INNOVATIVE APPROACHES IN MEADOW-RANGELAND AND FORAGE CROPS

Editor: Assoc. Prof. Dr. Seyithan SEYDOSOGLU

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Forages are the basis of sustainable agriculture. They include a wide variety of plant species ranging from grasses and herbaceous legumes. Climate change has the potential to impact the quantity and reliability of forage production, quality of forage, water demand for cultivation of forage crops, as well as large-scale rangeland vegetation patterns.

Abiotic stresses, factors limiting crop productivity and sustainability worldwide. Several agronomical and physiological mechanisms are involved in stress tolerance of crop plants. To alleviate the negative effects of environmental stresses, plants increase the production of various compatible osmolytes.

This book summarizes the highlighting the importance of forage crops, the present improvements and some of future directions for enhancing yield and nutritional quality under environment stress conditions. Accordingly, Recent agricultural technologies that have greatly increased food supply have had inadvertent, detrimental impacts on the environment and on ecosystem services, highlighting the need for more sustainable agricultural production.

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CHAPTER 1

CLIMATE, DROUGHT AND PASTURE

INTRODUCTION

The world has undergone constant climate changes since the beginning of time. But all scientists agree that climate changes will increase exponentially in the 21st century. It is assumed that the temperature will increase by 4 to 5 °C and the CO_2 density will increase from 330 ppm to 555 ppm until the year of 2060 (Pittock, 1993). In recent years, global climate changes and agriculture have been the most two important duo in our world. During the recent years, many scientists have focused on the effects of increasing CO_2, temperatures and precipitation on agriculture. For example, the FACE experiment in New Zealand, where I also had the opportunity to work for three months, began in the late 1990s, according to Newton et al. (2001). As the rest of the world, Turkey is also affected by climate change. It is said that climate change may cause adverse effects on agriculture, forestry and water resources especially in semi-arid and semi-humid regions such as Central Anatolia, South East Anatolia, Aegean and Mediterranean regions that are faced with the threat of desertification. According to researchers, climate zones appear to be shifting hundreds of kilometers poleward from the equator as happened before in the geological history of the earth; and Turkey may be exposed to the hot and dry climate zone prevailing in the Middle East and North Africa (Türkeş, 1998).

Water is the most strategically important resource in the world. It is the source of life and increasing population, urbanization as well as industrial and technological developments increase the demand for water everyday. However, using water efficiently is of particular importance for future generations. In pastures, plants meet their water needs from rainwater. In our world, food supply is as crucial as adequate water supply. Climate changes may cause food scarcity as well as adversely affecting productivity in agriculture. The most important need in nutrition is protein. And protein predominantly comes from animal products. Due to population growth, recent projections have suggested that the total world food production will need to be increased by about 50% by 2050 (Searchinger et al., 2019). Demand for meat will go up by about 65%. In order to meet this demand for food by nearly 10 billion people (a projected 2.4 billion increase over the present 7.6 billion) without negatively impacting the environment, the World Research Institute (WRI) (Searchinger et al., 2019) has proposed a plan for sustainable food production focused mainly on increasing crop yields, reducing meat consumption by modifying diets (with a focus on developed countries), reducing food waste, and reducing the demand for food through family planning assistance (i.e., managing population growth with a focus on developing countries) (Holechek et al., 2020).

For this reason, it is necessary to increase the efficiency of sources of coarse fodder to make animal production more efficient and economic. Sources of coarse fodder are forage crops, field crop residues and meadow pastures. Pastures, being one of the sources of coarse fodder, are important in terms of providing cheap and quality forage. In Turkey, there are 14,670,000 hectares of meadows and pastures and approximately 24 million units of cattle (TUIK, 2020 a,b).

Pastures that support livestock grazing often are highly susceptible to risk because forage production is tied to precipitation. Climate changes lead to suffering along with other agricultural producers; there is both intra- and interannual variability that makes proactive planning difficult. Prolonged drought with associated precipitation variability often forces a reduction in livestock numbers, reduction in per-head productivity, and restrictions to pasture irrigation, which are important to providing forage outside of the growing season (Dobrowolski and Engle, 2016). Once a region is experiencing a drought, some pasture producers reduce animal numbers and sell all at one time which triggers falling livestock prices. Where there are lower prices, other producers lack an incentive to sell their stock, so maintained stock grazing may lead to potential ecological damage (Stafford et al., 2007).

Therefore, questions of what could be the effects of climate changes on pastures and what can be done to benefit from pastures more intensively should be answered.

One of the first things that comes to mind to fight against the negative effects of climate change on agriculture is the breeding of drought-resistant plant species. If plants cannot meet their water needs from rainwater and soil, then wilting sets in and plants die eventually. Therefore, breeding of drought-resistant forage crops and spreading these species in pastures should be one of our priorities. As reported by Hatipoğlu et al. (2019), more weight should be given to breeding drought-resistant species in all cultivated plants as well as meadow-pasture plants. C4 forage crop species which are adaptable to our different ecological regions and for use in meadow-pasture and forage crop cultivation should be determined and new breeding techniques should be developed and new breeding studies should be carried out with these species.

Climate and soil factors are crucial for vegetative production. Being one of the climatic factors, rainfall affects the natural vegetation in a region. Pastures have high soil and water retention and provide a rich source of biodiversity, as well as cheap and high quality forage that creates a diverse nutritional composition with different species. Pastures that are usually barren are highly affected by the effects of climate change, especially by droughts. Among the factors of climate, precipitation is the most effective indicator (Hahn et al., 2005; Naderi, 2007) followed by temperature, and their interaction effectively determines rangeland production (Munkhtsetseg et al., 2007; Smart et al., 2007; Izadi et al., 2019). These changes in climate, together with direct effects of increased atmospheric CO_2 concentration on plant growth and transpiration, will influence factors such as soil water and nitrogen availability that regulate the provisioning of plant and animal products from rangelands (Polley et al., 2017) the alteration of rainfall distribution associated with long-term climate change/variability is expected to influence plant productivity and species diversity in semi-arid areas (Le Houerou, 1984; Cheng et al., 2011). Pasture productivity in arid and semi-arid ecosystems is usually limited or co-limited by nitrogen availability, which is tightly coupled with water availability through biogeochemical feedbacks (Lauenroth et al., 1978; Burke et al., 1998; Xiao et al., 2007; Gao et al., 2011, Gamoun, 2016).

Precipitation and temperature anomalies may affect plant life negatively in the long term, and cause a significant decrease in productivity and even productivity loss. Potential decreases in the total amount of precipitation or anomalies in seasonal distribution affect the production in pastures that are located in arid and semi-arid regions (Herbel and Pieper, 1991; Pittock, 1995; Bilgili and Daşcı, 2015). Increased precipitation in a region due to climate change causes water erosion; high wind speeds and soils that are dry enough to be blown by wind cause more severe wind erosions (Gökkuş and Koç, 1993). This limits vegetative production. Vegetative production decreases in pastures during periods of low precipitation (Holechek et al., 2004; Schönbach et al., 2012; Polley et al., 2013; Guido et al., 2014; Martin et al., 2014; Gamaun, 2016). The negative impact of drought on vegetation may be more severe in poor pastures than in good pastures, and pasture plants cannot meet their physiological needs during dry seasons when precipitation is low. This situation causes a rapid decrease in pasture productivity. Moreover, plants undergo physiological stress in case of intensive grazing before a dry spell that negatively affects the nutrient reserves in pastures, and the carrying capacity of pastures decreases in correlation with increasing drought (Thurow et al., 1999). Considering the change in precipitation for many years, pasture vegetations can be significantly affected by droughts lasting for two or more years, and normal or above-normal precipitation after a drought lasting for 1 year may reduce the negative effect of short-term drought on vegetation. In the event the drought continues for several years in a row, pasture productivity will decrease significantly (Holechek et al., 2004; Bilgili and Daşcı, 2015).

In very humid and fertile pastures, the change in precipitation will probably not cause any problems. However, as seasonal production depends on the precipitation amount and distribution, changes to the precipitation regime due to the climate change will also be important for these types of pastures (Knapp et al., 2001). The increase in precipitation amount generally causes an increase in meadow and pasture productivity. However, the effect of excess precipitation as a result of global warming will be avoided by water loss. Since the seasonal distribution and intensity of precipitation will affect the water dynamics of seasonal soil and efficient use of plant water, it will have more impact on pastures than precipitation (Giorgi et al., 1998). Heavy rainfall will cause an increase in runoffs and erosions. The drying effect of global warming will be particularly important in arid and semi-arid regions of the world where precipitation will not be much affected or decrease due to climate change (Hatipoğlu et al., 2019). Drought and precipitation regime changes, which are a result of climate change, reduce water reserves in the soil, and increased temperatures cause water loss in the soil through evapotranspiration as well as increased transpiration in plants. Plants use only 1% of the water they absorb from the soil for photosynthesis, and 99% of it returns to the atmosphere (Gençtan, 2006).

Pasture improvement is also important for drought in increasing productivity and quality. Due to draught, vegetative production decreases while the species composition of the pasture vegetation,

vegetation cover and the quality of forage are negatively affected. The more we can increase the vegetation cover, the more the water retention of the soil. The rangeland vegetation cover and its potential productivity could be limited by the long-term rainfall variability and its distribution in arid and semi-arid ecosystems (Thornton et al., 2009; Cheng et al., 2011). Fertilization, seeding, and weed control are the most common methods to increase productivity and quality in pasture improvement efforts. As a matter of fact, these methods are used in many pastures of Turkey considering the needs of the pasture, with the support of the Ministry of Agriculture and Forestry. Water use efficiency of plants increases by fertilization in pastures (Altın et al., 2005). In addition, it is recommended to use organic fertilizers to increase the organic matter in the soil to ensure more water retention in the soil. Organic matter in the soil increases the water absorption capacity of the soil as well as the water retention capacity (Baytekin, 2008). Plant nutrients are used more effectively thanks to water retention in the soil in pastures. At the same time, physiological damage to the plants will be prevented by regulating grazing and avoiding heavy grazing. These methods can help meet some of the water needs of pasture plants. However, lack of water in the soil in pastures causes a decrease in grazing capacity and hence animal production. Certain measures can also be taken to prevent water erosion in pastures, to retain water in the soil and to reduce the impact of drought. These include grain shape structures consisting of small pits in pastures, opening furrows, tearing (ventilation), building terraces (Altın et al., 2005).

