	1.391	2.57*	0.05	0.83 ns	0.60	2.01ns	0.03	5.82 **
Error	24	0.270		0.540		0.06		0.30		0.01	

**, %0.01; *, % 0.05; ns, non-significant; OS, Output speed; FWP, Fresh Weight Plant; DWP, Dry Weight Plant; FWR, Fresh Weight Root; DWR, Dry Weight Root

The averages and Duncan lettering of the effects of silicon (Si) and lead (Pb) applications on some morphological properties of barley are given in Table 4.

Table 4. Averages and Duncan Lettering of the Effects of Silicon and Lead Applications on Some Morphological Properties

Treatments	Pn	PH	RL	Til.	ER	OS	FWP	DWP	FWR	DWP
	No.	cm		No.	%	No.		g		
Pb, mg kg^{-1}										
0	3.89	43.01a	17.0	2.40b	51.1	5.38	5.58	1.048	1.711b	0.207b
75	4.11	42.81a	16.8	2.76ab	50.0	5.11	5.30	0.993	2.538a	0.335a
150	4.44	43.64a	16.8	2.48 b	47.8	4.87	5.48	0.989	2.818a	0.379a
300	4.00	39.45b	17.0	3.20 a	44.4	5.31	5.29	1.027	2.429a	0.400a
LSD(0.05)	0.97	2.71	1.1	0.64	12.8	0.51	0.72	0.235	0.534	0.073
Si, mM										
0	4.58a	41.54	16.7	2.54	55.8a	5.35a	4.63b	0.867b	2.531	0.370a
3	4.08ab	42.15	17.0	2.56	50.0ab	5.26ab	5.53a	1.039ab	2.421	0.317ab
6	3.67b	43.06	17.0	3.04	39.1b	4.89b	6.70a	1.138a	2.170	0.304b
LSD(0.05)	0.84	2.35	0.9	0.55	11.06	0.44	0.620	0.204	0.463	0.063

*There is no statistical difference between the averages shown with the same letter; Pn, Plant Number; PH, Plant Height; RL, Root Length; Til, Tillering; ER, Exit Rate; OS, Output speed; FWP, Fresh Weight Plant; DWP, Dry Weight Plant; FWR, Fresh Weight Root; DWR, Dry Weight Root

Although not statistically significant, there was a slight increase in the number of plants with increasing lead applications. The number of plants, which was 3.89 pieces/pot in the control, increased to 4.44 pieces/pot in 150 mg kg^{-1} application and this increase was 14.1%. Increasing silicon applications caused a significant decrease in the number of plants. The number of plants, which was 4.58 units/pot in the control, was determined as 3.67 units/pot in 6 mM silicon application. This decrease was 24.8% (Table 4).

While a decrease in plant height was determined with lead doses, an increase was obtained in silicon applications. The plant height, which was 43.01 cm in pots without lead, decreased to 39.45 cm in pots with 300 mg kg^{-1} lead application. This decrease was found to be at the level of 9.0% and statistically significant. The plant height, which was 41.54 cm in pots without silicon application, increased to 43.06 cm in 6 mM silicon application (Table 4).

The effect of both applications on root length was not found significant, it was determined that increasing lead applications had a significant ($P<0.01$) effect on the number of siblings. The number of siblings, which was 2.40 units/plant in the control, increased to 3.20 units/plant in 300 mg kg-1 Pb application. This increase was 33.3%. Although there was an increase of 19.7% with increasing silicon applications, this increase was not found to be statistically significant (Table 4).

Both lead and silicon applications had a decreasing effect on the emergence rate of barley. While the emergence rate was 51.11% in pots without lead, this rate decreased to 44.44% in pots treated with 300 mg kg^{-1} Pb. Increasing silicon applications decreased the emergence rate, this decrease was found to be at the level of 42.5% and statistically significant. The emergence rate was found to be 55.83% in pots without silicon, and this rate decreased to 39.17% in pots treated with 6 mM Si (Table 4).

It was determined that while silicon applications had a statistically significant ($P<0.01$) effect on the exit velocity, the effect of lead applications was not significant. With increasing silicon applications, the emergence rate decreased from 5.35 units/day to 4.86 units/day, and this decrease was realized as 9.4% (Table 4).

While the fresh and dry weight of the root was not affected by increasing lead applications, it increased significantly ($P<0.01$) with increasing silicon applications. The wet weight, which was 4.628 g in pots without silicon, increased to 6.704 g with 6 mM Si application, and this increase was 44.9%. Above-root dry weight increased from 0.867 g (control; 0 mM Si) to 1.138 g (6 mM Si) and this increase was 31.3% (Table 4).

Root wet weight increased with increasing lead applications compared to control. Root wet weight, which was 1.711 g in pots without lead, increased to 2.515 g in 150 mg kg^{-1}1 Pb application. This increase was 64.7%. It was observed that there was an insignificant decrease with increasing silicon applications (Table 4).

Increasing lead and silicon applications had a significant ($P<0.01$) effect on root dry weight. While the root wet weight was 1.758 g in pots without lead applied, it increased to 2.818 g in 150 mg kg^{-1} Pb application, and it was determined as 2.429 g in 300 mg kg^{-1} Pb application. These increases were 60.3% and 38.2%, respectively. Root wet weight, which was 2.748 g in the pot without silicon, decreased to 1.954 g in the application of 3 mM Si. This decrease was 40.6% (Table 4).

While the root dry weight increased with increasing lead applications, it decreased with silicon applications. Root dry weight was obtained as 0.370 g in pots without lead applied, and it was determined as 0.400 g in 300 mg kg^{-1} Pb application. This increase was 93.2%. Root dry weight decreased by 20.7% with silicon applications and this decrease was found to be statistically significant ($P<0.01$). Root dry weight, which was 0.370 g in pots without silicon, was 0.304 g in pots treated with 6 mM Si (Table 4).

The effects of the interactions are given in Figures 1, 2, 3 and 4. When the effect of interactions was examined, the significant effect of silicon on plant height was seen in the plots where lead was not applied, and it provided an increase of 15.0% in plant height. The application in which silicon increased the plant height with the addition of lead was 75 mg kg^{-1} Pb application, and 150 mg kg^{-1} Pb application had no effect. A slight increase in plant height was achieved with increasing silicon applications in 300 mg kg^{-1} Pb application. Ali et al., (2013) reported in their study that increased silicon applications in chromium toxicity provided a slight increase in plant height.

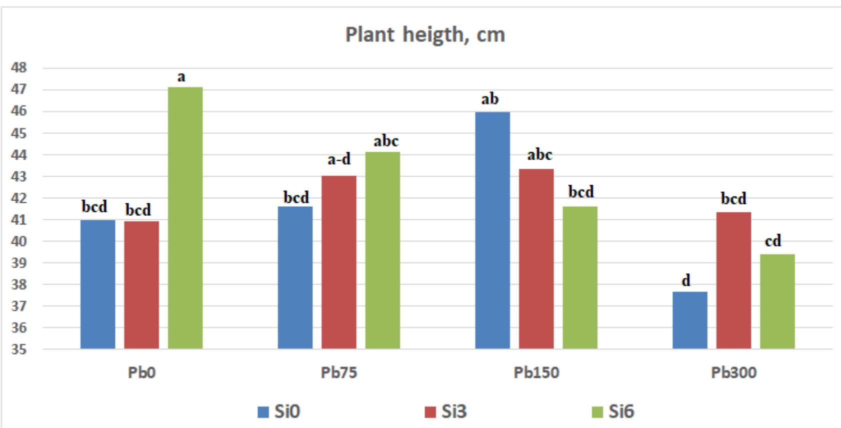

Figure 1. Effects of SixPb Interactions on Plant Height (P<0.05)

The most significant increase observed in fresh weight root was obtained in 6 mM Si application in pots without lead, and a weight gain of 77.5% was determined. In the application of 150 mg kg^{-1} Pb and 6 mM Si, a significant increase in the fresh root weight was obtained, and this increase was approximately 24.2% compared to the pots without silicon. Another significant fresh weight plant gain was achieved at the rate of

30.2% in 300 mg kg^{-1} Pb application (Figure 3). As a matter of fact, Bocharnikova (2016) reported that in the application of heavy metals and two different silicon sources in barley, the root and root weights of silicon increased in high-dose heavy metal applications. It was thought that this situation could be associated with the improvement in plant development by decreasing the uptake of heavy metals and their transport from root to stem, as well as increasing the tolerance of plants against heavy metals (Kaya et al., 2009).

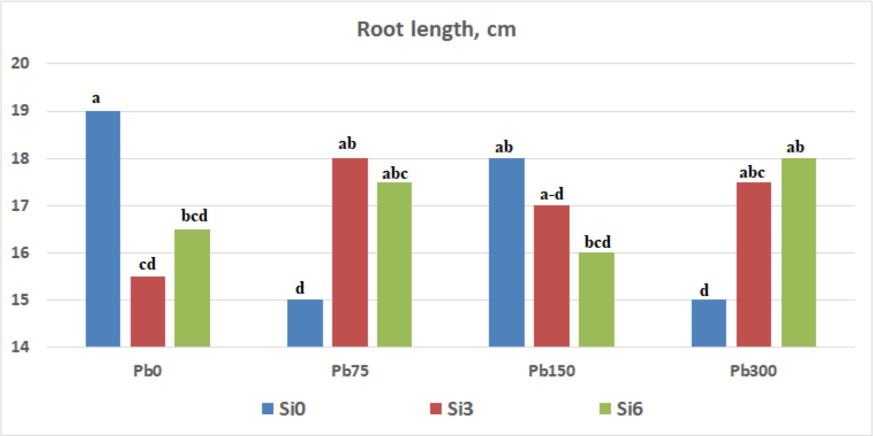

Figure 2. The Effects of SixPb Interactions on Root Length (P<0.01)

The significant effect of silicon applications on root dry weight was obtained by adding 3 mM silicon in 300 mg kg^{-1} Pb applied pots. It provided an increase of approximately 66.1%. Silicon application on root dry weight could not increase in other applications (Figure 4).

As a matter of fact, Ali et al. (2013) reported a significant increase in root dry weight with increasing silicon doses, even in the presence of 100 µM Cr in the medium.

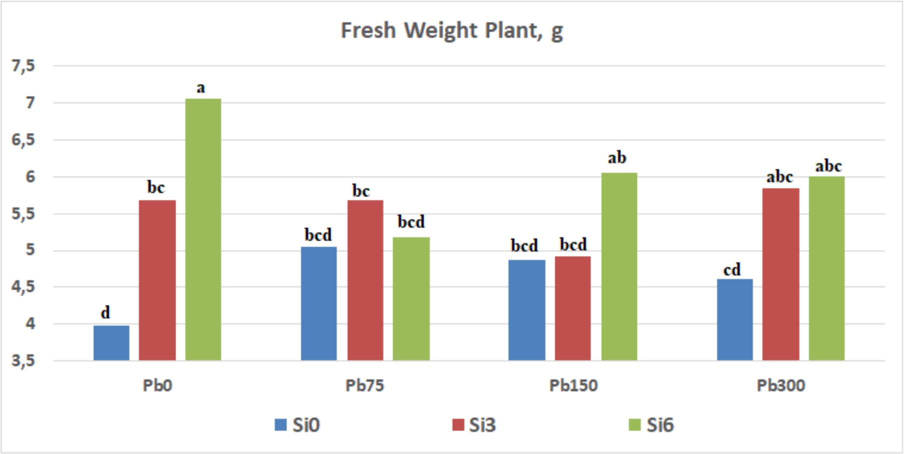

Figure 3. Effects of SixPb Interactions on Fresh Weight Plant

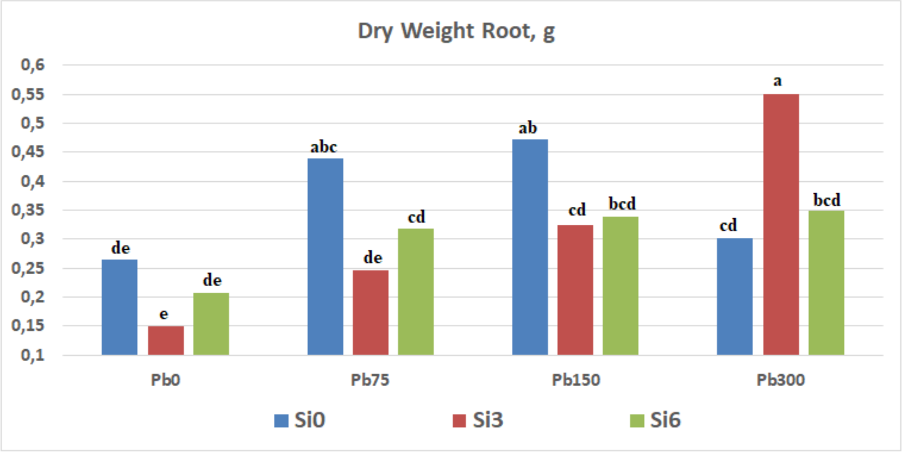

Figure 4. Effects of SixPb Interactions on Dry Weight Root

3.2 Effects of Applications on Micro Element Contents

The results of the variance analysis regarding the effect of increasing doses of lead and silicon on the macro element contents of barley plant are given in Table 5, the averages of the elements and Duncan letterings are given in Table 6. The results of the PbxSi interaction are given in Figure 5, 6 and 7.