Since soil moisture plays a key role in vegetation restoration and ecosystem stability in arid and semi-arid regions, the response of soil to rainfall pulses is an important hydrological process, which is strongly influenced by land use during the implementation of vegetation restoration. Soil moisture depends strongly on precipitation (Yu et al., 2015) and is a key rangeland health parameter because it is the principal limiting factor in semi-arid ecosystems (Weber and Gokhale, 2010). According to Mood (2008), low rainfall and continuous drought shorten the life cycle of annual plants. Annuals have a competitive advantage since they rapidly establish and produce more seed in a faster timeframe compared to perennials. Soil moisture is the principal determinant of productivity and the primary driver of rangeland conditions in semi-arid ecosystems. Drought is usually the most important environmental stress for the range of plants that try to survive against the constant consumption of animals. Low water availability in arid and semi-arid regions severely limits seed germination, seedling establishment, and persistence of perennial grasses (Bassiri et al., 1988). Deeply-rooted plants are more likely to survive extended periods of drought by accessing lower soil layers that contain higher levels of soil moisture (Chaves et al., 2003). It is generally assumed that plants respond to drought in surface layers by shifting water and nutrient uptake to deeper soil layers (Garwood and Sinclair, 1979; Sharp and Davies, 1985), Soil temperature, a controlling factor for soil moisture as it affects evaporation, is also affected by the amount of litter (Davidson et al., 1998). It is accepted that the average temperature increases all over the world. The flora has also changed due to climate change. The number of species has decreased in some parts of Europe in the last 30 years and it is believed that this is caused due to habitat loss and climate change. On the other hand, the number of species has increased in some parts of Western Europe including the Netherlands due to a hotter climate. On the other hand, there has been a decrease in the number of cool climate species (Mannetje, 2007). It is estimated that the number of species in Europe will decrease even more in the 21st century due to the inability of cool climate species to adapt to high temperatures (Hatipoğlu et al., 2019). To cite from a research, we have previously conducted; (Sen and Ozturk, 2017).

The study was conducted in two different coppice forest areas defined as A and B in 2014-2015. They are located to the north and south of the village within the borders of Kırklareli City, Luleburgaz District, and Sakizkoy Village. The region where the study area was located has a "semi-arid climate" feature (Donmez, 1968). While the total annual rainfall was 788.8 mm in the Luleburgaz District of Kırklareli Province in 2014, which was the first year of the study, it was only 493.0 mm in 2015. While the average relative humidity in 2014 was 84.4%, the average relative humidity in 2015 decreased to 75.2%. The average temperatures of the years 2014 and 2015 were measured as 14.2^{0}C and 15.6^{0}C, respectively. It was observed that the maximum temperature average of the year 2014 was 26.9^{0}C and the maximum temperature average of the year 2015 was 27.6^{0}C (Anonymous, 2016). As part of this study, the relationship between soil moisture and temperature and plant species were evaluated using the CANOCO 4.5 computer program (Ter Braak and Smilau, 2002). Soil temperature measurement results for 2014-2015 found that the soil temperature increased from 16.8 ^{0}C to 24.5 ^{0}C at site A and from 16.8 ^{0}C to 26.4 ^{0}C at site B. An examination of soil moisture found it was 8.4% at site A in 2014, but decreased to 5.6% in 2015. While the soil moisture was 7.6% at site B, it decreased to 6.4% in 2015. According to research results, soil moisture and temperature have a significant effect on vegetation. In the first year when soil moisture was high, hay yield was 2901.9 kg ha^{-1} while the yield decreased to 480.1 kg ha^{-1} after the soil temperature (which is inversely correlated with soil moisture) increased in the second year. It was determined that *Lolium perenne* (a dominant species of vegetation) was more common in parcels with high moisture whereas *Chrysopogon gryllus* was more common in parcels where the soil temperature is high.

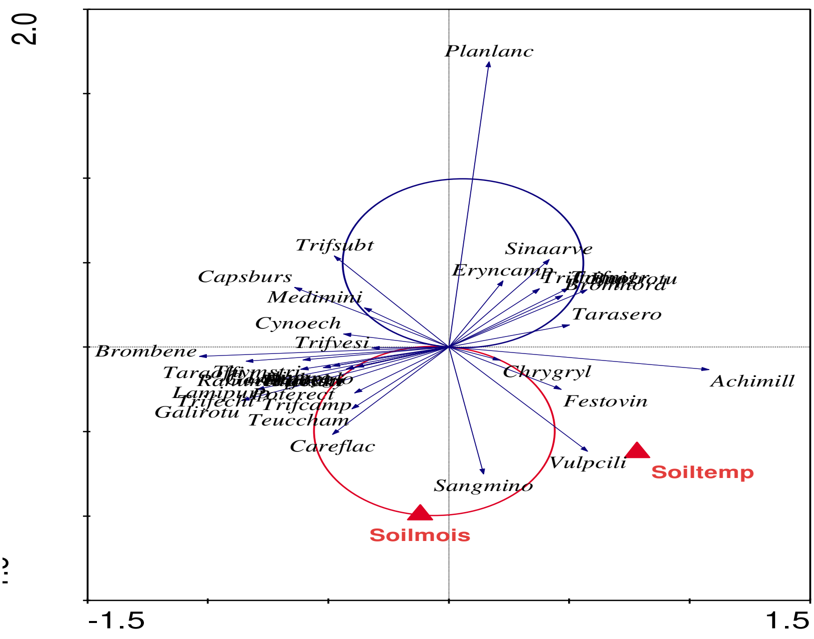

Figure 1. T- value plot of soil moisture

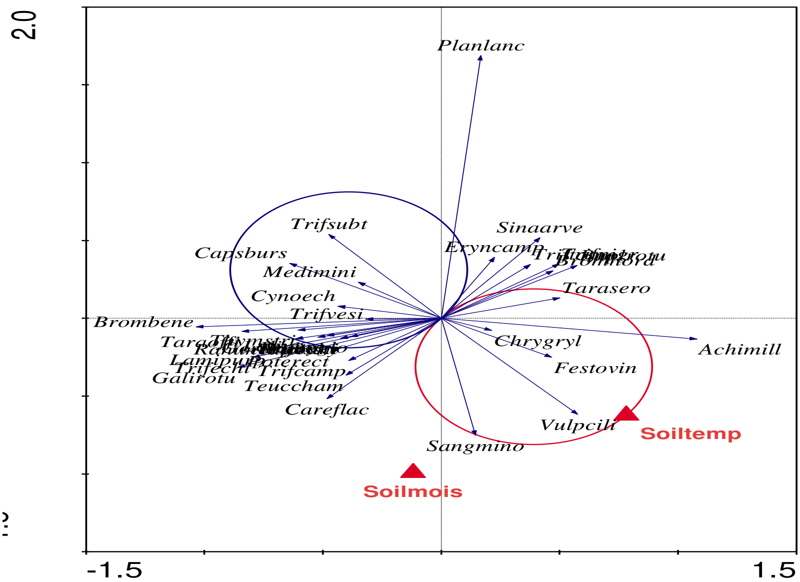

Figure 2. T- value plot of soil temperature

Species: *Achillea millefolium* Achimill; *Aira caryophyllea Airacary*, *Bromus benekenii* Brombene, *Bromus hordelymus* Bromhord, *Bupleurum rotundifolium* Buplrotun, *Capsella bursa-pastoris* Capsburs,*Carex flacca* Careflac, *Cynosurus echinatus* Cynoech, *Chrysopogon gryllus* Chrygryl, *Dactylis glomerata* Dactyglom, *Eryngium campestre* Eryncamp, *Festuca ovina* Festovin, *Galium rotundifolium* Galirotu, *Geranium robertianum* Gerarobe, *Koeleria nitidula* Koelnitu, *Lamium purpureum* Lamipurp, *Lolium perenne* Lolipere*, Medicago minima* Medimini, *Plantago lanceolata* Planlanc, *Potentilla recta* Poterect, *Ranunculus neapolitanus* Ranuneap, *Sanguisorba minor* Sangmino, *Sinapis arvensis* Sinaarve, *Taraxacum officinale* Taraoffi, *Taraxacum serotinum* Tarasero, *Teucrium chamaedrys* Teuccham, *Thymus striatus* Thymstri, *Trifolium campestre* Trifcamp, *Trifolium echinatum* Trifechi, *Trifolium nigrescens* Trifnigr, *Trifolium ochroleucum* Trifochr, *Trifolium subterraneum* Trifsubt,*Trifolium tomentosum* Triftome, *Trifolium vesiculosum* Trifvesi, *Vicia sativa* Vicisati,*Vulpia ciliata* Vulpcili

Environmental variables: Soil mois Soil moisture, Soil temp Soil temperature

In Figure 1, the t-values of the statistical significance relationship between soil moisture and plant species are presented with a Van-Dobben circle. It was determined that plants such as *Carex flacca, Trifolium campestre* and *Lolium perenne* had a positive relationship with soil moisture, whereas *Eryngium campestre* and

Sinapis arvensis had a negative relationship with soil moisture. Annual legumes such as *Trifolium campestre, Trifolium echinatum, Trifolium vesiculosum,* can also utilise the water in the soil using their taproot systems during a period of drought. It was determined that there was a positive relationship between soil temperature and *Festuca ovina, Chrysopogon gryllus, Vulpia ciliata*. Annual legumes such as *Medicago minima, Trifolium vesiculosum,* and *Trifolium subterraneum* have a negative relationship with soil temperature (Figure 2) (Sen and Ozturk, 2017)

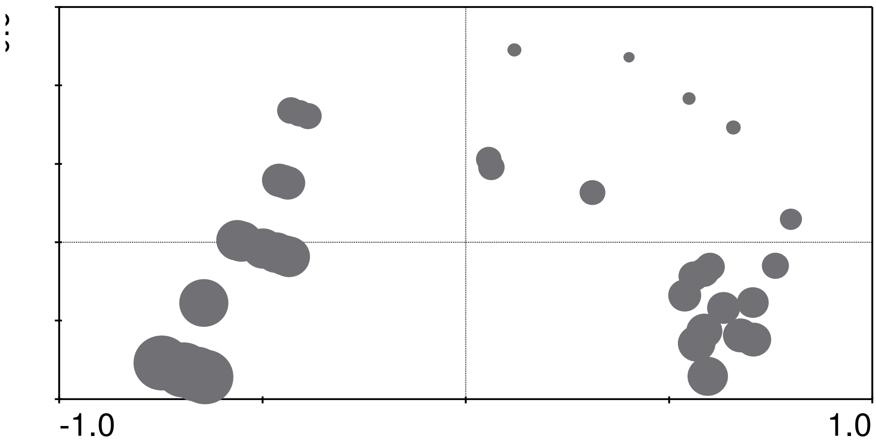

Figure 3. Distribution of parcels according to soil moisture

The distribution of the parcels according to the soil moisture in the study area is presented in Figure 3. The soil moisture in the parcels, as displayed by the dark-coloured symbols, in the biplot parcel refer to increased values. The parcels with higher ratios of *L. perenne* (Figure 4) generally show parallelism with the sites that have higher soil moisture levels (Figure 3).

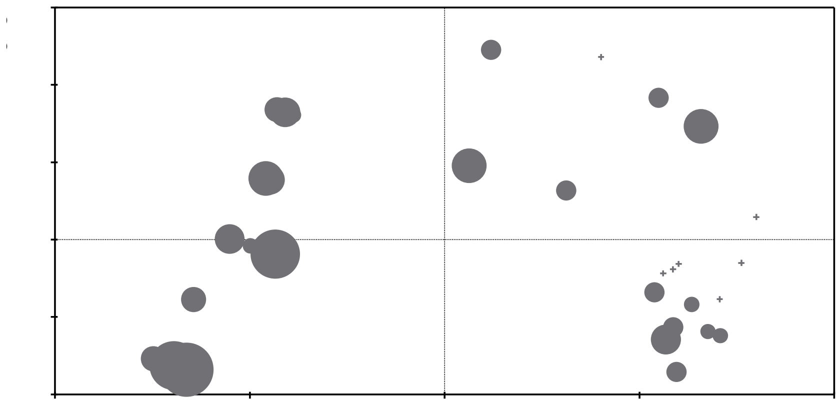

Figure 4. Presence of *Lolium perenne* in parcels

L. perenne was selected as an example, and presence in the parcels are shown in Figure 4. The *L. perenne* in the parcels, as displayed with dark-coloured symbols, in the biplot sites refer to high values. *L. perenne, Carex flacca,* and *Trifolium repens* are among the plant species in these shaped pasture sites that are more common in wet soils (Sen and Ozturk, 2017). *L. perenne* is a graminae that prefers damp, fertile and heavy soils Altın (1992)**.** Dengler et al. (2014) reported that water limitation reduces productivity as it reduces the ability of dominants to develop sufficient growth, even under nutrient-rich conditions. At the same time, taller plants were probably favoured by deeper soils which were more frequent in abandoned grasslands (Vassilev et al. 2011).