Table 5. Variance Analysis Results of the Effects of Silicon and Lead Applications on Microelements and Lead Content of Barley

Source	Df	Fe		Mn		Zn		Cu		Pb	
		MS	F	MS	F	MS	F	MS	F	MS	F
Pb	3	55380	17.25**	43.3	1.69ns	31.58	2.49ns	10.33	0.94ns	97.35	26.86**
Si	2	18639	5.80**	36.3	1.41ns	78.17	6.18**	33.18	3.02ns	49.93	13.78**
PbxSi	6	58053	18.08**	21.1	0.82ns	49.52	3.91**	12.66	1.15ns	17.71	4.88**
Error	24	3209		25.6		12.66		10.98		3.62	

**< significant at 0.01 *< significant at 0.05, ns: not significant

When the effects of the applications on micro elements and lead content were examined, it was seen that the source of lead variation had a significant effect at p>0.01 level in iron and lead, the interaction of silicon and lead x silicon had a significant effect at the p>0.01 level in iron, zinc and lead, and the effects on manganese and copper content were insignificant (Table 5).

Table 6. Averages and Duncan Lettering of the Effects of Silicon and Lead Applications on Microelements and Lead Content of Barley

Treatments	Iron	Manganese	Zinc	Copper	Lead
Pb, mg kg^{-1}					
0	516 c	77.96	23.10 a	20.03	13.856 c
75	703 a	79.56	21.36 ab	22.00	15.911 b
150	572 b	76.96	19.79 ab	21.02	19.567 a
300	601 b	81.99	18.82 b	19.60	21.022 a
LSD(0.05)	55	4.92	3.46	3.22	1.852
Si, mM					
0	642 a	80.30	23.69 a	19.74	19.898 a
3	585 b	79.93	19.62 b	19.67	16.833 b
6	566 b	77.12	18.99 b	22.58	16.034 b
LSD(0.05)	48	4.26	2.99	2.79	1.604

*There is no statistical difference between the averages shown with the same letter

The iron content of the barley plant increased with increasing lead application compared to the control, the highest iron content was reached in 75 mg kg^{-1} lead application and was measured as 703 mg kg^{-1}. An increase of approximately 36.2% was achieved. On the other hand, a decrease in iron content was obtained with silicon applications compared to control. Iron content, which was 642 mg kg^{-1} in the control, decreased to 566 mg kg^{-1} with 6 mM silicon application, and this decrease was 13.4% (Table 6).

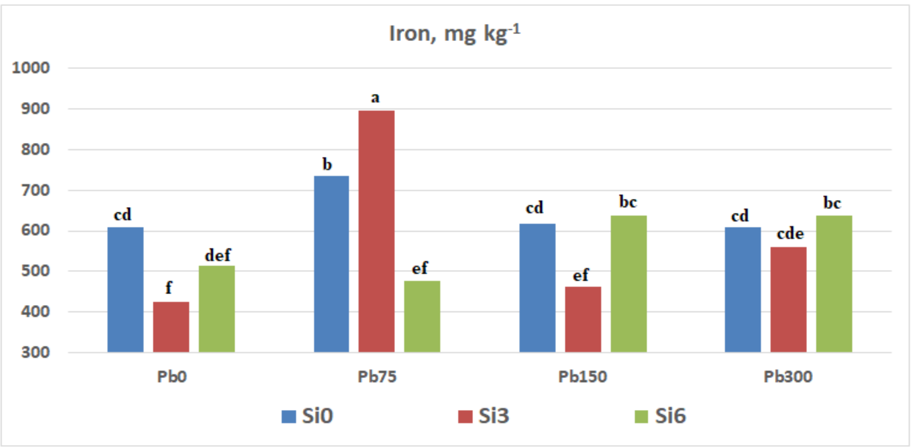

Figure 5. Effect of Si x Pb Interaction on Iron Content (P<0.001)

With increasing lead applications, the zinc content of the barley plant decreased compared to the control group plants. The zinc content, which was 21.10 mg kg^{-1} in the control group plants, decreased to 18.82 mg kg^{-1} with 300 mg kg^{-1} lead application. A similar situation has been determined in silicon applications. With increasing silicon applications, the zinc content was 23.69 mg kg^{-1} in the control, while it decreased to 18.99 mg kg^{-1} with 6 mM silicon application. A decrease of 22.7% was obtained with lead applications and 24.7% with silicon applications (Table 6).

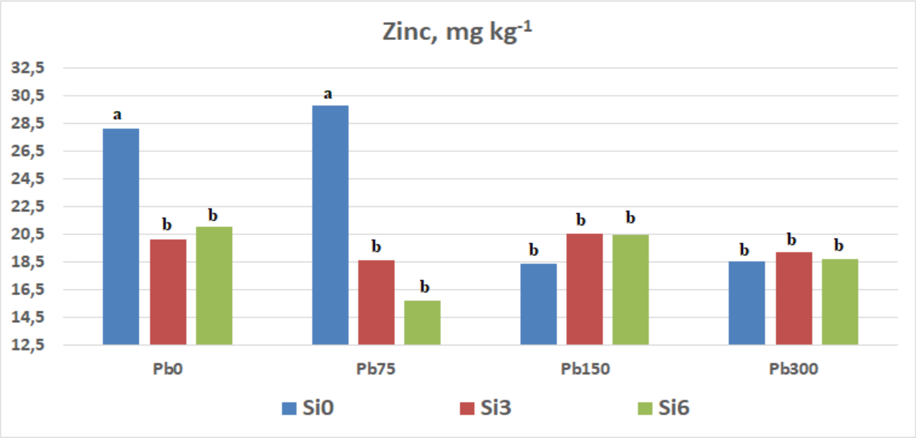

Figure 6. Effect of Si x Pb Interaction on Zinc Content

Although the manganese content increased with increasing lead applications compared to the control plants, this increase was not found to be significant. Although there was a decrease in silicon applications compared to control plants, this change was not determined to be significant. With increasing lead applications, an increase and then a decrease were obtained in copper, these changes were not found to be significant. Although the copper content of the plant increased with silicon applications compared to the control plants, this change was not determined to be significant (Table 6).

The lead content, which was determined as 13.86 mg kg^{-1} in the control group plants, increased with increasing lead doses, and reached the highest value as 21.02 mg kg^{-1} at 300 mg kg^{-1} lead dose. This increase was 51.7%. It was determined that there was a decrease in lead uptake with increasing silicon applications compared to control plants. Lead content, which was 19.89 mg kg^{-1} in control plants, reached the lowest value with 6 mM silicon application and was measured as 16.03 mg kg^{-1}. This change was 24.1% (Table 6). As a matter of fact, Bharwana et al. (2013) reported in their study that silicon applications decreased the lead content of roots, stems, and leaves and the translocation of lead from root to stem. It is reported that this situation is caused by the increase of lignification in the cell wall of silicon (Ali et al. 2013b) and thus increasing the binding of heavy metals in the cell wall (Ma et al. 2001).

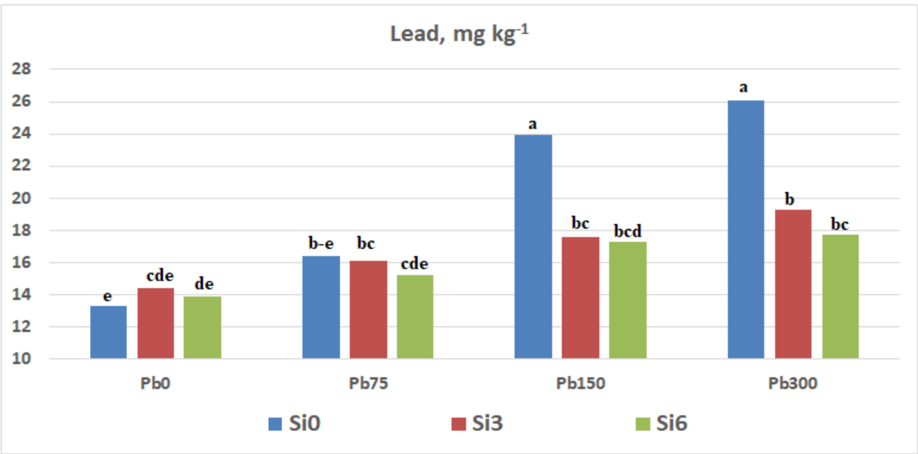

Figure 7. The effect of Si x Pb Interaction on Lead Content (P<0.001)

It has been observed that the plants that do not apply lead to the environment provide an insignificant increase in lead content. However, when lead was added to the medium, it was observed that silicon reduced lead uptake (Figure 7).

4. CONCLUSION

In this study, some morphological properties, nutritional elements, and changes in lead content of barley were investigated by the application of increasing doses of silicon to soil contaminated with different doses of lead.

The curative effect of silicon is seen in increasing lead applications. This situation was observed better especially in the number of siblings, fresh root weight, root dry weight, root fresh weight, root dry weight, emergence rate and emergence rate. Similarly, in some studies, it has been emphasized that silicon applications have a healing feature in the development of plants against the toxic effects of heavy metals (Ali et al., 2013a; Ali et al., 2013b; Güneş et al., 2007; Wang et al., 2000). This curative effect observed in silicon applications is explained by the accumulation of silicon in the form of silicic acid ($Si(OH)_4$) in plant roots (Ma and Takahashi, 2002) and the reduction of apoplastic flow in stem cells, thus preventing the uptake and transport of heavy metals from the root to the stem (Ma and Takahashi, 2002; Yamaji, 2006). The accumulation of silicon in the stem, leaf and stem increases the strength and durability of the cell wall and thus improves the resistance of the plant against abiotic stress factors (Gong et al., 2005; Zhu et al., 2004; Liang et al., 2003; Gong et al., 2003; Neumann and zur Nieden, 2001).

As a result, it was determined that silicon increased the uptake of some nutrients and decreased some of them with the development of the plant in increasing lead applications. It has also been observed that the plant increases the lead uptake, albeit in an amount, in conditions where there is no lead application.

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CHAPTER 9

USAGE OF RIBOSOMAL RNA (rRNA) INTERNAL TRANSCRIBED SPACER (ITS) GENE REGIONS IN PHLOGENETIC ANALYSIS OF INSECT POPULATIONS

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1. INTRODUCTION

Insects are invertebrates that are taxonomically referred to as the class Insecta. İnsect are the most numerous and most widespread terrestrial taxon within the phylum Arthropoda. They are the creatures with the most species on Earth, with more than 1,000,000 species numbers (Anonymus 2022a). They live almost worldwide, and their populations can sometimes be seen at high levels. The total number of species is estimated at 2,000,000 (older estimates) to 30,000,000 (more recent estimates), and they make up as much as 90% of the animals on Earth (Anonymus 2022b).

Accurate identification of insect specimens is an important step for biodiversity, pest management programs and forensic entomology. Numerous insect species are described each year. There are still many insect species awaitig for identification. It is aimed to reveal the number of species in many faunistic studies carried out in different regions of the world. In these studies, the identification of newly detected insect species is based only on morphological characters. It has been clearly shown in previous studies that this situation can be both difficult and time-consuming. As a matter of fact, according to Pinto and Stouthamer, (1994), it is still difficult to identify small insects depending on the morphological characters and it has been stated that special skills are required. Moreover, it is extremely important that an accurate diagnosis is made only by taxonomists and experts in this field. However, the number of insect taxonomists is decreasing day by day. Depending on these developments, rapid DNA sequencing techniques have emerged today, made possible by modern DNA sequencing technologies.Thus, such limitations that led to the discovery of new species and the global classification of fauna were resolved. DNA sequencing technology developed by Sang and Coulson (1975) has become the most preferred method in a short time because it is easier and more reliable.

DNA barcoding is expressed as a method of species identification using a short section of DNA from a particular gene or genes. “DNA barcoding”, a new PCR-based technology, enables accurate identification of the target taxon based on a specific DNA sequence that preferably functions as a species-specific nucleotide or molecular signature in the genome (Ankola et al. 2021).

DNA barcoding is commonly recognized as a valuable molecular tool for rapid and accurate species identification and biodiversity assessment (Hebert et al. 2016; Hendrich et al. 2015). Therefore, nowadays it has been reported that it takes advantage of diversity among DNA sequences to identify the organism (Boekhout et al. 1994; Wilson et al. 1995). Phylogenetic proximity or distance between populations and species can be obtained by using biochemical and immunological methods or gene sequence analysis methods (Belshaw et al. 1997; Valenzuela et al. 2007; Kang et al. 2012).

Identification of living groups, their genetic structures, gene flows and relationships between different populations; is obtanied with sequencing data of widely used cytochrome oxidase I and II, 12S and 16S genes and internal transcribed spacer (ITS) regions between ITS1 and ITS2. Polymorphisms in core ribosomal RNA (rRNA) (ITS) have been used in many cases to distinguish closely related organisms (Hillis and Davis, 1986; Mindell and Honeycutt, 1990; Hillis et al. 1991). Studies made using these sequences have revealed phylogenetic relationships and taxonomic levels in insects (Kwon and Ishikawa, 1992; Campbell et al. 1994; Kuperus and Chapco, 1994; Weekers et al. 2001; Marcilla et al. 2002; Liu et al. 2006; Peccoud et al. 2013).

By overcoming the shortcomings of morphological approaches, thanks to DNA data obtained from molecular studies, sister insect species can be recognized, taxonomic decisions are objective, and all life stages of insects can be identified (Hebert et al. 2003). In addition, pathogen spread and associated vectors can be monitored (Azpurua et al. 2010).

Recently, the widely used (rRNA) core sequence has been used for different purposes, from clarifying taxonomic problems, understanding pest species dynamics, revealing phylogenetic relationships, and species identification. There are many studies on these subjects (Hillis and Dixon, 1991; Wesson et al. 1993; Campbell et al. 1994; Collins and Paskewitz, 1996; Rich et al. 1997; Fenton et al. 1997; Kruger et al. 2000; Gallego and Galián, 2001, Mukha et al. 2002, Becerra, 2004; Coleman, 2007; Cuignet et al. 2007, Ercan et al. 2011; Coleman, 2015).