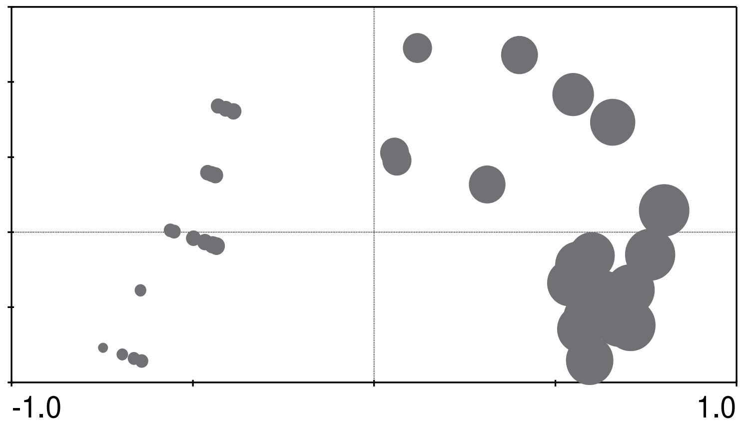

Figure 5. Distribution of parcels according to soil temperature

The distribution of the parcels according to the soil temperature of the study area is presented in Figure 5. The soil temperatures in the parcels, as displayed with dark-coloured symbols, in the biplot parcel refer to high values. These parcels include the soil temperatures collected during the second year of the study. The distribution (Terri and Stowe, 1976; Tieszen et al., 1979) and seasonal activities of C3 and C4 grasses (Kemp and Williams, 1980; Hicks et al., 1990) often are highly correlated with temperature (IPCC, 1995).

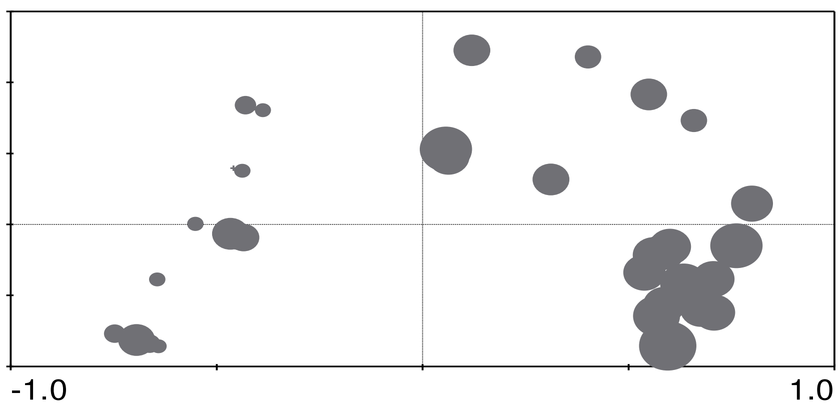

Figure 6. Presence of *Chrysopogon gryllus* in parcels

The distribution of the hot climatic plant *Chrysopogon gryllus* (C4), one of the more important species in the study area, is presented in Figure 6. There is a mutual relationship between plant species and environmental factors. *C. gryllus* in the parcels, as displayed with dark-coloured symbols, in the biplot parcel refers to high values. The parcels with the high ratios *of C. gryllus* (Figure 6) generally show parallelism with the parcels with a high soil temperature (Figure 6) (Sen and Ozturk, 2017). *C. gryllus* grows on warm, dry, illuminated, sandy grassy slopes and hills as well as on dry pasture land (Djurdjevıć et al., 2005; Dajıć Stevanovıć et al., 2008).

Another study was conducted in several pastures in the Kırklareli Province in 2016 (Sen, 2017). The study was conducted in four different villages, Elmacik, Korukoy, Karahıdır, and Kaynarca, in Kırklareli City. The purpose of my study was to determine the effects of soil moisture and soil temperature on vegetation composition and herbage yield in different natural pastures. There is a mutual relationship between plant species and environmental factors such as soil temperature and soil moisture. When these measurement results were compared, soil moisture had strongly influenced herbage yield and distribution of pasture species. It was found out that the plants such as *L. perenne*, *T. repens,* and *Agrostis stolonifera,* had a positive relationship with soil moisture. The highest herbage yield (3200 kg da^{-1}) was from the Elmacik pasture site while the lowest yield (280 kg da^{-1}) was from the Karahidir pasture site. The highest soil temperature (27 ^{0}C) was found at the Karahidir pasture site while the lowest soil temperature (17.5 ^{0}C) was at the Elmacik pasture site. Herbage yields were 880 kg da^{-1} and 480 kg da^{-1} in the Korukoy and Kaynarca pasture sites, respectively. Soil temperatures were measured as 19.2 ^{o}C and 25.8 ^{o}C at the Korukoy and Kaynarca pasture sites, respectively. Decreases were found in herbage yields that matched the decreasing soil moisture and increasing temperatures, and this was found to have a significant effect on plant species distribution, too (Sen, 2017).

These and similar studies will create a resource for future research into arid and semi-arid regions. In addition, they will allow us to understand more information about climate, and soil and pasture interactions. Future studies may extend the study area and scope and ensuring their continuity for many years. Such studies will also allow the determination of species that can better adapt to the arid conditions in the pastures. The availability of soil and air temperature data is necessary to understand plant-soil relationships and to be able to make comments on the optimal use of the soil (Dinc and Senol, 1998) and therefore this data will create a basis for future projections to be drawn about range management and improvements. Understanding the botanical composition, canopy cover and hay yield of natural pastures can lead to improvement of these lands to achieve optimal use. Success in animal production depends on producing forage in pastures. Even when the yield of plant canopy cover is high, management of these fields must be maintained correctly (Sen, 2017; Sen and Ozturk, 2017).

Above-ground plant biomass is an important indicator of rangeland productivity, and soil moisture plays an important role in the variation of biomass production in arid and semiarid pastures (Yang et al., 2009; He, 2014). Below is an example of two pasture plots located in the same place in Eskişehir, photographed in September. Picture 1: a pasture plot, non-irrigated with no soil humidity Picture 2: a pasture plot, irrigated with high soil moisture.

Picture 1. Natural pasture non- irrigated

Picture 2. Natural pasture irrigated

Do not pictures 1 and 2 show how important water is? In order to eliminate this issue, namely to provide more animal production, measures should be taken to ensure the long-term use of vegetation and irrigation should be done (Altın et al., 2005). In pastures with sufficient water resources for irrigation to create enough vegetation cover, irrigation done periodically during droughts can provide significant increases in forage productivity, especially in summer. However, water should be used for humans and animals firstly. Secondly, it should be used for economically important agricultural products that need irrigation. Thirdly, it should be used for pasture irrigation for an intensive pasture provided that it is economically viable. Irrigation can increase productivity during droughts in irrigable pastures. When choosing irrigation systems, the most affordable and easy to use systems should be considered. As a matter of fact, pivot and sprinkler irrigation systems have become widespread in pastures in recent years. These systems can be preferred after calculating the cost of the grass to be obtained from the pasture. The point to be considered is that excessive water in the pasture may cause an increase in invasive species, as well as insufficient air for roots or soil salinity problems in long-term irrigation. Pasture soil should be well-drained. Another issue is that animals should not be allowed to enter the pasture immediately after irrigation.

Drought is an impact of climate changes; more research should be conducted to determine the effects of drought on national, regional and local pastures and to protect the pastures. For these research studies, there should be more collaborative work done between the Universities, the Ministry of Agriculture and Forestry and other relevant organizations, and projects should be supported. Meadows and pastures, which cover (18.0%) of lands in Turkey, are the basis of livestock hence animal products. The sustainability of these areas is essential for better nutrition of generations. For this reason, highly productive and high quality products should be obtained from pastures in changing climatic conditions. Social awareness about the effects of climate change should be built up.

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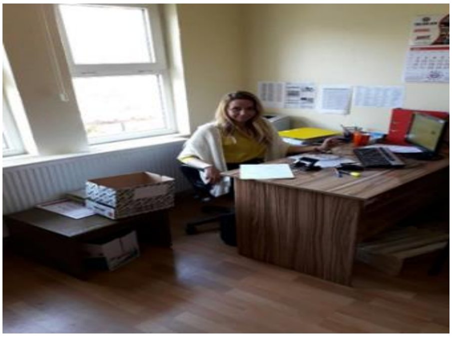

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CHAPTER 2

THE EFFECT OF DIFFERENT MICROBIAL AND COMPOUND FERTILIZER APPLICATIONS ON YIELD AND SOME OTHER CHARACTERISTICS OF MAIZE (*Zea mays* L.)

INTRODUCTION

Maize (*Zea mays* L.) is an important C4 plant, which is the most cultivated in the world after wheat and rice among grains and has the highest yield per unit area, and has the ability to produce large amounts of dry matter in a short time (Jellum et al., 1973). Maize which is an important food, feed and industrial product worldwide provides food security and income to several million small farmers in Africa, Latin America and Asia as well as developed countries. Like all other plants, the first thing to be done in maize production is the soil analysis and a fertilization program should be made in line with the results obtained. However, long term use of chemical fertilizers also led to a decline in crop yields and soil fertility in the intensive cropping systems (Dadhich et al., 2011). Most of the nitrogenous fertilizer produced in the world is used in the production of grains. However, the low nitrogen utilization efficiency of plants due to the loss of ammonia in the nitrogen used is also accepted by many researchers (Cui et al., 2010; Linquist et al., 2013; Abalos et al., 2014).

The negative consequences of chemical fertilizers can be reduced by reducing the use of chemical fertilizers. In recent years, commercial products containing different bacterial strains, living microorganisms such as fungi and algae or the products of these microorganisms, which are called microbial fertilizers or bio-fertilizers, have started to be used in agriculture (Okturen-Asri et al., 2011).