Internal transcribed spacer (ITS) gene regions (Figure 1) consist of high rates of evolution that are conserved and conserved between replications (Hillis and Dixon, 1991; Coleman and Vacquier, 2002). Furthermore, it was reported that the presence of conserved primers facilitated the isolation of target sequences by polymerase chain reaction (Hillis and Davis 1986; White et al. 1990). Because of their rapid evolutionary rates, the 18S, 5.8S and 28S genes (or their homologues), ITS regions between ITS1 and ITS2 (Fig. 1.6) have been popular in phylogenetic inference for closely related taxa (Schindel et al. 1995). The coding sequences are highly conserved and have been used to study relationships between more distant taxa (Hillis and Dixon, 1991). Moreover, mitochondrial markers have proven to have some limitations for insect species identification. For example, high levels of overlap have been shown in interspecies and interspecies distances to certain species (Ferreira et al. 2011).

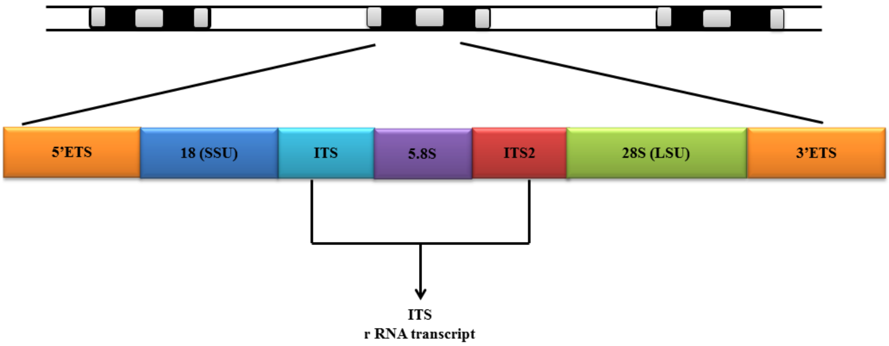

Figure 1. The location of the ITS gene region on the core (genomic) gDNA.

For all these reasons, it has become necessary to molecularly identify species with a nuclear marker such as ITS. Studies on the potential of ITS to reveal phylogenetic relationships within insect groups are increasing rapidly. It allows us to detect the differentiation between morphologically very similar and related insect species to the help of DNA barcoding techniques. In the last 15-20 years, one of the preferred and frequently used molecular markers in the phylogenetic analyzes of insect populations has been the rRNA-ITS gene regions. Some studies on the barcoding potential and phylogenetic analysis of ITS for insect species are presented in Table 1.

Table 1. Studies using Ribosomal DNA ITS (internal transcribed spacer) gene region in insect species identification, biogeographic, and phylogenetic analysis studies

Insect order and family	Insect species	Location	GenBank Number	References
(Coleoptera: Curculionidae)	*Miarus campanulae*	Finland	AY837679.1	Vahtera and Muona, (2006)
Coleoptera: Chysomelidae)	*Chrysolina aurichalcea*	Korea	JN601850	Park et al. (2011)
(Coleoptera: Cerambycidae)	*Morimus asper*	Serbia	MZ569316	Gojković et al. (2022)
(Hemiptera Psyllidae)	*Agonoscena pistcaiae*	Türkiye	OP257242	Dilmen et al. (2022)
	Bactericera cockerelli (Sulc)	North America	AY971897	Liu et al (2006)
(Hemiptera Psyllidae)	*Cacopsylla pyricola*	Korea	JF327670	Kang et al. (2012)
(Hymenoptera: Tenthredinidae)	*Dolerus Panzer, 1801*	Türkiye	OK642104	Gülmez et al. (2022)
(Orthoptera, Acrididae, Melanoplinae)	*Tonkinacris* sp.	China	MW054567	Wang et al. (2021)
	Longgenacris, Fruhstorferiola viridifemorata	China	MH934098	Gu et al. (2020)
(Odonata: Libellulidae)	*Leucorrhinia* sp.	America, Canada, Siberia, Asia	AF549525	Hovmöller and Johansson, (2004)
	Sympetrum sp.	Japan	JQ772621	Pilgrim et al. (2012)
(Diptera :Psychodidae)	*Phlebotomus* sp.	Greece	OL351577	Pavlou et al. (2022)
(Lepidoptera: Lycaenidae)	*Agrodiaetus* sp.	Iraq	AY556732	Shapoval and Lukhtanov, (2015).
(Lepidoptera: Pieridae)	*Euchloe bazae*	Spain	ON032819	Escuer et al. (2022)

When the studies conducted in different parts of the world (Table 1) are examined, the molecular genetic information of many insect species has been revealed using the ITS gene region. *Bactericera cockerelli* (Sulc) (Hemiptera, Psyllidae) causes 50%-80% yield losses in tomato in various years in North America. To determine that these pest outbreaks are the result of the evolution of a new *B. cockerelli* biotype Internally transcribed spacer 2 (ITS2) was used for molecular characterization of psyllid populations (Liu et al. 2006). In another study, Hovmöller and Johansson (2004) investigated the intra-individual variation by combining morphological characters with sequence data from the ITS1, 5.8S rDNA and ITS2 regions of the nuclear ribosomal repeat.

In the Southeastern Anatolia Region of Turkey, Dilmen et al. In a study conducted by 2022, an internal replicated spacer (ITS) DNA barcode identifier was used to determine whether recent outbreaks of *Agoinoscena pistaciae* were a simple spread or the evolution of a new *A. pistaciae* biotype. As a result of the study, it was determined that *A. pistaciae* living in these regions are the same species.

In a similar study, the population genetic structure of Pear psylidi, *Cacopsylla pyricola* (Hemiptera: Psyllidae), a serious pest of pear trees, collected from several pear orchards in Korea, to understand the nature of the species distribution and field ecology, the 658-bp region of the Mitochondrial COI gene and the 716-bp-long fully internally transcribed spacer 2 (ITS2) region of nuclear ribosomal DNA was examined (Kang et al. 2012).

In another study showing widespread use of ITS as a potential marker in insects, to obtain the first data on the ITS2 secondary structure, the phylogenetic relationship between 36 Dolerus Panzer, 1801 (Hymenoptera: Tenthredinidae) individuals collected between 2002 and 2018 was revealed (Gülmez et al. 2022).

Wang et al. (2021), used the mitochondrial COI barcode and the full sequences of ITS1 and ITS2, the phylogeny of the genus Tonkinacris and their interrelationships were reported. In another study, the complete sequences COI and ITS1 and ITS2 were used for molecular evidence-based phylogeny and species limitation of the genus *Longgenacris* and the species group *Fruhstorferiola viridifemorata* (Orthoptera: Acrididae: Melanoplinae). (Gu et al.. 2020).

Moreover, in a study by Hovmöller and Johansson, (2004), the phylogeny of *Leucorrhinia* (Odonata: Libellulidae) was revealed based on the ITS1, 5.8S and ITS2 rDNA sequences. In another similar study, to test the monophyly of the dragonfly genus *Sympetrum* (Odonata: Libellulidae) and to draw conclusions about the historical biogeography of the group, DNA sequences with nuclear genes elongation factor-1α (EF1), ITS2, mitochondrial genes 16S/tRNA-val/12S and COI were used. According to Pavlou et al. (2022), mitochondrial (mtDNA) and nuclear locus (nDNA) data were used to reveal the ancestral distributions and phylogeny of the local sand fly species *Phlebotomus* (Diptera: Psychodidae) found in 12 Greek Aegean Islands.

In a different study, the taxonomic status of *Euchloe bazae* (Lepidoptera: Pieridae) populations was made using multilocus phylogenetic inference COI, NADH dehydrogenase 1 (ND1) and ITS2 data (Escuer et al. 2022). When the studies carried out in different parts of the world are evaluated in general, Ribosomal RNA genes (ITS, ITS2) show that insect species are widely used in taxonomic, biogeographic, and phylogenetic analysis studies.

2. CONCLUSION

One of the key points in plant protection is the correct identification of major pests and major natural enemies at the species level. The taxonomy and systematics of insect species have traditionally been based on morphology. However, their small size and very similar morphological structures make it a difficult task. Due to these disadvantages, entomologists have used DNA barcoding method for species identification in the last 15-20 years. The core ribosomal RNA (rRNA) (ITS) region is one of the most important molecular markers that can be used to compare closely related species, kinship relationships, subspecies and populations. However, the number of barcoding studies in the ITS2 region for insect species is very few. The correct identification of ITS DNA barcode marker insect samples plays an important role in the success of biodiversity monitoring, biological control program and forensic entomology.

The lack of adequate and appropriate techniques for identification leads to failures in this sense due to the decrease in the number of expert taxonomists. At the same time, there are many insect species waiting to be identified in the world. Therefore, it can be said that there is a need to develop DNA barcoding techniques to understand biodiversity and to implement an effective pest management programs as well as to accurately identify species.

With the emergence of new technological developments, the use of sequences obtained from molecular techniques in insect systematics has become widespread in recent years. The success of DNA barcoding in the tracking and management of any taxon and in resolving taxonomic uncertainties that complicate the identification of management units is remarkable. In this sense, the rapid continuation of DNA barcoding studies in insect taxonomy can be seen as a pleasing development. Molecular markers from DNA barcoding techniques (ITS) are likely to make important contributions to the biological control of pest species as well as to the taxonomic identification of many insect species living in different parts of the world.

To summarize in general; we think that molecular characterization studies using ITS gene region data as well as COI, which is the standard DNA barcode region, may be useful in monitoring biological diversity, understanding population genetics of insects and revealing the prey-prey relationship.

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CHAPTER 10

DETERMINATION OF YIELD AND SOME YIELD COMPONENTS OF THE REGISTERED LENTIL (*Lens culinaris* MEDIC.) CULTIVARS OF TURKEY IN VAN CONDITIONS

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1. INTRODUCTION

Nutrition is an important problem in all countries of the world (Doğan et al. 2014). Lentil is an important edible legume plant that contains high protein (23.7%) in its grain and is used in human nutrition (Eser, 1978). Since lentil is an early and one-year plant that is resistant to drought, cold and high temperatures, not very selective in terms of soil demand, it enters a crop rotation with wheat in dry agricultural areas (Yesilbas and Togay 2021). It also plays an important role in narrowing the fallow areas (Güngör, 1991). Lentil is an edible legume plant that is rich in vitamins A, B and D as well as having a high protein content (Adams et al. 1985, Şehirali, 1988). For this reason, lentils are an important source to meet the protein needs of people, especially in underdeveloped and developing countries. Lentils are used in human nutrition as well as their stems are used in animal nutrition (Ucar, 2021). While there is 137.4 kg of protein in one ton of legume stalks, there is 70.5 kg of protein in one ton of grain straw. Lentil is one of the important plants that can be planted during the fallow period because it consumes very little water and is resistant to low temperatures and drought (Soysal et al, 2021). In addition, the selection and dissemination of high-yielding and high-quality varieties adapted to the region to be planted is an important factor for the solution. The increase in the production of lentils over the years depends on the increase in the amount of product obtained from the unit area as well as the increase in the cultivation areas (Karadeniz and Togay 2009). It is possible to say that more products can be obtained from the cultivation areas, and thus more products can be offered for export, by solving the problems such as not using suitable varieties and seeds that limit the yield in lentil production. The high cost of this product in our country makes international competition difficult and increases the need for low-cost, efficient and quality products. For this purpose, it is necessary either to eliminate the deficiencies in existing varieties or to obtain new varieties. It is important to evaluate the old and new varieties grown in the region, as the Southeastern Anatolia region meets a high rate of 98% of red lentil production.

This research, carried out for this purpose, will aim to determine the appropriate variety or varieties for the region by determining the yield and yield elements of these varieties by using different lentil varieties.

2. MATERIALS AND METHOD

The research was carried out in the experimental fields of Van Yüzüncü Yıl University, Faculty of Agriculture. 9 registered lentil cultivars (Yusufhan, Ceren, Ankara Yeşili, Sazak-91, Caucasian, Özbek, Çiftçi, Şakar and Fırat-87) were used in the trials.

Van has the harsh continental climate characteristics of the Eastern Anatolia Region. The summers are dry and hot, and the winters are cold and snowy. A transitional precipitation regime is observed between the Mediterranean and terrestrial precipitation regimes in the Van Section. The season with the highest precipitation is spring (39%). This is followed by winter (26.6%) and autumn (27.2%). The season with the least precipitation is summer (7.1%). The annual precipitation amount of the region where the research was conducted is 367.7 mm, the average temperature is 4.48 °C, and the average relative humidity is 61.8%. The amount of precipitation falling in the 2013 growing season is 395.6 mm. The average temperature was 5.920C and the average relative humidity was 41.57%.

Table 1. Meteorological data for the growing seasons of 2013-2014 and long term averages in Van, Turkey

	Precipitation (mm)		Average tem.(C^O)		Relative humidity (%) Number of Snowy Days				Number of Frost Days	
Months	13-14	LTA*	13-14	LTA*	13-14	LTA*	13-14	LTA*	13-14	LTA*
October	21.4	48.7	9.6	10.5	52.6	58.9	1	0.5		
November	35.9	51.5		4.7		67.1	4	10.0		4.0
December	33.6	42.0	-3.5	-0.7	69.2	72.5	29	23.5	7	8.0
January	27.5	46.2	-2.0	-1.8	71.4	70.8	26	27.5	2	5.5
February	123.5	82.0		-0.6		71.8	20	22.5	5	7.5
March	42.3	40.8	4.3	3.8	66.9	66.5	13	16.0		5.5
April	66.9	51.5	10.1	9.9	53.1	52.7	3	1.5		0.5
May	21.1	35.0	15.4	14.6	50.4			53.6		
June	23.4	16.0	19.4	19.2	40.0			42.3		
Total	395.6	367.7	53.3	40.4	374.2	54.3	96	101.5	14	5.1
Average	43.95	40.85	5.92	4.48	41.57	61.58	13.7	14.5	4.6	0.9

*LTA = Long-term average (1979-20014)

The soils are classified as entisols according to soil taxonomy (Soil Survey Staff, 1999). The results of calcareous soil analysis were as follows: sandy loam texture, very low in organic matter and moderate in available phosphorus (Table 2).