The usage area of microbial fertilizers in agriculture is quite wide. These fertilizers help many plants in areas such as increasing the nutrient intake of plants, increasing plant growth and productivity, increasing resistance to disease and pest control, controlling soil-borne diseases, improving soil structure and fertility, and decomposing organic residues. As a result of providing high resistance to plants, they significantly reduce the need for chemical inputs (Nishio, 1996). Ebrahimpour et al. (2011) indicates that bio fertilizers are a natural input that can be used instead of chemical fertilizers in agriculture. Integrated use of biofertilizers offers a cheaper low capital intensive and eco-friendly route to boosting farm productivity. Shirkhani and Nasrolahzadeh (2016) found that use of azotobacter and vermicompost significantly increased grain yield, leaf area index, leaf chlorophyll contents, the normalized difference vegetation index and leaf relative water content in normal and deficit irrigation in maize. Xu (2001) informed that even though there was an early lower growth rate for plants that received organic fertilizer compared with chemical fertilizer, the final biomass and grain yield from organic fertilizer was equal to or higher than from chemical fertilizer. Fadlalla et al. (2016) stated that bio-fertilizers significantly increased crop yield and yield components. In a meta-analysis conducted using a novel host crop-specific approach to evaluate the agronomic potential of bacterial biofertilizers for maize (Schmidt and Gaudin, 2018) greater efficacy of *Azospirillum* spp. and lower efficacy of *Bacillus* spp. and *Enterobacter* spp. was found under field conditions. Working with nine plant species with a meta-analysis on effective microorganisms, Megali et al. (2015) noted a positive effect on yield and growth in line with the overall estimate and a 16% increase in greenhouse. Researchers have therefore suggested that further localized studies are needed to efficiently incorporate effective microorganisms into traditional or sustainable agricultural management systems. In a study it is stated that bacterial species significantly stimulated the growth of maize shoot length, stem girth, leaf length, root length and root weight (Alori et al., 2019). Moreover, researchers stated that *Pseudomonas* significantly increased maize growth and yield under field experiment.

In the light of all these data, it is aimed to determine the effects of microbial fertilizer and compound fertilizer treatments on the yield and some other characteristics of the maize plant in such an area that has not been studied much in the world.

MATERIALS and METHODS

This research was conducted in Çal District, Denizli Province, Turkey under farmer conditions in Mediterranean climate conditions in 2018. Meteorological data of the trial site are given in Table 1. The soil in experimental area was clay loamy, light alkali, without salt, calcerous and low organic matter.

Table 1. Some meteorological data of the experimental area*

Months	Temperature (°C)	Precipitation (mm)	Humidity (%)
January	3.9	49.8	81.7
February	7.1	36.9	81.5
March	10.5	49.4	68.1
April	15.9	1.6	51.2
May	17.8	158.2	67.3
June	20.6	177.1	66.4
July	24.5	19.7	50.6
Agust	24.5	50.6	57.6
September	21.1	0.0	54.4
October	14.5	66.6	76.7
November	9.4	48.1	82.7
December	3.8	84.4	91.4
Aver./Tot.	14.5	724.4	69.1

* Ministry of Agriculture and Forestry, General Directorate of Meteorology

In the research, hybrid maize variety "Kontigos", which is widely sold as of the production season, suitable for regional production conditions, and microbial fertilizers "BM-MegaFlu (*Pantoea agglomerans*, *Bacillus megaterium* and *Pseudomonas fluorescens*) and BM-Coton-Plus (*Paenibacillus azotofixans* and *Bacillus subtilis*)" were used. For control purposes NPK fertilization, which is traditionally used in maize production, was used. The research was set up in a randomized complete block design with four replicates and the applications used in the experiment are given below:

a) BM-MegaFlu (*Pantoea agglomerans*, *Bacillus megaterium* and *Pseudomonas fluorescens*) 1000 cc/ha, soil application,

b) BM-Coton-Plus (*Paenibacillus azotofixans*, *Bacillus subtilis*) 1000 cc/ha, leaf application,

c) a + b,

d) Compound fertilization (180 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}, 80 kg K_2O ha^{-1}),

e) 80 kg NPK ha^{-1} + a, f) 80 kg NPK ha^{-1} + b.

The planting process of the trial was carried out on 16 April 2018. The planting was done by hand, with 70 cm between rows and 20 cm above rows, with 4 rows in each plot and the parcel dimensions were 5 m x 2.8 m = 14 m^2. In the compound fertilizer application (d): compound fertilizer was used as 80 kg NPK ha^{-1} in planting time and 100 kg N ha^{-1} was given as ammonium nitrate as the top fertilizer when the plants were sized approximately 50-60 cm. In (e) application, 80 kg NPK ha^{-1} was applied to the soil in planting time and afterward 1000 cc ha^{-1} of BM-MegaFlu to the soil. Similarly in (f) application, 80 kg NPK ha^{-1} was applied in planting time and 1000 cc ha^{-1} of BM-Coton-Plus was given to the leaves before the emergence of tassels. Similarly in (f) application, 80 kg NPK ha^{-1} was applied in planting time and 1000 cc ha^{-1} of BM-Coton-Plus was given to the leaves before the emergence of tassels. Applications (a), (b) and (c) were carried out as written above. Irrigation was done by drip irrigation four times from planting to harvest. After planting, hoeing was done for weed control twice. Twentyfive days after planting, the insecticide with 200 g l^{-1} Chlorantraniliprole active against maize cob borer (*Sesamia nonagrioides*) was pulverized from the top at 350 ml ha^{-1}. The harvest was realized on October 10, 2018, when grain moisture was at 16 %. In the harvest, the rows on the parcel edges were removed as edge effects, and the middle two rows were used for yield. In each plot 10 plant heights were taken and ear weight, diameter and length data were obtained on these plants' ears. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 17. LSD test was used to find if differences in the treatments were significant at $P \leq 0.05$ (Steel and Torrie, 1980).

RESULTS

While it was observed that the applications used in the study affected plant height, ear weight and 100 grain weight at $p < 0.01$, $p < 0.05$ and $p < 0.05$ respectively, it was observed that ear diameter, ear length, number of grains per ear and grain yield were not affected from the applications (Table 2). The highest plant height (2.93 m) was obtained from BM-MegaFlu + NPK application. This was followed by the combined application of BM-Coton-Plus and NPK fertilizers with

2.89 m. The lowest plant height (2.62 m) was taken with the application of BM-MegaFlu + BM-Coton-Plus fertilizers. The application of BM-Coton-Plus and BM-Coton-Plus + NPK fertilizers gave the highest ear weight (309 g), while BM-MegaFlu + BM-Coton-Plus application gave the lowest ear weight as 277 g. Regarding 100 seed weights, the highest values were taken from BM-MegaFlu as 40.2 g. Other applications except BM-MegaFlu + BM-Coton-Plus application were in the same statistical group. When examing ear diameter, ear length, number of grains per ear and grain yield, it was seen that values varied between 4.99-5.11 cm, 20.14-21.07 cm, 620-691 and 10.4-11.6 t ha^{-1}, respectively (Table 2).

Table 2. The effect of different microbial and compound fertilizer applications on some characteristics of maize

Application	Plant height (m)	Ear wight (g)	Ear diameter (cm)	Ear length (cm)	Numbe of grains per ear	Mass of 100 grains (g)	Grain yield (t/ha)
NPK	2.73c*	285bc	5.11	20.14	628	40.9a	10.9
BM-MegaFlu	2.75c	306ab	5.09	21.07	661	42.3a	11.3
BM-Coton Plus	2.86b	309a	5.09	20.96	664	42.2a	11.6
BM-MegaFlu+BM-Coton-Plus	2.62d	277c	4.99	20.45	646	39.2b	10.4
BM-MegaFlu+NPK	2.93a	299ab	5.08	20.77	620	42.1a	11.3
BM-Coton-Plus+NPK	2.89ab	309a	5.08	20.20	691	41.4a	11.3
F	**	*	ns	ns	ns	*	ns
LSD (0.05)	0.044	21.9	-	-	-	3.70	-

*: There are significant differences at P <0.05 between means in the same column. ns: not significant

Considering the ear diameter, it was seen that there was no consistent situation between the applications and the values of the ear diameter varied among 4.99 and 5.11 cm. A similar situation was obtained in ear length values and the values varied among 20.14 and 21.07 cm. While the number of grain in per ear varied among 620 and 691, grain yields varied among 10.4 and 11.6 t ha^{-1}.

DISCUSSION

In the study, it is understood that plant height, ear weight and mass of 100 grains weight were affected by biological and compound fertilizer applications. The highest plant height was obtained from BM-MegaFlu + NPK application. Umesha et al. (2014) also reported that organic and bio-fertilizers given with NPK at the recommended dose caused an increase in plant height from planting to harvest in maize. Beside this, researchers suggested that this increase may have been due to the combination of nutrient-rich organic fertilizers, as well as nitrogen fixing, phosphorus dissolving and plant growth bacteria in biofertilizers. Researchers also attributed the increase in maize growth to the enhanced nutrient use efficiency in the presence of organic fertilizers. Since organic fertilizers were not used in our study, the increase in plant height can be attributed to the indirect effects such as nitrogen fixing and phosphate solubilizer of the bacteria in biofertilizers. Rasheeed et al. (2003) stated that the use of different levels of fertilizers had a significant effect on the leaf area index of maize. Increase in plant height could be attributed to the increase of leaf area index.

Ear length and ear diameter are parameters that influence the number of grains per ear, grain size and subsequently ear weight and grain yield. Umesha et al. (2014) reported that the application with NPK + biological fertilizer + compost gave the highest ear weight (207.63 g) in maize. Although the diameter of the ear, the length of the earand the number of grains per ear were not affected by the applications in our study, the fact that the 100-grain weight was significant caused the weight of the ear to be significant. Applications including biofertilizers gave the highest ear weight compared to the NPK application alone.

One of the characteristics determining the yield in maize is the number of grains per ear. Although it is not statistically significant, it is seen that the BM-Coton-Plus + NPK application gave a higher value than other applications. Although it is not statistically significant, it is seen that BM-Coton-Plus + NPK application gave a higher value compared to other applications and NPK application alone. Some researchers (Tarang et al., 2013) reported that bio fertilizer has significant effects on the number of grains per row. Our results were partially in line with those of these researchers.

The lowest 100 grain weight was taken from the BM-MegaFlu + BM-Coton-Plus application. This situation can be thought to be caused by the microorganisms in biofertilizers affecting each other. Although all other applications are in the same statistical group, the fact that applications involving biofertilizers gave a slightly higher 100-grain weight than NPK alone, suggesting that biofertilizers may be beneficial. Umesha et al. (2014) found significantly higher grain weight per ear in their study containing NPK + biological fertilizer compost.

Researchers stated that this might be due to the positive effect of organic fertilizer and biofertilizers on better root development which resulted in more nutrient uptake. Beside, it was announced that these microorganisms produced vitamins and growth promoting substances (Anup et al., 2010). Fadlalla et al. (2016) found in their study that biofertilizers given with chicken manure yielded a higher 100-seed weight than biofertilizers given alone. Researchers attributed this difference in the increase in biological activities of microorganisms to the energy source provided to microorganisms by organic fertilizers. Similar observations and results were confirmed by Abdullahi et al. (2014).

Looking at the studies of maize with bio-fertilizers in the world, it is seen that biofertilizers generally have a positive effect on maize grain yield. Galindo et al. (2019) reported that *Azospirillum brasilense* inoculation has a positive effect on yield by increasing the leaf chlorophyll index, stem diameter, ear length and nitrogen use efficiency in maize, while Shirkhani and Nasrolahzadeh (2016) stated that the use of vermicompost and Azotobacter in maize increased grain yield in normal and insufficient irrigation conditions. Xu (2001), who tested a mixture of microorganisms consisting of various bacteria, yeast, actinomycetes and some fungi in sugar maize with organic fertilizers, reported that final biomass and grain yields of plants were higher compared to chemical fertilizers. Similar results are expressed by some other researchers (Fadlalla et al., 2016; Alori et al., 2019; Umesha et al., 2014) as well. But some researchers (Schmidt and Gaudin, 2018) have suggested that their effectiveness varies greatly between studies and whether they deliver the promised benefit is uncertain. Although not statistically significant in our study, the yield increase of approximately 6.5% from 10.9 t ha^{-1} obtained in standard NPK fertilization in the BM-Coton Plus application complies with the general estimates.

CONCLUSION

While microbial and compound fertilizer applications had significant effects on maize plant height, ear weight and 100-grain weight; it was observed that the effects on the ear diameter, ear length, number of grains per ear and yield were not significant. However, studies conducted in many countries, especially on cereals, show that the use of these bacteria in N deprived environments resembles the development of plants grown under sufficient N conditions. In our study, although it is not statistically significant, it can be considered positive to obtain approximately 6.5% more grain yield than the parcels with standard chemical fertilizers with the application of BM-Coton Plus. However, the study is a one-year MSc study. it is thought that the data are insufficient for a clear recommendation and more definite suggestions can be possible by repeating similar studies with more than one year, location, dose and cultivar.

AUTHOR CONTRIBUTION STATEMENT

Elif Uyanik conducted the current research study. Ahmet Esen Celen planned, designed as well as supervised this research study as supervisor.

CONFLICT OF INTEREST

The authors have no conflict of interest for this research study.

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CHAPTER 3

FORAGE CHICORY (*Cichorium intybus* L.): A REVIEW

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INTRODUCTION

As the demand for livestock products increases, utilizing non-legume herbs (forbs) become more important to meet this demand in many developed countries that has advanced agriculture and stock rising techniques. Chicory (*Cichorium intybus* L.) is one of the non-legume herbs that uses livestock feeding. Chicory has been used in many ways. Historically, it was used by people of ancient Egypt, believed that the plant purifies the blood and liver and cures cardiac diseases (Munoz, 2004; Plmuier, 1972). The Romans consumed chicory roots as boiled or raw to treat liver problems (Kiers, 2000; Plmuier, 1972). The essence of chicory has long been used for coffee in the United States during World War II (Howard, 1987). In the late 1600s people have used as a substitute for coffee and consumed vegetables (Barcaccia et al., 2016). In South Africa, prepared a kind of tea used stems and roots of chicory that was used as a tonic and purifying remedy for babies. Locals, living in Anatolia, made ointment from leaves to heal wounds (Tabata et al., 1994; Roustakhiz and Majnabadi, 2017). Chicory was first described as a forage plant in the 17th century by British farmers, but the first scientific researches were made in New Zealand in 1915, and it was described as a good quality forage plant in 1978 (Barry, 1998).

Chicory has started to come into prominence as a forage crop in animal nutrition in recent years. It is a very new pasture plant for many countries, although chicory has a widespread plant in the world. Chicory is classified high-quality forage plant with high palatability, digestibility, non-structural carbohydrates and rich in mineral substances. Also, its good drought-tolerance ability makes it a valuable forage plant especially warm-season period of a year. In addition to those, chicory helps to reduce bloat hazard and parasite formation in ruminants (Barry, 1998; Athanasiadou et al., 2007; Marley et al., 2014). Chicory extends the grazing period in pasture thanks to its high-ability to grow in warm summer season when other grasses and legumes mainly dormant form at that time (Kemp et al., 2002).

All these features make chicory as an important forage crop for cut-and-carry system and especially grazing. Chicory shows wide range of distribution in the Turkey's natural flora that remarks its high adaptation capability to different ecological conditions and potential ecological diversity.

TAXONOMY and PLANT CHARACTERISTICS

Chicory (*Cichorium intybus* L.) is a cool-season perennial forb that belongs to the Asteraceae family, grouped into three subfamilies: *Asteroideae*, *Barnadesioideae* and *Cichorioideae*. There are about 32.000 different species subdivided into 1900 genera group. It originated in Europe, central Russia, western Asia and North Africa. It was introduced to temperate and dry zone of the other continents and regions (Figure 1).

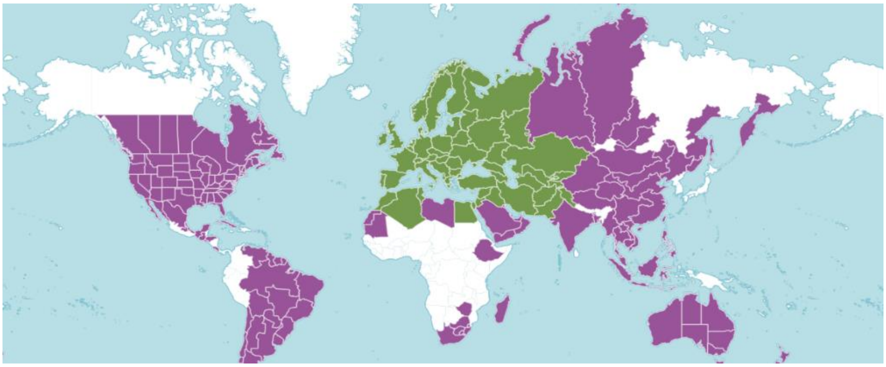

Figure 1. Distribution area of chicory (Green:Native; Purple:Introduced) (Anon, 1)

The genus *Cichorium* contains many subsections, but 2 of them (*C. intybus* and *C. endivia*) are economically valuable (Table 1). *C. intybus* and *C. endivia* are very similar to each other morphologically. *C. intybus* can be distinguished from *C. endivia* by being perennial and self-incompatible. *C. intybus* is the most common and diverse species of the *Cichorium* genus in the world (Kiers, 2000). There are mainly three subspecies of *C. intybus* namely *C. intybus* L. *var. foliosum* (Hegi) Bisch., *C. intybus* L. *var. silvestre* Bisch, and *C. intybus* L. *var. sativus* Bishoff (Das et al., 2016).

Table 1. Life-form and origin of some chicory species

Species	**Life-form**	**Origin**
Cichorium intybus L. var. *foliosum* (Hegi) Bisch var. *silvestre* Bisch var. *sativus* Bishoff.	Perennial	Europe, Middle and West Asia and North Africa
Cichorium endivia L.	Annual	Egypt and Indonesia
Cichorium pumilum Jacq.	Annual	Mediterranean
Cichorium spinosum L.	Perennial	Europe- Mediterranean
Cichorium calvum Sch.Bip. ex Aschers.	Annual	Mediterranean
Cichorium bottae Deflers	Perennial	Saudi Arabia, Yemen

Chicory is a perennial diploid with a chromosome number of 14. The plant performs root development in the first year and forms its stems, flowers and seeds in the second and following years (Figure 2). Phenological stages of chicory development; growing degree days (GDD) and days (D) respectively;1. Epigeal emergence (95 GDD-7 D), 2. 4-5 leaves (347 GDD-24 D), 3. 7-8 leaves (498 GDD-34 D), 4. 18-20 leaves (1149 GDD-67 D), 5. bud stage (1302 GDD-74 D), 6. 10% flowering (2160 GDD-113 D), 7. 50-60% flowering (2429 GDD-126 D), 8. full flowering stage (2729 GDD-140 D), 9. Dormancy (Rosette) (Autumn and winter) (Moghaddam et al., 2015).

Figure 2. The life cycle of chicory in the first 18 months after spring sowing (Anon, 3)

Root: Typically, the wild type of chicory taproot system grows to a dept of up to 20 cm long by 20 mm wide; side roots 2–5 mm thick (Reaume, 2010). The cultivated varieties of chicory have a single taproot over 100 cm and the effective root depth is 80-90 cm. This deep of root system, and perenniality of crowns that store carbohydrates as an energy reserve, make it very resistant, especially to droughts (Durham and Hancock, 2010).

a)  b) 

Figure 3. The root system of 2 types of chicory (a: wild; b:Cv. Puna II)

Stem: Chicory plants have a crown above the ground and stems grow from the crown to approximately 45-200 cm height by 5-18 mm wide, depending on genotype. Stems are empty inside (in the late generative stage) and hairy. It has an erect growing habit. Stems are four-cornered. Especially during the flowering period, the inside of the stem is soft and filled with whitish juice. In wild species, more than one stem from the crown is formed, whereas, in cultivated varieties, a single stem generally grows (Reaume, 2010; Anon, 2) (Figure 4).

a)

b)

Figure 4. Stem structure in chicory (a: wild; b: Cv. Commander)

Leaves: Chicory has two types of leaves as basal (large-dandelion-shaped) and stem (small lanceolate-to-oblong-shaped) leaves. Leaves have short surface, marginal hair. They have placed on the stem alternately. At the base, basal leaves range 7–40 cm long and 2–13 cm wide. It consists of a winged petiole from 1–3 cm long. The upper stem leaves consist of a pinnate petiole about 3–33 cm long and 0.9–11 cm wide. Midrib of leaves have rough hairy. While the edge of leaves in wild type chicory plants are deep toothed structure, leaves are fine-toothed or straight in cultivars (Reaume, 2010; Anon, 2) (Figure 5).

a)

b)

Figure 5. Leafe type of two chicory entries (a: wild; b: Cv. Commander)

Flower: Chicory flower is formed with generally blue or rarely pink and white ray florets. The flowers are attached to the stem with stemless or very short stems. Generally, flowers of chicory bloom throughout morning, and wither in the afternoon. Flowering occurs from down to tip, and an average of 0-30 flowers bloom per day. There are 5-6 pieces outer sepal and 8 pieces inner sepal in a flower. Petals consist of 11-21 pieces. Chicory has no disc florets; even though most Aster family species have them. The ovary is white, hairless, and flat. A flower has five and blue color stamens, and white pollens (Figure 6). Stigma has two branches, and they are curled. It takes 6-7 weeks for the flowers to turn into fruit. Fruits are loosely attached to the inner bracts

(Reaume, 2010; Anon, 2). The total number of flowers of the chicory is 227 flowers / plants. Pollination in flowers is largely (70%) provided by honeybees (Clapham et al., 2001).

Figure 6. Flower structure of chicory

Fruit: Chicory has achene type fruit, and each fruit contains 1 seed. The seed is 2.2–2.8 mm long, 1–1.5 mm wide, 0.7–1 mm thick, dark brown in color. At the point where it attaches to the petals, there are 28-45 imbricate scales (Reaume, 2010; Anon, 2). Thousand seed weight is 1.3-1.7 grams (Figure 7).

Figure 7. Fruit structure of chicory (Reaume, 2010)

Although chicory has been used in various ways for thousands of years, it has been classified as a forage plant in recent years. New varieties have been developed from wild types, which are widely distributed around the world. The 'Grasslands Puna' variety, which is preferred by ruminants, was first cultivated in New Zealand in 1985. The "Grasslands Puna" variety has some drawbacks like low persistence in the mixture, non-homogeneous leaf structure, and susceptibility to fungal diseases, especially *Sclerotinia* fungus. Thus, new breeding studies have been started (Rumball et al., 2003). Puna II variety was developed in 1997 as a result of new breeding studies. It is a variety with high winter activity, high levels of sesquiterpene lactones, lactucin, and lactucopicrin, which provides long-term grazing. Also, it has a uniform leaf structure and resistant to fungal diseases (*Sclerotinia* ssp.). Puna II has a high content of phenolic compounds (sesquiterpene lactones, lactucin, and lactucopicrin). However, these phenolic compounds lead to nasty odor and bad flavor of milk. Especially for dairy farming, Choice variety with lower phenolic content was developed in 2002. Some later developed chicory varieties have uniform leaf structures and show more erect growth than Puna but this reduced resistance to heavy grazing conditions. It is a good companion plant with *Brassicas* species. It has the ability to produce a high amount of stem. Chico variety is suitable for short-term production, and it has higher dry matter yield production than Puna in winter. However, in spring and summer, Puna shows higher performance to produce dry matter yield than Chico. Some varieties of chicory developed as forage crops are given in Table 2.