Table 2. Some properties of the <2 mm fraction of the top 20 cm of soil used for site

Soil properties	2013-14
Texture	loam
pH[A]	8.88
Clay (%)[B]	40.8
$CaCO_3$ (%)[C]	6.6
Olsen soil test P (ppm)[D]	8,9
Total Salt (%)[E]	0.01
Organic matter (%)[F]	1.89

[A] 1 : 2.5 soil : water, [B] Bouyoucos (1951), [C] lime by calcimetric methods, [D] Olsen et al. (1954), [E] Richard (1954), [F] Jackson (1962).

The study was designed as Randomized Blocks with three replications. The plot was 5 m^2 (1 m x 5 m) and included five rows and sown wheat manually in rows 20 cm apart and not irrigated. The amount of seeds to be planted per m^2 was determined as 350 seeds for small-seeded varieties and 300 seeds for large-seeded varieties. The trial was established on 25.10.2013. At harvest, plants within 50 cm of each of the 5 rows forming the parcel and one row on each side and within 50 cm of the parcel heads were excluded as an edge effect (Ceylan and Sepetoğlu, 1979). Measurements and weighing were made over an area of 0.6 m x 4 m = 2.4 m^2. DAP fertilizer was applied to the soil with the planting, equivalent to 14 kg per decare, on an equal basis for each plot (Engin, 1989). Sowing, harvesting and threshing were done by hand. Weed control in the experimental area was carried out twice, before and after flowering. Measuring, counting and threshing processes of harvested plants were done with great care and average values were taken. Plot yields were calculated by threshing the plants after they were dried in bunches. Since the experiment was carried out in dry conditions, irrigation was not done.

The effect of treatments on wheat were analyzed using analysis of variance procedures for Randomized Blocks with the COSTAT statistical package. The means related with yield and yield components in wheat were evaluated with Duncan's Multiple Range Test statistical analysis.

3. RESULTS AND DISCUSSION

The average plant height of the lentil cultivars used in the experiment ranged from 20.13 to 26.96 cm (Table 1). While the Caucasian variety was the shortest variety with 20.13 cm, the difference between Ceren, Özbek, Çiftçi and Şakar varieties was found to be statistically insignificant. The tallest variety is Fırat-87 with 26.96 cm. Türk and Koç (2003) reported that they obtained the highest plant height from the Native Red variety (30.45 cm) and the lowest plant height from the Seyran-96 variety (25.0 cm) in their study under Ceylanpınar conditions. Çokkızgın and Anlarsal (2008) reported that the highest plant height was obtained from the K. Maraş genotype. Demirhan (2006) reported that the highest plant height was obtained from Ali Dayı and Fırat-87 cultivars, and the lowest plant height was obtained from Sultan-1 cultivar. Although there are some similarities between the findings of the researcher and the findings obtained, there are some differences. This is thought to be due to climatic conditions.

The average height of the first pod of the lentil cultivars used in the study varied between 7.33-10.60 cm. While the lowest first pod height was obtained in Ankara Yeşili cultivar, the difference between Caucasian, Özbek and Çiftçi cultivars was found to be insignificant. Sazak 91 variety had the highest first pod height. Karadeniz and Toğay (2009) average first pod height 7.30-12.06 cm, Biçer and Şakar (2007) average first pod height 9.33-15.33 cm, Demirhan (2006) average first pod height 10-16 cm, Türk et al. (1995) 13-23 cm, Türk and Koç (2003) reported that it varies between 10.7-14.45 cm. It is thought that the reasons why the findings obtained by the researchers and the findings obtained in this study are similar or different are due to the aforementioned reasons. Although the height of the first pod is primarily affected by the genetic structure of the plant, environmental conditions also significantly affect the height of the first pod.

The average number of pods per plant of the lentil cultivars used in the study varied between 17.8-24.3. While the Caucasian variety had the lowest average with an average of 17.8 pods, the Sazak 91 variety was the variety with the highest pod number with 24.3 pods. Sepetoğlu (1994) and Şehirali (1988) reported that the number of pods in the plant varied significantly depending on the genotype and plant density. Çölkesen et al. (2005) reported that the results obtained in Şanlıurfa were insignificant, although the values obtained in Kahramanmaraş were significantly different from each other in their study with 11 different lentil varieties. In the study of Çokkızgın et al. (2005) found the average number of pods per plant as 36.2-47.5. Gunel et al. (1993), on the other hand, found the average number of pods per plant 8.92-13.88 per plant, Erman et al. (2005) reported that the Domestic Red variety produced 28.3 pods, and the Winter Red 51 variety produced 23.8 pods in Siirt. It is thought that the reason why the findings obtained in this study differ from the findings of the researchers is due to the different types, climate and soil conditions.

Table 1. The averages of the investigated traits of lentil cultivars and Duncan groups formed

Varieties	Plant height	First pod height	pods per plant.	seeds per plant.	Grain yield per unit area	1000 seed weight	Harvet index
Yusufhan	22.30 c	9.00 bc	22.0 c	24.12 bcd	95.5 bcd	54.0 a	33.5 c
Ceren	20.93 cd	8.76 bcd	21.1 d	23.69 cd	104.9 abc	34.0 d	36..0 b
Anka.Yeşili	20.50 cd	7.33 d	20.9 d	22.66 cd	87.7 cd	50.3 b	33.1 c
Sazak 91	25.20 b	10.60 a	24.3 a	29.91 bc	111.3 ab	56.8 a	37.0 a
Kafkas	20.13 d	7.70 cd	17.8 e	25.85 bcd	86.3 cd	39.1 c	33.7 c
Özbek	21.23 cd	7.76 cd	23.1 b	31.31 ab	105.9 abc	38.8 c	36.0 b
Çiftçi	20.93 cd	8.40 cd	24.9 a	37.33 a	122.0 a	42.5 c	37.0 a
Şakar	21.93 cd	7.83 cd	16.0 f	19.41 d	85.2 cd	41.6 c	31.5 d
Fırat 87	26.96 a	9.00 bc	15.9 f	19.80 d	74.6 d	42.5 c	33.6 c

* Values belonging to the same letter group are not different according to Duncan 5%.

The average number of grains per plant of the lentil cultivars used in the study ranged from 19.41 to 37.33. While Sakar cultivar had the lowest average number of grains in 19.41 plants, the difference between Fırat 87 cultivar was statistically insignificant. Farmer variety was the variety with the highest average number of grains in 37.33 plants. The difference between them and the Uzbek variety was found to be statistically insignificant. If the precipitation distribution is regular during the pod-seeding period, the yield of lentils will be high (Bejiga et al. 1995), the yield in humid conditions is higher than in dry conditions, but high yields in some dry periods are associated with avoidance of drought during the flowering period (Silim et al. 1993). Çölkesen et al. (2005) reported that the number of seeds per plant was 66.95 in Winter Red 51 variety, 46.22 in Yerli Kırmızı variety, 111.9 and 83.0 in Kahramanmaraş, respectively. Erman (1998) reported that it varies between 17.02-37.1 units. Demirhan (2006) reported that the number of seeds per plant varied between 12.75-54.25, Ali Dayı and Fırat-87 varieties were the varieties with the highest number of seeds per plant, and Sultan-1 variety was the variety with the lowest number of seeds per plant. The findings obtained in this study are similar to the findings of the researcher.

The average grain yield per unit area of the lentil cultivars used in the experiment varied between 74.6-122.0 kg/da. While Fırat-87 cultivar had the lowest average grain yield per unit area of 74.6 kg/da, the difference between Şakar, Caucasian and Ankara Yeşili cultivars was statistically insignificant. Farmer variety was the variety with the highest average grain yield per unit area of 122.0 kg/da. Our findings are similar to Russell (1994), Buyer (1997) and Koç (2004). In the study of Çokkızgın et al. (2005) in their study, the yield was 140-198.9 kg/da, Çölkesen et al. (2005) in Kahramanmaraş and Şanlıurfa conditions, the yield was 157.3-230.8 kg/da, Türk and Koç (2003) showed that the yield was 60.6-86.3 kg/da in the study they carried out under Ceylanpınar conditions, and the yield was 53.77 in Erman (1998)'s Van conditions. They reported that it varies between -184.02 kg/da. There are similarities and differences between the findings obtained in this study and the findings of the researchers. It is thought that the reason for this is due to the differences in the ecology of the region and some of the cultivars used.

The average thousand grain weight of the lentil varieties used in the study ranged from 38.8 to 56.8 g. While the Özbek cultivar had the lowest thousand grain weight with an average of 38.8 g thousand grain weight, the difference between Çiftçi Şakar and Fırat-87 cultivars was found to be statistically insignificant. The highest thousand grain weight average was obtained in Sazak-91 variety (Table 4.18 and Figure 4.8). Although the thousand-grain weight is a feature specific to varieties, it can be affected by environmental conditions. Çölkesen et al. (2005) K. Maraş and Ş. They reported that the 1000-grain weight values of the same cultivars in Urfa had different values in different locations. Demirhan (2006), in his study on lentils, reported that thousand kernel weights varied between 26.25-65.5 g, the highest thousand kernel weight was obtained from Fruitci-2001 variety, and the lowest thousand kernel weight was obtained from Winter Kırmızı-51 variety.

The average harvest index of the lentil cultivars used in the study varied between 31.5-37.0%. While Şakar variety had the lowest average harvest index, the highest harvest index average was obtained from Çiftçi and Sazak-91 varieties with 37.0%. Altun (1994) reported in his study that the average harvest index varied between 22.7-32.86%. Demirhan (2006), in his study with 16 lentil varieties in Siirt conditions, the harvest index averages were 25.1-38.72%. The data obtained in this study and the findings of the researchers are similar.

4. CONCLUSION

In this study, it was aimed to determine the cultivar and adaptation characteristics of some lentil cultivars in Van conditions. The experiment was set up with 3 replications according to the randomized blocks experimental design and 9 varieties were used in the experiment. In the study, plant height, first pod height, number of branches per plant, number of pods and seeds per plant, number of grains per pod, grain yield per unit area, harvest index, biological yield and thousand-seed weight properties were investigated in lentils. While the highest grain yield per unit area was obtained from Ciftci variety with 122.0 kg/da, the lowest grain yield per unit area was obtained from Fırat 87 variety with 74.6 kg/da. As a result of the research, Çiftçi variety was superior in terms of all yield characteristics in Van ecological conditions. In order to improve lentil cultivation in the region, it is necessary to repeat this study and to carry out scientific studies such as variety, planting time, plant density and fertilization.

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CHAPTER 11

VERMICOMPOST PROPERTIES AND USE IN AGRICULTURAL PRODUCTION

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1. INTRODUCTION

The urbanization and rapid industrialization have led to the formation of large amounts of waste. The wrong methods used in the disposal of these wastes cause health problems and environmental pollution. However, these wastes can be converted into organic fertilizers by many different methods (Khedr et al. 2019; Ucar et al, 2021). Vermicompost is a substance obtained as a result of composting organic waste such as leaves, stems, straw, household fruit/vegetable waste, and animal feces, passing through the digestive system of worms (Ucar et al, 2020; Yılmaz and Yılmaz, 2021). Organic wastes, after entering the digestive system of worms, undergo biochemical changes and turn into odorless and neutral substances (Iderawumi and Oluremi, 2021; Ucar, 2021). Earthworms are called "Bioengineers" because of their ability to convert organic waste into nutrient-rich compost materials (Saha et al., 2022). There are more than 4000 species of worms in the world, but some worms are only useful for composting (Gupta et al., 2022). In addition, the climate and weather conditions of the region where vermicompost will be produced are important factors in the selection of the worm species used. (Ceritoğlu et al, 2019). The main types of worms used in the production of vermicompost; *Eudrilus eugeniae* (African nightcrawler), *Eisenia fetida* (tiger worm), *Lumbricus rubellus* (red worm), *Dendrobaena veneta*, *Eisenia andrei* (red tiger worm), *Perionyx excavatus* (Indian blue worm) (Domínguez and Edwards, 2011; Ceritoğlu et al., 2019).

The nutrient content of the substrat vermicompost greatly affects vermicompost (Iderawumi and Oluremi, 2021). The materials used as substrat in vermicompost production are generally cattle manure, vegetable wastes, domestic wastes, and industrial wastes (Ceritoğlu et al., 2019). It has been successfully converted into vermicompost of cattle manure, orange peel, and filter cake (Pigatin et al., 2016). Sugar cane residue was used as vermicompost raw material (Bhat et al., 2016). Paper industry and household waste were converted into vermicompost (Amouei et al. 2017). Paper waste, rice straw, and cow dung can be used for vermicompost of substances such as (Sharma et al., 2018). The most common raw material used for vermicompost production is rother soil (Ceritoğlu et al., 2019). The fertilizers of voltaic such as chickens, ducks, and pigeons are not suitable for the production of vermicompost because they contain a high amount of ammonia that causes damage to plants (Tchobanoglous et al., 1993, Ceritoğlu et al., 2019).

2. CHEMICAL AND PHYSICAL PROPERTIES OF VERMICOMPOST PROPERTIES OF VERMICOMPOST

The chemical composition of vermicompost varies depending on the type of substrat, worm specie, and ambient conditions i.e., humidity and tepmerature during production. It was stated that the type of substrat affects EC, pH, carbon, lignin cellulose, and hemicellulose ratios. For example, the pH value of sheep manure is 8.6 while the pH value of sewage waste is around 7.2 (Ceritoğlu et al., 2018).

Worm castings contain nutrients such as nitrogen, potash, phosphorus, magnesium, calcium, iron,zinc, and manganese. However, it is higher than phosphorus and potash (Gupta et al., 2022). Vermicompost also contains gibberellins, cytokinins, auxins, humic acids, vitamins, and enzymes (Amooaghaie and Golmohammadi 2017; Ravindran et al.

2016). Vermicompost plays an important role in the growth of plants, as it contains higher amounts of humic substances, enzymes, and growth hormones (Bhat et al., 2018).

A comparison of the nutrient content of vermicompost and several organic fertilizers is given in Table 1 (Rana, 2020). It is stated that the average nutrient content of vermicompost is richer than conventional compost. The amount of calcium in vermicompost is higher than in other composts (Saha et al., 2022). In addition, vermicompost has a higher dehydrogenase enzyme and some other enzymes than other compost products (Ceritoğlu et al., 2018).

Vermicompost is rich in almost all essential micro and macro plant nutrients. Vermicompost nutritional content values are given in Table 2 (Rana, 2020). It is stated that vermicompost is superior in many respects to other organic fertilizers (Kiyasudeen et al., 2015).

Table 1. Comparison of nutritional values of vermicompost and other organic fertilizers

Nutrient	Vermicompost	Farmyard manure	Bacterial compost
N (%)	2.1 – 2.6	1.1 – 1.5	1.2 – 1.5
P (%)	1.5 – 1.7	0.7 – 0.8	0.7 – 0.9
K (%)	1.4 – 1.6	0.6 – 0.7	0.6 – 0.7

Table 2. Nutrients and their values in vermicompost

Nutrient (%)	**Vermicompost**
Organic carbon	9.15 - 17.98 %
Total nitrogen	1.5 - 2.10 %
Total phosphorus	1.0 - 1.50 %
Total potassium	0.60 %
Ca and Mg	22.00 - 70.00 m.e / 100 g
Copper	100 ppm
Iron	1800 ppm
Zinc	50 ppm

Vermicompost physically has a granular structure. It is also dark in color and odorless (Doube and Brown, 1998). In quality vermicompost, the porosity should constitute 70-80% of the total volume. At the same time, the air ratio in the pores should be between 20-30% and 55-75% (Atiyeh et al., 2001). Vermicompost has a high water holding capacity (Ceritoğlu et al., 2018). The moisture content is around 50-90% (Dominguez and Edwards, 2011; Ceritoğlu et al. 2018). In addition to all these, vermicompost does not contain any adverse pathogens (Kalika-Singh et al., 2022).

3. EFFECTS OF VERMICOMPOST ON AGRICULTURAL PRODUCTION

The use of vermicompost as organic fertilizer in agricultural production provides great benefits. It has enormous effects on the growth of various plants, including vegetables, ornamental and flowering plants, cereals, and legumes (Çirka et al., 2022). Vermicompost increased the germination, yield, growth and quality of Abelmoschus esculentus fruits (Hussain et al.,2017). According to studies, worm castings can be used instead of chemical fertilizers in bean cultivation (Sadeghipour, 2017). The highest vegetative component in the maize plant is 40% vermicompost it was found that in practice (Durukan et al., 2020). Vermicompost is more widely applied in field plants due to its easy application and low cost (Yılmaz and Yılmaz, 2021). In the studies conducted, it was found that the application of vermicompost improves wheat growth and increases its yield (Ding et al., 2021). Vermicompost applications had positive effects on the yield and some yield components of the maize plant (Öktem and Öktem, 2020). The highest maize yield was seen in the 750 kg/da vermicompost application (Özel, 2019). The highest hectoliter weight, ear weight, ear number and grain yield values were obtained from the application of vermicompost at 200 kg/da. (Öktem et al.,2018). In addition, vermicompost application increases nodulation and symbiotic mycorrhizal association with roots in legumes (Rana, 2020). It was observed that vermicompost application provided the greatest biomass increase, especially in herbs and legumes belonging to Cucurbitaceae and Asteraceae families (Blouin, 2019). In addition, as a result of a meta-analysis, it was found that vermicompost provided an average increase of 26% in yield, 13% in total biomass, 78% in shoot biomass and 57% in root biomass (Blouin, 2019). An increase of 65.26% was observed in the total dry matter amount of chickpea plant with increasing vermicompost doses. (Shrimal and Khan, 2017). It has been observed that the application of 20% vermicompost to the soil provides better growth in chickpea (Ceritoğlu et al., 2021).

The importance of using vermicompost in the cultivation of vegetable crops is great because it is cheap, organic, environmentally friendly, and contains many nutrients (Kalika-Singh et al., 2022). Kenea and Gedama (2018) found that it increased the dry matter ratio by 12.5% for onions. Dos Santos et al. (2020) stated that vermicompost can be used to stimulate the growth and development of pepper cultivation. Vermicompost can be used as an alternative to chemical fertilizer in bean cultivation (Sadeghipour, 2017). In tomato cultivation, the highest yield and quality was obtained as a result of applying 60% vermicompost to the soil. (Troung et al., 2018). Vermicompost was found to increase P and K contents in eggplant and pepper plants. It is also suggested that vermicompost can be used to grow pepper and eggplant (Bellitürk, 2018). Nurhidayati et al. (2016) found that vermicompost provided a significant increase in vitamin C, sugar content, and yield in Brassica oleracea L. It was observed that the yield and plant height increased with increasing vermicompost dose in the spinach plant of vermicompost applied at doses of 0, 1, 2, 3, 4, 5 tons (Muftüoğlu, 2016). Aksu et al. (2017) obtained the highest plant fresh weight in the chard plant in 1000 kg vermicompost application. Koksal et al. (2017), it was observed that vermicompost applied at doses of 0, 250, 500, 750 and 1000 kg/da positively affected the plant growth parameters of Beta vulgaris L. The highest plant height, tuber weight, dry matter, and root length of vermicompost and chemical fertilizer were found in vermicompost applications (Kumar and Gupta, 2018).

Vermicompost is a rich source of nutrients, enzymes, vitamins, antibiotics, and hormones. Due to these properties, it gives disease resistance to plants (Rana, 2020). Vermicompost contains plant growth promoters such as auxins, gibberellins, cytokinins, and beneficial microbes. With these substances it contains, it increases the activity of antagonistic microorganisms and nematodes that suppress pests and diseases caused by these pests. It also stimulates disease tolerance (Yato et al., 2021). Vermicompost reduced the incidence of diseases such as Fusarium oxysporum in cucumber and Phytophthora infestation potato (Zhang et al. 2020; Peerzada et al. 2020). In the presence of vermicompost, the population and egg number of the pepper pest Polyphagotarsonemus latus decreased compared to the control (Jangra et al., 2019).

Application of vermicompost alone or in combination with other fertilizers provides an increase in dry matter rate, leaf growth, and fruit rate. It also corrects the pH value and soil structure (Saha et al., 2022). Joshi et al. (2020) found that vermicompost contains higher macronutrient values compared to compost. It has been reported that root-knot nematode and Erwinia carotovora disease are managed when vermicompost and Bacillus subtilis are applied together (Rao, 2017). Compared to the application of vermicompost, zinc, and iron alone, the use of iron and zinc together with vermicompost resulted in higher quality and yield in maize (Pandey et al., 2022). Muhammad et al. (2016) observed that the combined use of inorganic phosphorus and vermicompost increased the uptake of some essential plant nutrients and increased yield and plant height by approximately 50%. The combined use of vermicompost and humic acid fertilizers increased shoot, biomass, yield, and root N, P, and K content of maize plants (Liu et al., 2019). Biofertilizer application and vermicompost application increased corn yield, and all other components such as ear weight and plant height (Roychowdhury et al., 2017).

4. EFFECTS OF VERMICOMPOST ON SOIL STRUCTURE

Vermicompost improves soil's physical properties (Di et al., 2019). Soils treated with vermicompost have a porous structure and better aeration (Zhu et al. 2017). Vermicomposts containing high humic acid improve soil structure (Maji et al., 2017). Vermicompost is a common organic matter used to improve saline-alkaline soil (Liu et al., 2020). It also improves soil aggregation of vermicompost fertilizer, and increases nutrient availability, regulates the soil microbial community and promotes salt infiltration (Liu et al., 2019). Soil worms can accumulate metals in their bodies, and the effect of heavy metals in the soil can be reduced by worms (Taciroglu et al., 2016). These abilities are due to the involvement of worm intestines and their powerful metabolic system (Bhat et al., 2018). Adiloglu et al. (2018) noted that increasing doses of vermicompost reduced the concentration of heavy metals.

Vermicompost applications increase the microbial biomass concentration in the soil (Şahin et al., 2016). Vermicompost helps feed certain microbial populations, which aids in P solubility and N fixation. Vermicompost also contains enzymes such as lipase, protease, amylase, chitinase, and cellulase. These enzymes break down the residues in the soil (Rana, 2020). The combined use of vermicompost and humic acid fertilizer has increased soil nutrient availability by changing the number of soil bacteria and fungi (Liu et al., 2019). Since vermicompost is rich in nutrients, vitamins, hormones, humic substances, and enzymes, it has the potential to help improve soils (Ceritoğlu et al., 2018).

5. LIMITATIONS IN THE USE OF VERMICOMPOST

Worms are pH-sensitive creatures. In addition, activities such as metabolism, growth, reproduction, and respiration of worms are significantly affected by temperature. It can be removed in extreme cold and extreme heat. In addition, earthworms are often found in soils with a lot of organic matter. Even for a short time, they can even take nutrients from the soil under adverse conditions (Malik and Baba, 2020). In addition, making vermicompost is a time-consuming process. It takes about 6 months to decompose the organic wastes to be used as vermicompost substrat. Vermicompost making requires more maintenance than traditional composting (Saha et al., 2022). All these are the disadvantages experienced in the preparation of vermicompost.

6. CONCLUSION

Vermicompost is a form of production in which industrial, animal, and vegetable waste is converted into organic fertilizer. The use of vermicompost in agricultural fields improves the organic matter in the soil. In addition, it positively affects the physical, chemical, and biological properties of the soil. The rich substances it contains provide many benefits to plant growth and product quality directly and indirectly. All this has been proven by the research carried out. By encouraging the production and use of vermicompost, the productivity and organic matter ratio in agricultural lands will be increased.

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CHAPTER 12

PLANT GROWTH PROMOTING RHIZOBACTERIA IN THE BIOLOGICAL CONTROL OF HARMFUL INSECTS

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1. INTRODUCTION

Insects belonging to the Arthropod (Arthropoda) branch are the most populous creatures living with more than 1,000,000 species in the world. Insects are found in almost every habitat on Earth and can sometimes reach high populations (Chapman, 2009). Undoubtedly, the most important factors affecting the yield and quality of agricultural products are diseases, pests and weeds, which are called harmful organisms. Among these organisms, harmful insect species are vectors of many disease agents as well as the direct damage they cause while feeding on plants. Plants generally have defenses against these harmful species, but they may be more susceptible to pest attacks, especially in areas where plants are weak, under stress for various reasons, or where the natural balance is disturbed. Among the control methods, biological control is an environmentally friendly, inexpensive and sustainable control method. (Özkan et al. 2020). On the other hand, various chemical pesticides, which act in a short time and are easily available in the control of harmful organisms, have become the most preferred tool by growers. However, as a result of excessive and random use of pesticides, the environment and human health are adversely affected, non-target organisms are under threat, it leads to loss of biodiversity, residue risk occurs, and in addition to these, negative effects such as resistance problems occur. Commonly used pesticides significantly affect natural enemies, leading to their death and considerably affecting the diversity in the ecosystem, causing the deterioration of the natural balance (Chen et al. 1999, Kaçar and Koca, 2020). Because in many studies, the negative effects of pesticides have been reported (Theiling and Croft, 1988; Margni et al. 2002; Alewu ve Nosiri, 2011; Cloyd, 2012; Nicolopoulou-Stamati ve ark., 2016; Shah, 2020). Due to all these negative reasons, it has become a necessity to develop alternative control methods within the scope of Integrated pest management (IPM). In this context, the studies carried out in the world and in our country continue at an increasing pace (Rutledge et al. 2004; Özkan et al. 2006; Schreinemachers et al. 2015; Akdaş et al. 2020; Mokrini et al. 2020).

On the one hand, studies are carried out to identify natural enemies of economic importance, studies are carried out on the potential of use of plant biopesticides and microbial pesticides against harmful insects, nematodes and other invertebrates, their future trends and mechanisms of action. Furthermore, in recent years, the antagonistic properties of plant growth promoting bacteria (PGPB) against some harmful species in cultivated plants have been investigated within the scope of IPM. There are also some studies conducted in this context (Keren et al. 2000; Tjamos et al. 2005; Tan et al. 2006; Ghiribi et al. 2012; Cordova-Kreylos et al. 2013).

The fact that PGPB is not harmful to human and environmental health, does not create residues in agricultural products and has positive effects on non-target organisms and natural enemies can be shown as the most critical features of its choice as a biological insecticide. In this study, which is handled for this purpose, the potentials of use of PGPBs that can be used against harmful insect species in IPM programs are summarized in the light of current literatüre.

2. PESTICIDE USE IN THE WORLD

The use of pesticides in the world has been going on since ancient times B.C. Before 2000, people used pesticides to protect their crops. The first known pesticide was elemental sulfur powder, which was used in ancient Sumer in Mesopotamia about 4,500 years ago. In the 15th century, toxic chemicals such as arsenic, mercury, and lead were applied to crops to kill pests. In the 17th century, nicotine sulfate was extracted from tobacco leaves for use as an insecticide. Since the 1950s, agriculture has started to develop rapidly. Pesticide production and, accordingly, pesticide use has also increased. Therefore, since this period, pesticide production has become an important sector in the world. Global pesticide sales amount has reached 45 billion dollars (Anonymus, 2022). While pesticides used in agricultural fields were 3,000,000 tons in 2000, it reached 3,700,000 tons in 2007 and 4,110,000 tons in 2017(Anonymus, 2021). (Figure 1).