Table 2. Some forage chicory varieties and plant features

Varieyt Name	**Origin**	**Plant Features**	**Growing Period**
Grasslands Puna	New Zealand	It is resistant to grazing and has a wide adaptation capacity with tolerance to drought, diseases and pests.	Summer active
Puna II	New Zealand	Long longevity, uniform leaf structure, slow self-thinning, resistant to fungi (*Sclerotinia*), and recommended for cattle that are not milked.	Winter active
Choice	New Zealand	Contains a little amount of lactone (lactucin and lactone) that spoils the taste of milk.	Winter active
Grouse	New Zealand	It is a good companion plant with Brassicas species. It produces abundant stems. It is susceptible to the trampling effect.	Winter active
Chico	New Zealand	It is a short-lived variety. Suitable for one-year production.	Winter active
INIA Le Lacerta	Uruguay	It can tolerate high temperatures and drought stress. It is a short-lived variety.	Winter active
Forage Feast	France	It has a wide range of climate adaptation. It is winter hardy as well as drought tolerant. It has a palatable forage crop with low tannin content.	Summer active
Six Point	USA	It is grazing-resistant, has broad leaves, is resistant to many diseases, and provides a high level of forage in summer.	Summer active
Commander	Italy	It has high self-propagation ability, year-round development, drought tolerance, and erect growth habit.	Winter active

Lacerta, Forage Feast, and Six Point variants have been developed in the USA (Li and Kemp, 2005). "Lacerta" is a synthetic variety with erect growth habit. It is known that it produces twice as much as grass in winter than Puna, but its longevity is less than Puna. (Hayes et al., 2006). The Forage Feast variety was selected from the root type chicory varieties used for fructan production in France, and the low tannin content makes the plant more palatable. In addition to winter hardiness, it provides good forage production in summer. Six

Point variety is robust to grazing pressure, resistant to diseases, and provides a longer grazing period due to its ability of early growing habit in spring. Commander is an Australian variety originated from Italy. Although growing period is winter, it tends to grow throughout the year. It is tolerant to many fungal diseases. Thanks to the low growing buds, it is resistant to intensive grazing. It also has an erect growth habit with abundant leaves makes it suitable for grazing (Foster et al., 2009).

YIELD and NUTRITIVE VALUE

Chicory is classified high-quality forage plant with high palatability, digestibility, non-structural carbohydrates and rich in mineral substances. Also, its good drought-tolerance ability makes it a valuable forage plant especially warm-season period of a year. In addition to those, chicory helps to reduce bloat hazard and parasite formation in ruminants (Barry, 1998; Athanasiadou et al., 2007).

In addition to the use of chicory as grazing, hay and silage, its grains are also used for animal feeding. The most common use of chicory is pasture mixtures. In dry conditions, it produces forage with high nutritive value in rotational grazing systems (Ditsch and Sears, 2007). In the summer season, when many forage plants dry up or become dormant in the pastures, chicory provides high quality livestock herbage and extends grazing period (Kemp et al., 2002). These properties make the chicory a valuable forage plant for the Mediterranean climate zone. In these regions, it creates successful mixtures with white clover, red clover, birdsfoot trefoil, perennial ryegrass and cooksfood (Hume et al., 1995). The use of chicory in white clover and grass-dominated pastures increases the quality of animal products by meeting vitamin needs of livestock (Marley et al., 2003). In some studies, dry matter yields of pure stand and in mixtures of chicory are given in Table 3.

Table 3. Dry matter yield of some pure stand, simple and complex mixtures of chicory (t ha^{-1})

Experiment site	Growing system	Dry matter yield (t ha^{-1})		Resource
Pure stand				
		First year	Second year	
Rock Springs, ABD	Chicory	8.1	7.3	Sanderson et al. 2003
Prince Edward, Canada	Chicory	7.1	6.4	Kunelius and McRae, 1999
Palmerston North, NZ	Chicory	8.5	9.4	Li et al., 1997
Hamilton, New Zealand	Chicory	9.5	10.6	Lee et al., 2015
Sardinia, Italy	Chicory	3.0	4.1	Sitzia et al., 2006
simple mixture				
Tingvoll, Norway	R/C	3.4	-	Kıdane et al., 2014
West Virginia ABD	OG/C	6.2	5.8	Belesky et al., 1999
Samsun, Turkey	RCL/C	20.5	13.2	Can and Ayan, 2019
Samsun, Turkey	WCL/C	10.8	10.6	Can and Ayan, 2019
Samsun, Turkey	BFT/C	11.7	8.5	Can and Ayan, 2019
multi mixture				
Samsun, Turkey	RCL/OG/C	26.2	16.8	Can and Ayan, 2019
Prince Edward, Canada	WCL/MF/C/OG	6.6	7.4	Kunelius and McRae, 1999
Rådde, Sweden	T/RCL/WCL/MF/C	14.6	16.6	Lindström et al., 2014
Pennsylvania, ABD	OG/TF/A/RCL/BFT/C	10.3	-	Deak et al., 2007
Pennsylvania, ABD	OG/TF/R/RCL/BFT/C/WCL/A/B	5.8	3.2	Sanderson, 2010

C, chicory; R, perennial ryegrass; OG, orchardgrass; RCL, red clover WCL, white clover; BFT, birdsfoot trefoil; MF, meadow fescue; T, timoty; TF, tall fescue; A, alfalfa; B, bluegrass.

When taking a look at the pure stand chicory studies in Table 3, Sanderson et al. (2003), studied dry matter yield of Grasslands Puna chicory variety and reported 8.1 – 7.3 t ha^{-1} in a year in the USA.

Kunelius and McRae (1999) reported that chicory mixtures show persistence to harsh winter conditions and successfully forage production throughout the year (7.1-6.4 t ha^{-1}) in Canada. Li et al. (1997) determined high forage yields (8.5-9.4 t ha^{-1}) in two years, but the yield decreased depending on the low plant density in the following years. Lee et al. (2015), in their study on the cutting height of plantain and chicory in New Zealand, reported that if chicory is utilized for a long time, it should start grazing at the plant height of 250 mm. Sitzia et al. (2006) reported that chicory provided high forage production for sheep or goats as pure stand (3.0-4.1 t ha^{-1}) or in mixtures with alfalfa and orchardgrass in two years in the dry areas of Southern Italy (Figure 8).

When looking at the simple mixture of chicory studies in Table 3, Kidane et al. (2014) reported 3.4 t ha^{-1} dry matter yield from a simple mixture of chicory throughout the year. Researchers indicated that mixtures with chicory provide a certain mineral matter and nutrient balance that directly affects animal health and yield. They reported that also, chicory contributes to increasing the nutritional content in the grass mixtures. Chicory can be successfully grown with cool season forage crops. In mixtures, it replaces cool-season forage crops that become dormant, especially in summer, and provides pasture production throughout the season. Belesky et al. (1999) reported that 6.2-5.8 t ha^{-1} dry matter yields were obtained in chicory and orchardgrass mixtures throughout the year. Can and Ayan (2019) reported that dry matter (DM) yields (kg ha^{-1}) of the chicory pasture were 20.5 and 13.2 t ha^{-1}with a mixture of red clover, 10.8 and 10.6 t ha^{-1} with a mixture of white clover, and 11.7 and 8.5 t ha^{-1} with a mixture of birdsfood trefoil for two years. In a study conducted in similar ecology, the researcher use the Commander variety of chicory in a mixture determined the highest dry matter production (12.3 t ha^{-1}) in the mixture ratio of 40% Commander and 60% red clover (Öztürk, 2019). Chicory is a forage plant with high nutritive value, especially in summer. Besides, the high level of water-soluble carbohydrate and pectin and low structural carbohydrates are decent indicators of chicory's nutritive value. Therefore, it has a high metabolizable energy value. Chicory creates a good mixture with perennial ryegrass and red clover due to its growing period compatibility with both of them (Li and Kemp, 2005). Nevertheless, chicory should not exceed 50% of the dairy cattle diets. When dairy cattle feed with only chicory, the smell of milk changes (Figure 8).

When looking at the multi mixture of chicory studies in Table 3, Can and Ayan (2019) determined 26.2-16.8 t ha^{-1} dry matter production on the multi mixture pasture with 3 different species for two following years in Turkey. Also, they reported that the roots of chicory carry some nutrients to upper layer of soil from lower layers and companion legumes and grasses take advantage of this, therefore, increase the yield of the pasture. Besides, it has been reported that since the chicory produces plenty of leaves, it reduces the evapo-transpiration of the plants next to it, therefore, contributes to meet water demand (Skinner et al., 2004). Kunelius and McRae (1999) reported that 6.6-7.4 t ha^{-1} dry matter yield was taken on the multi mixture pasture with 4 different species in two years. The use of chicory in the mixtures contributed to the balanced seasonal distribution of the yield and also provided pasture production in the dry late season. Lindström et al. (2014) determined 14.6-16.6 t ha^{-1} dry matter yield on the multi-mixture pasture with 5 different species in the first two years. Also, they indicated that the ratio of chicory in botanical composition remained below 10% due to poor soil conditions. Deak et al. (2007) determined 10.3 t ha^{-1} dry matter yield as the average of three years in the mixture of 6 species. However, while the ratio of chicory in the mixture was 10% in the establishment year, it decreased by 0.1% at the end of the third year. In another study, 5.8-3.2 t ha^{-1} dry matter yield was determined on the multi mixture pasture with 9 different species. Although chicory was 20% in the mixture in the first year, its ratio in the mixture decreased in the second year as legumes became dominant. Also, the inclusion of chicory in the mixture provides more dry matter production in spring, summer, and autumn (Sanderson, 2010) (Figure 8).

Chicory is a high nutritive value forage crop. Crude protein ratio varies according to plant species, plant parts, growing period and climatic conditions. Generally, legumes have higher crude protein than grasses, leaves also have more crude protein than the stem. The plants that is early growing stage has a higher ratio of crude protein than the late development stage and spring cuttings compared to summer cuttings. Chicory has lower crude protein than legumes but higher than forage grasses (Table 4).

Figure 8. Chicory field pictures as pure stands and mixtures

Hayes et al., (2010) determined the highest crude protein level in alfalfa and chicory, %22.3 and %19.9 respectively among different forage species in Australia. In a study conducted with legumes, grasses, and chicory, it was determined that the crude protein ratio of chicory was lower than legumes but higher than grasses (Can and Ayan, 2019). As in other species, the crude protein ratio decreases with increasing the ratio of stem/leaf and maturity level (Jung et al., 1996). Another factor affecting the crude protein ratio is climate. Hayes et al. (2010) found the highest crude protein ratio in chicory in spring and winter, while the lowest in summer. The ADF and NDF ratio of chicory is proximate to legumes but lower than grasses (Table 4). According to the American Forage and Grassland Council (AFGC, 2015), chicory and legumes are in the very good or good class in terms of ADF and NDF (Can and Ayan, 2019). However, the low levels of ADF and NDF in chicory may cause some problems in the digestive system of ruminants (Belesky et al., 2001). In addition to chicory, grass and legume forage crops must be added to the daily ration of ruminants. In New Zealand, Barry (1998), compared chicory to the perennial ryegrass and red clover. He concluded that chicory is especially superior in Ca, ash, and soluble sugars, and is also preferable for cellulose and hemicellulose levels.