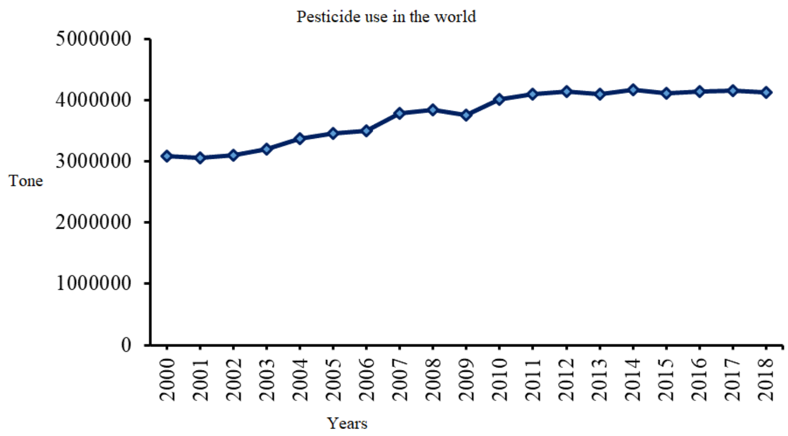

Figure 1. Global pesticide agricultural use 2020-2018 (Anonymus, 2021).

Asian continent ranks first with 52.8% in pesticide use in the world. After the continent of Asian 30% America, 13.8% Europe, 2.1% Africa and 1.3% Oceania, respectively is coming (Figure 2).

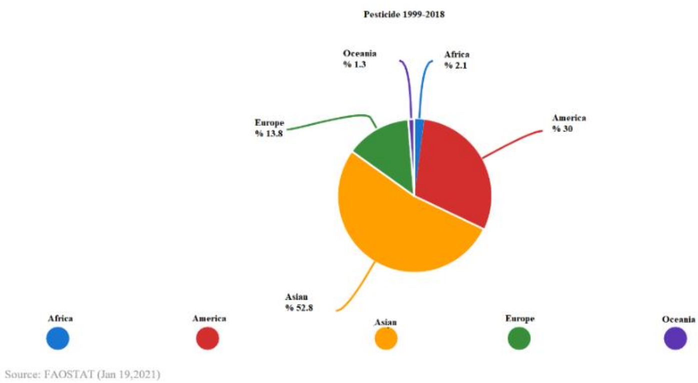

Figure 2. Global pesticide agricultural use 1999-2018 by continents (Anonymus, 2021).

When the countries in the world are examined in terms of pesticide use, China is seen in the first place. This country is followed by the United States, Brazil and France (Anonymus, 2021).

3. PESTICIDE USE IN TÜRKIYE

Although the use of pesticides in Turkey fluctuated between 2000 and 2018, it reached 60020 tons in 2018 and increased by approximately 15 thousand tons in total after 2006 (Anonymus, 2021) (Figure 3).

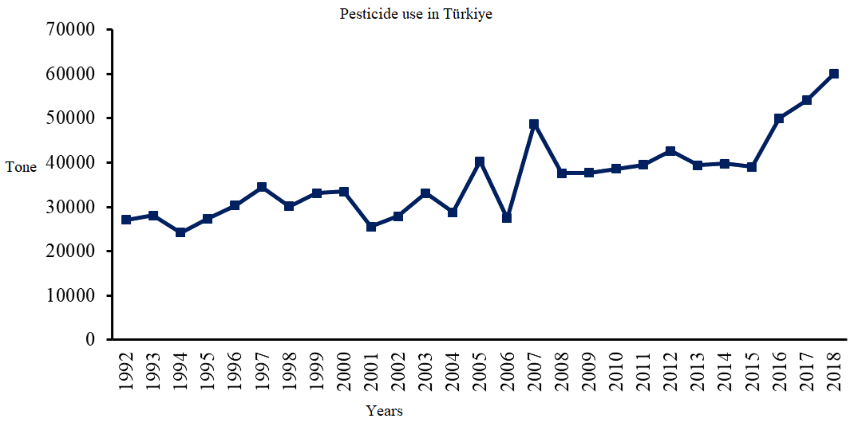

Figure 3. Pesticide agricultural use in Türkiye 1992-2018 (Anonymus, 2021).

Considering the usage shares of pesticides used in Turkey, fungicides and bactericides were mostly used against disease agents with a rate of 41%.

It was followed by insecticides used against harmful insects (26%) and herbicides used to control weeds (22%) (Figure 4).

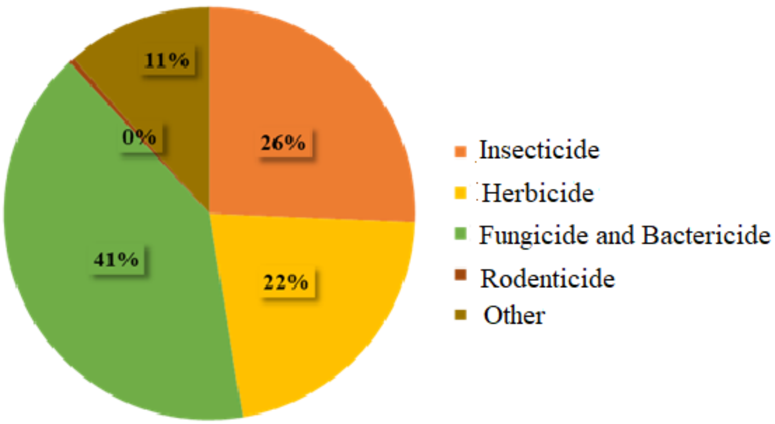

Figure 4. Usage shares of pesticides in Turkey in 2017 (Anonymus, 2021).

4. GENERAL INFORMATION ABOUT PLANT GROWTH PROMOTING RHIZOBACTERIA

The increase in world population is expected to make global food availability one of its major problems in the future. In order to take precautions against this threat, it is very important to increase crop productivity (Adedeji et al. 2020). The increase in agricultural production is tried to be achieved with synthetic fertilizers and pesticides. Nitrates and pesticides from over-fertilization have been found in the groundwater of many agricultural areas. It has also been reported by the World Health Organization that at least three million people in the world are poisoned by chemical drugs every year, of which 20,000 die (Singh, 2021). In addition to all these, the use of chemical drugs and fertilizers leads to deterioration of soil quality and fertility (Sindhu and Sharma, October 2019). Worldwide, soil-borne diseases have caused 10-20% annual yield loss (Ray et al. 2017). Therefore, reliable and environmentally friendly methods are needed to meet the growing demand for food in a sustainable way. Organic agriculture has emerged to bring sustainability to agriculture as environmentally friendly. Organic farming, in short, means growing plants without the use of chemical pesticides or fertilizers. One of the aims of organic agriculture is to provide organic matter to the soil by using existing resources without disturbing the soil structure (Singh, 2021).

Plant growth promoting rhizobacteria (PGPR) are known as bacteria that colonize the rhizosphere of plants and increase crop yield and plant growth (Rajput et al. 2019). PGPRs provide a beneficial plant-microbe interaction by facilitating plant nutrient uptake (Guptave et al. 2021).

PGPRS have been proven in many studies that their application in organic agriculture is possible because they are naturally occurring and non-toxic microorganisms in the soil. They are also involved in biotic and abiotic stress tolerance, in addition to being able to stimulate soil health and plant development. Therefore, they can be preferred over the use of chemicals in traditional agriculture (Kenawy et al. 2019). According to their species and mechanism of action, rhizobacteria that stimulate plant growth are used as biocontrol, biofertilizers, phytostimulators and biopesticides (Rajput et al. 2019). PGPRs have been commercialized as a inoculation method due to their many features (Sakure and Bhosale, 2019).

PGPRs dissolve minerals and other compounds found in the soil, helping it grow. It release different phyto-harmones, such as cytokinin, gibberellic acid (GA3) auxin, and indoleacetic acid (IAA). They also kill pathogens in the soil by secreting iron-chelating siderophores, biocides, detoxification compounds, volatile compounds and antibiotics, allelochemicals and metabolites. PGPRS are used in the biological control of insects and pests because they produce metabolites and enzymes that can digest the internal organs of pests and insects. Therefore, the use of PGPRS in agriculture is a promising method for inhibiting the damage of soil-borne pests, insects and pathogens. (Mathur et al. 2019). Among the PGPR species, especially Pseudomonas, Bacillus, Azospirillum, Rhizobium and Serratia species play an important role in killing or inhibiting pathogenic microorganism (Kenawy et al. 2019).

5. PLANT GROWTH PROMOTING RHIZOBACTERIA USED IN THE MANAGEMENT OF PEST SPECIES

Worldwide, harmful insect species cause significant losses during plant production. Cramer (1967) reported that about 35% of crop losses occurred in plant products by harmful organisms, 14% of these losses were caused by insect pests, 12% by plant diseases and 9% by weeds. Therefore, both in our country and in the world, the use of chemical pesticides for years to increase agricultural productivity and protect stored products can have dangerous consequences for the environment and human health. Due to the harmful effects of pesticides on the natural environment, it is under pressure to be removed from the market. At the same time, Lamiri et al. (2001). stated that pesticides carry a residue risk for the consumer and the environment. Moreover, this problem has become important due to the development of pesticide resistance in some pests. Various populations of aerobic endospore-forming bacteria occur in agricultural areas and can contribute directly and indirectly to crop yields. At the same time, there are many sources that show significant potential in the control of some harmful insects that cause yield losses in agricultural production. Due to all these concerns, studies have been started in recent years to determine the potential of using plant growth regulators in the control of harmful species in different parts of the world within the scope of alternative methods in the control of harmful insect species. Worldwide contucted studies, many bacterial isolates with various insecticidal properties have been identified and started to be used against various harmful insect species (Table 1). In this context, Ghiribi et al. (2012) investigated the toxicity of *Bacillus subtilis* SPB1 compound against *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) and its histopathological effects on the midgut in a study conducted under laboratory conditions, and they found that the tested doses had strong effects in the midgut of the pest.

In another similar study, the effects of Chitinase from *Bacillus subtilis* strains on the intestinal enzymes lactate dehydrogenase, acid phosphatase, alkaline phosphatase and adenosine triphosphatase of the larvae of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) were investigated. As a result of the study, it was reported that Chitin-based bioformulation can serve as an effective biocide against many polyphagous pests such as (Chandrasekaran et al. 2014). In some studies conducted in India, it has been determined that *B. subtilis* has the ability to infect the 2nd stage larvae of mosquitoes (*Anophelis culicifacies*), which is the insect vector of malaria, and cause death (Gupta and Vyas 1989; Geetha et al. 2007).

Glare et al. (2020), a well-known activity of another bacterial species, *Brevibacillus laterosporus*, has been reported as insecticidal activities against some Diptera, Lepidoptera and Coleoptera species. Moreover, the effect of *Brevibacillus laterosporus* strains isolated from soil samples in Brazil on the larvae of Coleopter *Anthonomus grandis* was investigated, and it was reported that mortality rates were between 33% and 63% (De Oliveira et al. 2004). In another study, it was determined that two *Brevibacillus laterosporus* isolates caused the death of the larvae of *Plutella xylostella* L. (Lepidoptera: Plutellidae), which is an important pest of Brassica worldwide (Van Zijll de Jong, 2016).

Attention has been drawn to the significant potential of *Brevibacillus laterosporus* Laubach, against the house fly, *Musca domestica* L. (Diptera: Muscidae), a ubiquitous and very common insect species that causes significant nuisance in humans and animals (Ruiu, 2013, Ruiu et al. 2008, Ruiu et al. 2014). In another study, it was reported that *Pseudomonas chlororaphis*, another bacterial species living in the soil, protects the corn plant against cornworm attack (Schellenberger et al. 2016). In another similar study, they showed that the strains of *Serratia* spp. (Enterobacteriacea) tested in New Zealand had a high virulence against the larvae of *Costelytra zealandica* (Coleoptera: Scarabaeidae) (Tan et al. 2006). Besides in a study, it was reported that Serratia marcescens strains were obtained from other tephritides such as Ceratitis capitata Weidermann and *Dacus* (*Bactrocera*) *dorsalis* hendel flies (Grimont and Grimont 1978).

Entomopathogenic strains of *Serratia* have been used to control various insect genera, including Anomala, Costelytra, and Phyllophaga (Nunez-Valdez et al. 2008). At the same time, it has also been shown to use liquid culture of *Serratia* sp. as a biocontrol agent to control EML-SE1, the diamondback moth *Plutella xylostella* (Jeong et al. 2010).

Various studies have reported that treatment of tobacco budworm (Lepidoptera: Noctuidae), Heliothis virescens with S. marcescens (Bizio) produces non-lethal effects such as reduced adult lifespan and reduced spawning and hatching rate (Sikorowski and Lawrence 1998; Inglis and Lawrence 2001).

In addition, in many studies *Streptomyces* spp. bacteria have been reported on insecticidal activity on various pest species; Cotton leafworm *Spodopetra littoralis* (Biosduval) (Bream et al. (2001), cotton leafworm *S. litura* (Arasu et al. 2013), vinegar fly *Drosophila melanogaster* (Meigen) (Gadelhak et al. 2005), green wolf *Helicoverpa armigera* (Hubner) (Osman et al. 20015) and *Anopheles mosquito* larvae (Dhanasekaran et al. 2010) (Table 1).