Table 4. Crude protein, ADF, NDF, macro and micro mineral contents of chicory and some forage crops

%	Chicory	Plantain	Alfalfa	White clover	Red clover	Cocksfoot	Ryegrass
Crude protein	23.4	22.9	24.5	26.2	24.6	16.6	17.7
ADF	27.6	24.3	27.7	24.7	30.3	33.4	29.4
NDF	37.9	36.1	34.7	34.1	43.1	55.9	47.8
Macro-minerals (g kg $^{-1}$)							
Ca	14.0	15.7	17.3	19.4	16.5	3.8	4.2
P	4.7	3.8	2.6	3.0	2.5	3.4	3.7
Mg	3.2	2.8	2.7	3.1	3.8	1.9	1.7
K	40.7	30.0	21.2	27.6	22.6	31.7	38
Na	3.9	0.6	1.0	2.0	0.5	0.3	1.8
S	3.7	3.7	2.4	2.1	1.7	-	3.4
Micro-minerals (mg kg $^{-1}$)							
Zn	37.5	30.8	24.0	25.9	25.7	21	22
Cu	9.3	8.2	6.6	7.8	9.2	6	7.9
Mn	76.8	33.3	45.6	84.0	60.1	111	99
Fe	79.5	63.5	66.5	93.9	62.2	85	151
Mo	0.8	0.4	0.9	0.9	0.8	-	0.6

(Pirhofer-Walzl et al., 2011; Can and Ayan, 2019; Jung et al., 1996; Harrington et al., 2006; Hayes et al., 2010)

Macro (N, P, K, Ca, Mg and S) and micro (Fe, Mn, Cu, Mo, Zn, B, Cl and Ni) minerals are vital for normal functioning of nerve and muscle functions, bone and tooth development, growth, development, reproduction, regulation of digestive activities and cell osmotic pressure. They are also key to the process of establishing neutral pH in tissues, becoming the building blocks of proteins or converting nutrients into useful forms for livestock. Ca and P account for about 70% of the mineral content of the animal body (Kutlu and Çelik, 2005). Therefore, deficit or excessive consumption of these minerals causes serious health problems and may have harmful or toxic effects. In general, the macro and micro mineral content of chicory are higher than grasses and legumes if we ignore a few exceptions (Table 4). It is reported that the mineral content of chicory meets or exceeds dairy and beef cattle demands (Belesky et al., 2001). Especially in early spring, the inclusion of chicory in grass mixtures reduces the risk of tetany (Jung et al., 1996). When the legume + grass + chicory mixtures compared to monoculture diets, most of the mineral substances needed by the livestocks are met (Pirhofer-Walzl et al., 2011). Schmidt et al. (2013) examined the chemical composition of 5 different forage crops and determined that the crude protein and α-tocopherol, magnesium, phosphorus, calcium and micronutrient content of chicory were higher than other forage crops.

Although chicory contains a certain amount of tannins, it is not at a level that slows the digestion of proteins in the rumen. Concordantly, Scharenberg et al. (2007) determined the tannin content of fresh herbage was 86.8 g / kg for sainfoin, 28.0 g / kg for birdsfoot trefoil, and 11.1 g / kg for chicory. Kälber et al. (2014) reported that the total tannin content of chicory was 8.69 g / kg in the vegetative period and 6.95 g / kg in the generative period. Moreover, they determined that it did not contain condensed tannins but only hydrolyzable tannins.

When chicory is included in mixtures, it reduces the risk of bloating thanks to the tannin it contains. Bloating is mostly caused by ruminally degraded proteins forming a permanent foam layer in the rumen. The digestion of the chicory plant in the rumen is fast. Thus, ruminally degraded proteins stay less in the rumen, hence the rumen pH and the foaming decreases. All parts of a chicory plant contain tannins. Shad et al. (2013) in their study with chicory plants collected from natural flora of Pakistan, determined the tannin content was 1.51 g / 100 g in the root, 1.32 g / 100 g in the stem, 0.89 g / 100 g in the seed and 0.66 g / 100 g in the leaf. Besides tannins, chicory contains some secondary compounds such as sesquiterpene, lactones (lactucin, lactupicrib, 8-deoxylactucin), chicoriin (a type of coumarin) and chicoric acid (derivative of caffeic acid) (Barry, 1998). These compounds cause the herbage to have a slightly bitter taste and the color of the milk to change. The proportion of these secondary compounds has been reduced in recently developed varieties. The problem of internal parasite formation in sheep grazing on chicory pastures is lower than that of sheep grazing on grass pastures thanks to secondary compounds chicory has. There are fewer nematode eggs and larvae on chicory plants than grasses. In addition, the erect growth habit of the chicory and less contact with the soil is also a factor in this less nematode formation. Marley et al. (2003) in a study conducted in England (Aberystwyth); the parasite intensity in lambs and sheep grazing in a mixture of chicory, birdsfoot trefoil, and perennial ryegrass + white clover was determined. They reported that the amount of parasites found in the intestines of lambs and sheep was 7.1 - 10.8 g / 100 g in grazing chicory pastures, and 17.9 - 18.3 g / 100 g in grazing perennial ryegrass + white clover mixture.

CULTIVATION and MANAGEMENT

The most suitable soil properties for chicory cultivation are medium to high fertility and well-drained soils. If chicory is grown in low fertile soils, it needs substantial fertilizer supplements for sustainability and high yield (Belesky et al., 2001). The optimum soil pH for chicory is 5.6-6.0, but it can tolerate a wide range of pH (4.5-8.3) (Crush and Evans, 1990). Lime must be applied while chicory is grown in acidic soil conditions. In a study conducted in Australia, it was determined that chicory is more tolerant to acidic soil conditions than alfalfa and stated that chicory can easily be used in areas where alfalfa cultivation is restricted due to high pH (Moloney, 1992). Salinity is another limiting factor in agricultural landscapes. The seed germination rate of chicory is over 90%. Sergio et al. (2012) reported that the percentage of seed germination of chicory decreased approximately 10% at a 140 mM NaCl concentration and approximately 40% at a 200 mM NaCl concentration. It has been reported that wild chicory has a high capacity in activating protective mechanisms against oxidative damage caused by salt stress in both roots and leaves (Sergio et al., 2012). Chicory grows successfully in regions with annual precipitation of 300-400 mm and an average temperature of 6-27 ° C (Moloney and Milne, 1993). Since it is a cool-season forage plant, it tolerates summer heat moderately and should be irrigated for high yields in arid conditions (Tan and Temel, 2012). It was reported that chicory was the only forage species that produces a sufficient amount of herbage during the summer drought in Australia in 1990-1991 (Kemp et al., 2002)**.** Chicory was the only forage crop that grown in the drought summer condition of 2017 in the Central Black Sea Region of Turkey (Figure 9). Also, chicory can survive for several weeks at low temperatures (up to -7 ° C) thanks to its high taproot storage ability (Neefs et al., 2000; Skinner and Gustine, 2002).

Figure 9. The development of chicory in drought conditions

Chicory has small size seeds (Hare et al., 1990). Therefore, good soil preparation and optimum planting depth are very important to get seedling emergence and weed control. The optimum seed rate is 5-10 kg ha^{-1} in pure stand, 1.5-3 kg ha^{-1} in mixtures and the sowing depth is suggested to be 0.75 - 1.5 cm in chicory pastures (Ditsch and Sears, 2007). It has been reported that the row spacing of 30 cm is appropriate especially for weed control (Hare et al., 1990). From cultivation, roller and air drills are the most accurate (Moloney and Milne, 1993). Chicory can be seeded in autumn or spring. If chicory is planted in autumn, it vernalization demand is met and transition to generative period accelerates as the temperature increases, so, grazing interval periods should be adjusted well for autumn planted chicory. Spring planted chicory does not transform to generative period in the same year, so it can be grazed at longer intervals.

To get a high yield from chicory, it is necessary to supply the missing plant nutrients to the soil. Moloney and Milne (1993) reported that Grasslands Puna needs 20-30 mg kg^{-1} of phosphorus, more than 8 mg kg^{-1} of potassium, and more than 10 mg kg^{-1} of sulfur for optimum growth. The need of phosphorus, potassium, sulfur, and nitrogen for high-quality herbage is essential especially during the seedling period. Nitrogen fertilizer rate and application time should be adjusted well due to its ability of the high volume of vegetation on the landscape (Rowarth et al., 1996). As the need for fertilizer, 35-40 kg ha^{-1} of N, 25-40 kg ha^{-1} of P and K, and 20-30 kg ha^{-1} of S fertilizers should be applied in early spring. Also, a second nitrogen fertilizer application should be made at the beginning of summer at 20-25 kg ha^{-1} of N, and a third nitrogen fertilizer application can be made in regions with good autumn growth (Moloney and Milne, 1993; Upjohn et al., 2002).

Chicory is a perennial short-lived plant (3-4 years) and it is highly productive for up to 4 years in grazing conditions. It can provide quality forage for 4 years in the summer-autumn period with a well-adjusted rotational grazing system (Tan and Temel, 2012). Chicory is generally recommended in mixtures with legumes. Although chicory can survive for a long time (4 years or more) under a well-adjusted rotational grazing system, it disappears from vegetation in a short time (2-3 years) under heavy grazing conditions. Puna chicory can tolerate intensive grazing. It is recommended that grazing should be below 10 cm in height at three-week intervals in spring, and below 15 cm at five-week intervals after mid-summer to maximizes the leaf formation and minimizes stem development of chicory (Hare et al., 1990). The most important problem in chicory pastures is reduction of plant numbers. When the number of plants in a chicory pasture falls below 25 plants per square meter, the pasture is considered to have completed its productive life. Li et al. (1997) determined the number of plants per square meter in chicory pasture as 66 in the first year and 24 at the end of four years. For preventing of rapid self-thinning, grazing should not be done in rainy and winter periods (Tan and Temel, 2012). Another factor affecting the rapid self-tinning is grazing height. In a study conducted on the grazing height of chicory, the lowest stem ratio was determined when chicory plants grazed they reached a height of 150 - 250 mm, and the highest dry matter yield at 350 - 550 mm height. It has been reported that the most suitable grazing height is 250 mm in terms of persistence of pasture stand, yield, and quality of chicory (Lee et al., 2015).