Table 1. Some Plant Growth Promoting Bacteria Used in the Control of Pest Species

Bacteria species	Harmfull insect species	References
Bacillus subtilis	*Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae)	(Ghiribi et al. 2012)
	Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae)	(Chandrasekaran et al. 2014)
	Anophelis culicifacies Giles 1901 (Diptera: Culicidae)	(Gupta and Vyas 1989), (Geetha et al. 2007)
Brevibacillus laterosporus	Diptera, Lepidoptera ve Coleoptera böcek türleri	(Glare et al. 2020)
	Anthonomus grandisv Boheman (Coleoptera: Curculionidae)	(De Oliveira et al. 2004)
	Plutella xylostella L. (Lepidoptera: Plutellidae)	(Van Zijll de Jong, 2016).
	Musca domestica L. (Diptera: Muscidae)	(Ruiu, 2013) , (Ruiu et al. 2008), (Ruiu et al. 2014)
Pseudomonas chlororaphis	*Ostrinia nubilalis* Hübner (Lepidoptera: Pyralidae)	(Schellenberger et al. 2016)
Serratia spp	*Costelytra zealandica* (White) (Coleoptera: Scarabaeidae)	(Tan et al. 2006)
	Plutella xylostella (Linnaeus) (Lepidoptera: Plutellidae)	(Jeong et al. 2010).
Serratia marcescens	*Ceratitis capitata Weidermann ve Dacus (Bactrocera) dorsalis hendel* (Diptera: Tephritidae)	(Grimont and Grimont 1978)
	Anomala, Costelytra ve Phyllophaga	(Nunez-Valdez et al. 2008)
	Heliothis virescens (Fabricius) (Lepidoptera: Noctuidae)	(Sikorowski and Lawrence 1998), (Inglis and Lawrence 2001)
Streptomyces spp	*Spodopetra littoralis* (Boisduval) (Lepidoptera: Noctuidae)	(Bream et al. 2001),
	Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae)	(Arasu et al. 2013)
	Drosophila melanogaster (Meigen) (Diptera: Drosophilidae)	(Gadelhak et al. 2005)
	Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae)	(Osman et al.20015)
	Anopheles (Diptera: Culicidae)	(Dhanasekaran et al. 2010).

6. CONCLUSION

Biological control as part of integrated pest management has attracted attention among researchers as it is an environmentally friendly and safe strategy for pest management. Biological control practices should be known as a pest control method that should be addressed primarily in IPM, as it is promising for sustainable agricultural production and development and is environmentally friendly. Otherwise, excessive and random pesticides can cause many irreversible damages. In particular, microbial control agents offer alternatives to chemical control methods, as they can be more selective than chemical insecticides. For this purpose, it will be extremely valuable to carry out detailed studies on the use of some plant-regulating bacteria strains used within the scope of alternative control in the biological control of harmful insect species that cause yield losses in agricultural production.

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CHAPTER 13

USE OF BACTERIA INSTEAD OF CHEMICAL FERTILIZER IN LEGUMES AGRICULTURE IN TURKEY

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INTRODUCTION

In addition to being an important plant group in nutrition due to the high protein content of their grains, edible legumes are also sought after plants in crop rotation systems due to their nitrogen fixing properties.

Food legumes, which are protein-rich plants, have a protein content of 18-36% in their composition according to their type, and they are rich in vitamins A, B, and D, as well as phosphorus, iron, calcium and potassium. As they are rich in nutritional values, they also have positive effects on the soil in which they are grown. Food grain legumes, the grains of which are used in human nutrition, are also used in animal nutrition, as well as grains and stems. While there is 70.5 kg of protein in 1 ton of grain straw, this value is 137.4 kg in legumes and 1 ton of legume stalk contains protein equivalent to 2 tons of cereal straw. Legumes are also very important plants in terms of sustainable agriculture because they can make biological nitrogen fixation and are suitable plants for crop rotation. Rhizobium bacteria, which live in association with legumes, bind the nitrogen, which is free in the air but cannot be used directly by living things, to the soil they live in. Thus, these soils enriched with nitrogen by plant roots spreading to the soil layers are utilized by the plants to be planted after these plants. Although it varies according to the plant variety and environmental conditions, the amount of nitrogen that legume plants fix to the soil is generally around 5-19 kg per decare per year (Şehirali 1988). Food Grain Legumes take the nitrogen necessary for their development from the soil, fertilizer or air by biological nitrogen fixation. If there is no active bacteria in the soil where the legume plant will be grown, or if the number of bacteria is low, it should be inoculated with bacteria. Grafting can be done to the seed as well as to the soil.

2. FOOD LEGUMES AGRICULTURE IN TURKEY

In our country, six genera are examined under the name of edible legumes, namely beans, chickpeas, lentils, broad beans, peas and cowpeas.

Particularly, with the implementation of the project of Narrowing Fallow Areas after 1980, the cultivation area of legumes for edible grains increased since lentils and chickpeas were produced in fallow areas, and 1989 was the year it had the highest cultivation area with an area of 2 037 180 ha. However, since this year, as a result of wrongly applied agricultural policies, the failure to develop varieties that are highly adaptable to environmental conditions, suitable for machine farming, and resistant to diseases and pests, significant decreases have been observed in the edible grain legume cultivation area. Although there is an increase in the cultivation area today, we can say that unfortunately this increase is very small and insufficient when compared to 1989.

Our total edible legume cultivation area was 709 863 ha in 2021, and the production was 1 074 268 tons. The cultivation area, production and yield values for edible legume plants in our country in 2021 are given in Table 2.1. Accordingly, the edible legume plant with the highest cultivation area is chickpea with 487 886 ha. Chickpea is in the second place with a cultivation area of 308 359 hectares, followed by lentils and beans of 107 796 hectares in the third place. It is seen that the cultivation areas of broad beans, cowpea and peas among the edible legumes in our country are quite low and the least cultivated legume plant with 679 ha cultivation area is pea. The most produced edible legume is chickpea with 470 000 tons, beans with 305 000 tons, lentils with 263 000 tons, and cowpea with a production amount of 1281 tons.

Table 2.1. Cultivation area, production and yield values of legume crops for 2021 in Turkey (TUIK, 2022).

Legume	Fields area (ha)	Production (tonnes)	Yield (kg/da)
Chickpea	487 886	475 000	97
Lentil	308 359	263 000	161
Bean	107 796	305 000	283
Broad beans	2 796	7 049	252
Kidney bean	1 245	1 281	103
Pea	679	1 805	266
Total	908 761	1 053 135	

3. CHEMICAL FERTILIZER

The main purpose in agricultural production is to buy high quality products and to increase the income to be obtained as a result of these. It will be possible to achieve this goal only by protecting and increasing the yield power of the soil, which is the natural growth environment of plants. The soil, which is the habitat of plants, is fertile as long as it can provide the water and nutrients that plants need throughout their life span. Plants growing in the soil take almost all of the nutrients they need from the soil through their roots. As a result, the impoverishment of agricultural lands by plant nutrients is an inevitable result. By following this situation carefully and doing the necessary, only a lot of qualified products will be purchased. Impoverishment of agricultural lands and depletion of plant nutrients; It can occur due to various reasons such as uptake of nutrients by plants, removal from the soil by washing, erosion and gas. While the essential elements for plants are classified as macro and micro elements according to their amount in the plant, carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca)), magnesium (Mg), sulfur (S) as absolute essential macro plant nutrients, iron (Fe), zinc (Zn), manganese (Mn), boron (B), copper (Cu), molybdenum (Mo), chlorine (Cl), sodium (Na), cobalt (Co), vanadium (V) and silicon (Si) are considered as micro plant nutrients (Kaçar and Katkat, 2007). Plants take C, H and O from water and air, and other nutrients from the soil. Chemicals that provide these elements for plants in inorganic solid, liquid or gaseous form are called chemical fertilizers or inorganic fertilizers. Those containing a nutrient element such as ammonium nitrate and urea are called simple fertilizers, and fertilizers containing more than one plant nutrient element are called composite fertilizers. Composite fertilizers contain at least two nutrients in varying proportions. Chemical fertilizers, which enrich agricultural soils in terms of plant nutrients and increase the quality and quantity of the product, have high production costs together with their raw materials, since their production requires non-renewable energy. For these reasons, the fact that the sales prices are high in the future as it is today, forces the purchasing power of the manufacturers in many countries such as our country.

Excessive and unconscious application of chemical fertilizers to agricultural lands can not only negatively affect the producer's budget, but also the state budget, it can also cause irreparable damage to the soil and environment. For these reasons, first of all, the correct determination of the nutrients needed by the soil, knowing the properties of the chemical fertilizers to be applied, determining the chemical fertilizers and amounts to be used, taking into account the needs of the plant to be grown, the time to be applied and the method of application are very important issues (Kaçar and Katkat, 2014, Soysal and Yilmaz, 2021).

As the most important source of agricultural production, soils that have become poor over time as a result of taking plant nutrients, washing and erosion by plants; Efforts are made to make it productive by applying agricultural techniques such as fertilization, pest control, processing and irrigation.

The fertilization of the nutrients taken from the soil by the plants is one of the important issues in maintaining the fertility of the soil. For this reason, fertilizers have been keeping their priority for years (Sönmez et al., 2008).

Table 2.2 for fertilizer use in our country.'s view, between the years 2016 and 2021 each year, 10.5 million tons of fertilizer is used, according to these fertilizers in the year 2021, with a maximum of 8.5 million tons of nitrogen fertilizer, phosphorus fertilizer and potash fertilizer 0.3 3.7 million tons million tons.

Table 2.2. Fertilizers used between 2016 and 2021 in Turkey and the amount of use of these fertilizers (TUIK, 2022).

Years	2016	2017	2018	2019	2020	2021
Used Fertilization (tonnes)	13 925 448	13 089 074	10 567 457	12 167 571	14 495 815	12 546 543
N (%21 N)	9 028 793	8 401 087	7 272 531	8 010 324	9 774 691	8 511 183
P (%17 P_2O_5)	4 660 032	4 438 096	3 063 902	3 924 247	4 491 994	3 726 914
K (%50 K_2O)	236 623	249 891	231 024	233 000	229 130	308 446

One of the most important inputs in agricultural production is the use of chemical fertilizers. Looking at Table 2.3 for various fertilizers and their prices, the increasing fertilizer prices every year cause a significant increase in input costs for producers.

Table 2.3. Fertilizer types and prices between 2010 and 2020 in Turkey (Anonymous, 2022).

	Fertilizer Prices TL/Tonnes					
Years	**Types of fertilizers**					
	%21 A.S	**%26 CAN**	**%33 A.N**	**Üre**	**DAP**	**20.20.0**
2010	382	483	584	694	1 011	679
2011	585	617	745	982	1 498	1 060
2012	641	761	880	1 178	1 465	1 054
2013	623	813	920	1 120	1 330	960
2014	620	879	980	1 159	1 568	1 062
2015	681	853	982	1 176	1 825	1 260
2016	586	717	928	938	1 337	966
2017	708	865	-	1 156	1 538	1 096
2018	1 011	978	-	1 664	2 383	1 587
2019	1 219	1 222	-	2 018	2 654	1 892
2020	1 282	1 435	-	2 195	2 647	1 974

3. BACTERIA

Bacteria, fungi, algae, actinomycetes, and protozoa, there are a group of microorganisms, including in the land, these symbiotic that live inside plant tissues as biological fertilizer, the nitrogen in the air to be able to offer the use of the plant, phosphorus, and other nutrients plants that can take the form of microorganisms that produce enzymes that can convert to a plant growth stimulating collection. Microorganisms that live freely in the soil and are used as biological fertilizers that promote plant development are called rhizobacteria (PGPR) that promote plant development. These bacteria mostly belong to the genus *Acetobacter, Acinetobacter, Achromobacter, Aereobacter, Agrobacterium, Alcaligenes, Artrobacter, Azospirillum, Azotobacter, Bacillus, Burkholderia, Clostridium, Enterobacter, Erwinia, Flavobacterium, Klebsiella, Microccocus, Pseudomonas, Rhizobium, Serratia* and *Xanthomonas* (Çakmakçı, 2005). Intense research has been carried out on Bacillus species in recent years. These microorganisms, which are more prominent as biological fertilizers, can be applied to the soil, seeds or plant surface.

The use of microorganisms as biological fertilizers; It has many benefits such as not having a toxic effect on plants, not polluting groundwater, not changing soil pH and being cheaper. These biological fertilizers not only increase plant growth by producing plant growth promoting and hormonal substances with the effect of biological nitrogen fixation, but also ensure the uptake and economic use of plant nutrients in the soil. These microorganisms reduce the damage to the plant of the microorganisms that adversely affect the yield in the environment they are in, by keeping them under pressure and help organic mineralization. In addition, systemic resistance is supported by the different biochemical substances they give to the environment in terms of plant health, and protection from insects and pests is provided. Microbial diversity is an endless resource for these purposes.

Chemical fertilizer production is not sustainable and depends on the use of non-renewable resources that require high energy (Jensen and Nielsen, 2003). Nitrogen production causes deterioration of ecological balance, changes in nitrogen cycle, depletion of fossil fuel reserves, increase of various greenhouse gases, and pollution of groundwater by washing. For the production of 1 ton of NH3, 1.3 tons of oil or equivalent energy is required, while energy must be used for the transportation and storage of fertilizers. In addition, a significant amount of energy is used in the application processes of these fertilizers. In the next 50 years could run out of oil and natural gas reserves, the inability to be discovered in the case of very serious energy, new energy sources, prices will rise excessively and the continuation of existing conditions of agriculture fertilizer production would not be possible due to a lack of food shortages as a result of their forecasted (Bockman, 1997). Contractions in fossil fuel supply and increases in prices have focused attention on biological nitrogen fixation research. Nitrogen fixation and bioavailability of phosphorus are regulated by plant growth promoting rhizobacteria (PGPR) (Glick, 1995, Lucy et al., 2004). Biological nitrogen fixation, which is less costly and energy-saving compared to chemical fertilizers, converts nitrogen (N2), which is free in the atmosphere, which cannot be used by plants by some microorganism species, into usable form (NH4) with the help of nitrogenase enzyme.

The use of PGPR as a biological fertilizer is becoming widespread in many parts of the world in order to reduce the applications of industrial fertilizers and pesticides, which are potential pollutants (Burdman et al., 2000). Symbiotic and non-symbiotic nitrogen fixation of biological fertilizers are the most prominent features of plant growth, mobilized plant nutrients, secretion of plant growth stimulating substances and biological control of soil-borne diseases are other features (Lucy et al., 2004).

Yield, drought tolerance, germination rate, root development, leaf area, chlorophyll rate, root and stem weight increase, aging of leaves is delayed and resistance to some diseases is provided by PGPR applications. Ensuring the continuity of resources, preventing environmental pollution, agricultural sustainability and cost reduction increase the importance of the use of nitrogen-fixing and phosphate-solving bacteria.

4. THE STUDIES CARRIED OUT

Meral (1998) A. U. faculty, research and application Farm in 1995, the effects of different doses of nitrogen and inoculation methods in order to determine plant characteristics; as the material Akçin-91 *Rhizobium* inoculant is used as the seeds of chickpea varieties *Cicer* according to the research results, nodulasyon in your applications without bacteria inoculation did not, consequently, root weight, plant height, plant weight, number of fruits plant, grain weight and yield the lowest values were obtained. In the seed grafting application; nodules are larger and formed close to the main root, while the root weight has also increased, in the soil grafting method; although the number of nodules is the highest, nodules are small and formed around capillary roots. The plant characteristics discussed in seed grafting and soil grafting applications showed similar results, and both bacterial grafting methods and nitrogen doses provided an increase in yield.

Rain and Engin (2005) ILC 482 chickpeas (*Cicer arietinum L.*) in Van ecological conditions.) in a study conducted in 1997 and 1998 to determine the effects of inoculation with four different phosphorus, four different nitrogen doses and rhizobium bacteria on grain yield and some yield elements of the variety; increasing nitrogen doses in the first year of the experiment, some yield components and grain yield in 1998, was found to significantly affect grain yield and some yield components, while increasing levels of phosphorus doses on grain yield and some yield components were statistically significant increase in 1997, the experiment was repeated in 1998 and some items of significant increases yield, grain yield statistically ($p<0.05$ and $p<0.01$ level) have found that does not significantly affect. On the other hand, they found that the effect of vaccination on all characters in both years was not statistically significant (at the level of $P<0.05$ and $P<0.01$).

According to Kaçar et al. (2004) ecological conditions in Bursa province, Uludag University Faculty of Agriculture Agricultural Research and Application Center at inoculation and different nitrogen doses on yield and yield components in some bean cultivars in order to determine the effect of a study carried out in 1999-2000 as plant material in Yalova-5 and Yalova-17 priming with a common area in Bursa with Sahin-90 bean varieties, nitrogen fertilizer as ammonium nitrate (26%) and 5 doses (0, 3, 6, 9, 12 kg/DA), the grafting material as bacterial strain of beans and some agronomic characteristics were examined. Looking at the combined data of two years in the ecological conditions of Bursa, they concluded that vaccination has no effect on the studied characteristics on the varieties, and increases in yield and yield components are usually achieved with increasing fertilizer doses.

In 2008, Akkurt used bean varieties with the names Judia, Gina, Nazikız, Göynük 98, Balkız and Rhizobium phaseoli mixed bean as the bean nodosite bacteria in the study they carried out in the laboratories of the Field Crops Department of Ordu University, Faculty of Agriculture, with the soil they took from the research and application land of the Ordu University Faculty of Agriculture. Nitrogen fixation of bacterial inoculation in bean plant using peat culture inoculation material, plant height, number of clusters per plant, number of nodes, number of leaves, root length, dry stem weight, dry root weight, number of nodules, nodule weight, N % above soil content, root Characteristics such as %N content, %N content in the nodule were thinned. As a result of research, cultivars, plant height, and root length, dry weight, root dry weight, nodule weight per plant and number of nodules per plant and the effects of that are not statistically significant, on the other hand, panicle number per plant varieties still, the number of nodes per plant, number of leaves per plant body %N ratio, root %nodule N ratio and %N rate effect wasn't significant, the effect of bacteria inoculation of root dry weight only statistically significant effect of the other observations that have seen that is not important. They reported that the effect of soil sterilization conditions on the number of nodes and nodule weight in the plant was statistically significant, and the effect on other observations was not significant.

Göksu (2012) Bursa-Bursa Yenisehir Bursa and peas in 2008 and 2010 at two locations, chemical, and microbial protein ratio with yield and yield components of organic fertilizer application in a study carried out in order to examine the effects of the varieties of peas 2 (Dual and Spring) and chemical fertilizer (46% N, % P2O5 46-48), organic fertilization (chicken manure) fertilization and microbial (Bacillus megaterium Bacillus megaterium M3 nitrogen fixation and phosphate solvent disturbing BA142) in different blends of them used. As a result of the research, according to two-year combined data, while obtaining the lowest values from control plots; they found significant increases in yield and yield components when chicken manure was added to chemical fertilizers at the rate of ½. In this context, they stated that it would be useful to introduce chicken manure for the creation of a sustainable agricultural system, productivity and better soil properties, taking into account the ability to use the soil in pea production. However, they reported that the application of phosphorus and nitrogen biofertilizers in pea production cannot be an alternative to the application of commercial phosphorus and nitrogen fertilizers.

Sönmez (2012) phosphate solvent bacteria on nutrient content and yield of chickpea plants 5 (N2; Bacillus megaterium m-3, TV-6I; Cellulosimicrobium cellulans, TV-34A; Hafnia alvei, TV-69E; Acetobacter pasteurianus and TV-83F; Bacillus cereus) and organic fertilizer (0, 1, and 2 ton/DA) application under field conditions, the effects of bacteria at the end of a study carried out in 2010 and 2011, particularly grain yield and biological yield per unit area with the applications they obtained a significant increase in bacteria under conditions of nutrient content of organic fertilizer, except for unimplemented they reported significant increases in copper. In case of combined use of organic fertilizers and bacteria, while also achieving a further increase in yield first highest grain yield (102 kg/ha) and second year (179.3 kg/da) 2 ton/da + N2 (Bacillus megaterium m-3) obtained in terms of organic fertilizer phosphorus uptake in the organism they implemented every two years stated that they were more active in bacteria circumstances.

Ozturan Akman (2017) Samsun, Black Sea Agricultural Research Institute research station in 2012 and 2013 to Wednesday Ambarkopru bean cultivar and Rhizobium alone and together under unfertilized conditions of guano and zulbi mikoriza of inoculation on plant growth, some agronomic characters, grain yield and seed study carried out in order to assess the effect on the nutrient content of; in 2012, the number of nodules per plant fertilizer application (47.50 nodules/plant) control (unfertilized) application (57.15 nodules/plant) compared to reduced seed inoculation with Rhizobium bacteria, vaccination in accordance with the application not control nodules per plant in both years and in 2012 the number of analyses have found that combined increases significantly. However, there was no difference in the number of nodules they formed on the roots between the Rhizobium inoculants, consisting of a mixture of standard and local isolates, and the mycorrhiza application was nodule per plant both in 2012 (46.16 nodules/plant) and in the combined years (52.31 nodules/plant) compared to the application without mycorrhiza inoculation. They stated that they reduced the number of (58.49 and 58.39 nodules/plant) and this could be attributed to the decrease in the number of nodules formed by Rhizobium bacteria due to the competition between Rhizobium and mycorrhiza.

Özaktan (2017) used Göynük 98 white bean (*Phaseolus vulgaris L.*) cultivars in the study they carried out in the production season of 2015 and 2016 on the central campus lands belonging to Erciyes University Agricultural Research and Application Center. Humic acid, microbial fertilizer with Bacillus pumilus C26 phosphate dissolving properties and phosphate rock (29.3% P2O5) were applied in the experiment. At the end of the trial period, the highest grain yield was obtained with 314.3 kg/da on average over the years in the plots where phosphate rock was applied at 22.5 kg/da together with humic acid and microbial fertilizer applications, while 173.8 kg/da was obtained in the control plots. They stated that the effect of yield increase in beans is significant compared to the control plots of all applications, and that humic acid and microbial fertilizer applications together with phosphate rock at 22.5 kg/da (29.3% P2O5) is most suitable for high grain yield for sustainable agriculture in conventional and organic bean cultivation.

Özsoy Altunkaynak as a result of the study they carried out in 2016 in Altınekin district of Konya province to determine the effects of different nitrogen fertilization (Ammonium Sulphate) and bacterial inoculation on some agricultural characteristics and grain yield of Alberto bean variety; Although they did not propose a definite result due to the one-year study, they stated that they thought that it would be more appropriate to recommend 5 kg/da N application in sowing in order to obtain high grain yield in bean cultivation.

Sen (2018) and Bitlis Adilcevaz County during the breeding season in 2016, potassium Humate Bean yield and yield components in different practices and vaccination trial in a bid to determine the effects on vaccination and doses of potassium humate as a result, increases in yield and yield components provided by designated, high seed yield, 225.44 kg/ha immunization with + potassium Humate (300 g/100 kg seed) are obtained from the application of.

Soysal and Erman (2020) between the years 2016-2017 and 2017-2018 Siirt ecological conditions, microbiological and inorganic fertilization on chickpea (Cicer arietinum L.)' s yield, yield components and determine the effects on nodulasyon carried out in order to study the symbiotic bacteria Bacillus atrophaeus bacteria Mesorhizobium Cicer asimbiyotik The Binding of nitrogen, phosphate as solvent GC Bacillus group and were used as inorganic fertilizer DAP fertilizer. Bacillus atrophaeus (N)+ DAP was obtained as 174.0 kg/da in 50% application.

Şahin (2018) 2018 spring and early summer growing season conditions in Diyarbakır, Göynük 98 and Cihan bean varieties, nitrogen, Rhizobium inoculation (Rhizobium phaseoli) of the application in a study carried out in order to determine the effect of yield and yield components, grain yield in the control group (106.80 kg/ha) and nitrogen doses on the implementation of the bacteria (Cihan variety 88.8 kg/DA) and Göynük 98 cultivar in 93.58 kg/da) they obtained higher values for high temperature and low humidity is an important factor limiting the cultivation of beans in the province of Diyarbakır in low yield values was the result of a rivalry with the climatic conditions of the plant are reported.

Doğan (2019) Arda and Azkan chickpea varieties and microbial fertilizers (Nitrogen-fixing Bacillus megaterium TV126C, Phosphate solvent Bacillus megaterium TV119E and combined Bacillus megaterium TV53D), organic fertilizer vermicompost 300 kg/da, chicken manure 2 tons/da in Mardin ecological conditions and worm manure at 300 kg/ha and chemical fertilizers (Control, DAP/2 and DAP) applications on yield and yield characteristics, protein ratio, grain phosphorus content and grain potassium content in 2018 and 2019 in a summer cottage. As a result, they obtained data on the fact that microbial applications contributed positively to all the examined properties and that organic fertilizer applications in chickpea cultivation could be an alternative to chemical fertilizer applications.

The flow of the varieties of beans in Van ecological conditions in 2020 Erdin and Kulaz 98 inorganic fertilizer applications on yield and some agronomic and in order to determine the effect of microbial, Yuzuncu Yil University, Faculty of Agriculture, the trial grounds are fertilizers that promote plant growth of different microbial isolates (Bacillus atrophaeus (TV126C), Bacillus-GC group (TV119E), Bacillus atrophaeus (TV126C9 + Bacillus-GC group (TV119E) and Rhizobium gallicum (NCPI MZ156852)) with combinations of inorganic fertilization (Control, 100% of a full dose of NP and 50% NP-reduced dose) they used. As a result of the research, the highest grain yield was obtained from Bacillus atrophaeus (N)+ Rhizobium gallicum bacteria applications as 238.15 kg/da.

Baran and Kulaz 2021 in Van Yüzüncü Yıl University, Faculty of Agriculture, Department of field crops land application of microbial fertilizers that promotes plant growth in cowpea varieties to stick Karagöz (binding Nitrogen, Phosphorus solver, Mycorhizae Rhizobium bacteria and fungus) and organic fertilizer (humic acid, manure, and chicken manure Worm) on yield and yield components in order to determine the effects of their work as a result, 85.96 kg/da and mycorhizae as the highest grain yield obtained from the application of vermikompost.

5. CONCLUSION

Healthy nutrition is the most important criterion for people to be healthy, and this will only be possible with healthy food production, and healthy food production will only be possible with a healthy agricultural system. The basis of a healthy agriculture system is to clean the pollutants in the agro-ecosystem by biological means and to strengthen the soil rhizosphere with the conversion of biological fertilizers and organic residues. It is imperative for healthy production not to use chemicals that have harmful effects on human health or to use them in a controlled manner. As the world population increases, the need for food is also increasing rapidly. In order to obtain the maximum production from the unit area, a high-efficiency production method is chosen and the need to combat diseases and pests with an effective fertilizer method arises. Chemical fertilizers and pesticides have been used until today, but increasing health problems, environmental problems, increases in the cost of chemical fertilizers, as well as the sustainability of agriculture have led to alternative production resources. At the beginning of these sources are microorganisms naturally found in our environment, and studies on different microorganisms continue and Bacillus sp bacteria group emerges as the most promising. It is known that since the prices of chemical fertilizers, which have increased significantly in recent years, cause the input costs to rise, it puts the agricultural producers in a very difficult situation. Some producers try to reduce the cost by not using chemical fertilizers in order to reduce these input costs, but in this case, since the amount of product they will obtain from the unit area will decrease, they may suffer serious losses in profit and may face bad economic results. It is thought that the use of chemical fertilizers at certain rates together with the application of bacteria in the cultivation of edible grains will contribute to sustainability in agriculture, ensuring the continuity of resources and preventing environmental pollution, and it will also provide economic gain by reducing the cost.

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