Chicory can be utilized as hay or silage in case the plants bolting due to delay of grazing or the last grazing coincides with winter rains. Moghaddam et al. (2015) conducted a study to determine the effect of different harvest periods (10% flowering, 50-60% flowering, and full flowering stage) and plant density (10, 20, and 40 plants m^{-2}) on dry matter production of chicory. It has been determined that the yield increases with the increase in the number of plants per unit area (1.2, 1.3, and 1.5 t ha^{-1}) and the most suitable harvest period is 50-60% flowering (1.5 t ha^{-1}). The same researchers reported that 5.9 t ha^{-1} in the first and 2.4 t ha^{-1} hay yields in the second cutting were obtained in chicory pasture when organic and chemical fertilizers were used during the 50-60% flowering stage (Moghaddam et al., 2013). Can and Ayan (2020), in a study conducted in Turkey with chicory and some forage crops mixtures, determined dry matter yield of 7.0 t ha^{-1} and 2.9 t ha^{-1} from the pure stand chicory pasture, 25.6 t ha^{-1}and 14.6 t ha^{-1} from the mixture of red clover + orchardgrass + chicory pastures in the bud stage in two following years. Öztürk et al. (2006), in their study on the nutritive value of chicory, the crude protein ratio was determined as 11.23 - 8.56%, ADF ratio as 35.37 - 40.57%, and NDF ratio as 44.09 - 47.00% in flowering and seed binding stage, respectively. A study conducted that chicory had 10.5% crude protein, 41% ADF, and 47.8% NDF at the flowering stage (Yılmaz et al., 2015). In a study with genotypes collected from Turkey, total plant dry matter production (167.80 to 564.60 g plant^{-1}), crude protein ratio (11.85 to 16.60%), potassium (2.022 to 2.442%), phosphorus (0.367 to 0.413%), calcium (0.963 to 1.232%) and magnesium (0.250 to 0.407%) contents were determined (Başaran et al., 2019).

PROCESS TO SILAGE

Stevens et al. (1993) determined the crude protein ratio of 12.6 and 17.1%, the dry matter digestibility rate of 73.7-72.9% for chicory and hybridryegrass (*Lolium perenne* L. x *Lolium multijlorum* L.) mixture silages in two following years. Also, it has been reported that the silage quality of chicory was better than timothy + red clover and pure stand hybridryegrass. Kälber et al. (2012) conducted a study on chicory + perennial ryegrass, buckwheat + perennial ryegrass mixtures and pure stand ryegrass silages and determined crude protein ratio (17.9, 13.5 and 15.6%), ADF ratio (29.6, 44.5 and 33.4%), NDF ratio (35.9, 53.8 and 51.5%), pH value (5.3, 4.7 and 4.9), lactic acid ratio (4.89, 3.42 and 7.63%), acetic acid ratio (5.66, 0.87 and 2.69), and ammonia ratio (0.69, 0.16 and 0.49%), respectively. In addition to this they reported that although chicory silage has a high crude protein ratio and low fiber content, parameters that deteriorate the silage quality such as pH, acetic acid, and ammonia should be improved. Scharenberg et al. (2007) compared the fresh, dry herbage, and the silage of chicory, birdsfoot trefoil, and sainfoin for tannin content. The tannin content of chicory was 1.11% in fresh herbage, 1.31% in dry herbage, and 1.14% in silage, and it was reported that the tannin content was lower compared to other plants. Kälber et al. (2013) determined that the total phenol content of chicory + perennial ryegrass, buckwheat + perennial ryegrass, and pure stand perennial ryegrass by silage was 0.74, 1.02, and 0.89%, and the total tannin content was 0.43, 0.72, and 0.53%, respectively. It has also been reported that the silage of buckwheat and chicory mixture has the potential to reduce the phenolic acid compound and tannin content, improve the transfer of fatty acids from feed to milk and contribute to the cheese-making process. In the silage study of chicory with white clover and orchardgrass mixtures, it was determined that the quality class of the silage is good quality or very good quality. The lactic acid ratio of the silages should be above 2%, the acetic acid ratio should be below the critical level of 0.8%, and the butyric acid ratio should be at very low levels (Woolford, 1984). They reported that the lactic acid, acetic and butyric acid values of chicory silage varied between 1.852-0.088%, 0.048-0.224%, and 0.002-0.015%, respectively in two following years, and thus chicory in mixtures could be successfully processed to silage (Can et al., 2020a). In a study in which the silage quality of chicory and some forage plant mixtures, it was determined the crude protein, ADF and NDF ratios of silages were 11.82% -19.22%, 19.27-34.15% and 25.29-57.64% in two years, respectively. Moreover, it was reported that the most suitable silage is 40% chicory + 30% perennial ryegrass + 30% white clover considering the quality and mineral content of the silages (Can et al., 2020b).

OTHER BENEFITS

The plant parts of the chicory have been utilized in many different ways throughout history. Its roots has been used as a coffee components and leaves as a green salad component, alongside recently used as a pasture crop in mixtures for livestock feeding. However, there is little information on chicory seeds. Ying and Gui (2012), determined that the seed of Puna and Commander chicory varieties contain significant amounts of crude ash (6.80 - 6.91%), crude protein 19.20 - 19.57%, crude fat (22.56 - 22.89%), and carbohydrates (31.66 - 34.72%). They reported that the crude ash and crude protein contents of chicory were twice as high as corn seed, and the crude fat content was significantly higher compared to alfalfa seeds. They determined that chicory seeds are rich in essential amino acids and total amino acid content is higher than alfalfa seeds. Also, it was reported that chicory seeds have higher macro/micro elements compared to alfalfa (except sodium and iron). Researchers have stated that chicory seed can be included in human and animal diets because of its high nutrient content.

CONCLUSION

Historically, chicory has a wide distribution in the world, goes back to ancient Egypt. Although chicory has been used as vegetables, coffee, and some illness cure for many years, its use as a forage plant has a relatively recent history. In addition to being widely used in pasture mixtures, chicory is also used as hay and silage in livestock production systems. Chicory is classified high-quality forage plant with high palatability, digestibility, non-structural carbohydrates and rich in mineral substances. Also, its good drought-tolerance ability makes it a valuable forage plant especially in warm-season period of a year. In addition to those, chicory helps to reduce bloat hazard and internal parasite formation in ruminants. Chicory extends the grazing period in pasture thanks to its high-ability to grow especially in the warm summer season.

Chicory produces plenty of good quality ruminant livestock feed during dry seasons thanks to its deep taproot. Chicory extends the grazing period in a pasture in the warm summer season when other grasses and legumes mainly dormant form at that time. It increases the quality of the mixture in the spring and summer season when chicory is used in grass and legume mixtures. It has positive effects on the weight gain of livestock. Chicory does not cause bloat hazard in ruminant livestock thanks to its tannin content. In addition to these, the containing of phenolic compounds protects harmful effects of internal parasite formation. These compounds cause the herbage to have a slightly bitter taste and the color of the milk to change. The proportion of these secondary compounds has been reduced in recently developed varieties. The efficiency and sustainability of chicory plants can be increased with proper management in the pasture. In chicory pastures, nitrogen application rate, number of cutting, time of grazing, and frequency should be well adjusted. Chicory tolerates heavy grazing, but it can cause rapid self-thinning from the pasture. Chicory should be grazed when the plant reaches 20-25 cm height at a residual of 5-7 cm stubble for a high quality of yield. The grazing frequency of the chicory should be done at three-week intervals in spring and at five-week intervals in summer and autumn as well as avoiding grazing in winter extends sustainability of chicory.

In conclusion, it is predicted that the temperature will increase due to global warming and the water resources will gradually decrease. The development of new varieties such as chicory suitable for changing conditions and/or the improvement of existing varieties and popularizing these varieties in production areas is seen as a good scenario.

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CHAPTER 4

THE EFFECTS OF THE TYPE AND HARVEST SEASONS OF ANNUAL FORAGE LEGUMES ON THE SPECIFIC CHARACTERISTICS RELATED TO FORAGE QUALITY

INTRODUCTION

A vast portion of the pasture surveys conducted in the southeastern Anatolia region are under the conditions of a weak pasture (Seydosoglu and Kökten, 2018; Seydosoglu et al., 2018; Seydosoglu et al., 2019). In Turkey, a significant ratio of animal feeding needs is composed of meadow pasture lands, agricultural crop waste, post-harvest husks, and hays and similar low-quality feeds. The truth is, in feed procurement, the fastest effective and prolific system is growing forage crops within field agriculture (Karaköse, 2018). Due to their physiology, ruminants need forage and consume forage since the feed allows digestive operations such as the pH optimization of paunch, movement of microorganism, rumination, and saliva secretion to continue healthy functioning (Adiyaman, 2014).

Currently, the required feed costs for animals makes up approximately 70% of all costs related to animal production. In order to develop a cost-effective husbandry, it is urgent that pasture lands be improved and forage production lands be increased within field agriculture. With respect to quality, to meet the forage needed for a balanced and sufficient diet for the rising quantity of animals, it is necessary to enhance forage lands and their fertility (Kusvuran et al., 2011).

The dietary habits of humans vary depending on their development level. It has been reported that, in developed states like the USA, the annual per person meat consumption is 36 kg, 18 kg in the EU, and 15 kg in Turkey (Anonymous, 2017). The main objective in meat production is to escalate current production levels while lowering the cost. Nonetheless, in the procurement of forage that plays a critical role in animal feeding, there are potential problems that could result in negative effects on animal production and product prices. Forage resources are feed crops grown in natural meadow and pastures as well as in field agriculture. Misuse, heavy grazing, and many other causes lead to the gradual decrease of fertility in our meadow pasture lands, thereby resulting in a deficit in high-quality forage and thus unfulfilled needs (Senturk, 2019).

As a result of the prevalent arid climate in Turkey, meadows and pastures are the land types that exhibit average and low quality features, and, since annual precipitation fails to meet expected levels, they can, in general, be utilized as sheep prairies (Cinar, 2012).

Although an increase was witnessed in irrigable farming areas after the opening of state lands in the southeastern Anatolia region to farming, there has been an increase in the cultivation of plants such as cotton and corn that absorb excessive ratios of nutrients from the soil in the farming lands of our region. In the cultivation of such plants, soil salinity, alkalinity, and organic substance deficiencies are potential adversities caused by employing incorrect irrigation techniques and excessive fertilization. To overcome these adversities, it is suggested that crop rotation systems be applied that comply with farming winter by-products for ecological conditions; hence, by cultivating annual forage legumes, in addition to forage production, the physical, chemical, and biological features of the soil can be improved, and thus the practice of sustainable farming can be viable (Tuncer, 2012).

In forage crops, quality is determined by a range of factors including the ripening season of the plant, the type of plant, the harvest, storage, climate and soil conditions. Among these factors, ripening (the harvest season) is the first main feature to affect quality (Rebole et al., 2004; Caballero et al., 1996). In order to increase lands for forage production, it is suggested that the current potential for alternative forage that can fit with regional ecologies should be determined.

In order to enable the healthy nutrition of current animals in the region, it is critical to improve the farming of forage in the southeastern Anatolia region, which exhibits a favorable ecology for cultivating all types of forage crops (Sayar et al., 2010). Today, in this region, the total forage production obtained by forage cultivation and the natural meadow pasture lands can barely meet the needs of 33.39% of the current animal population. In order to enable the healthy nutrition of current animals in the region, it is critical to improve the farming of forage in the southeastern Anatolia region which exhibits a favorable ecology for cultivating all types of forage crops (Sayar et al., 2010).

In order to minimize the potential cultivation risks in regions with harsh winter conditions, it is suggested that Hungarian vetch (*Vicia pannonica* Crantz.) be planted, which is resistant to winter conditions (Tas et al., 2007). Particularly in summer cultivation, there is a significantly low level of yield in dry seasons. On that account, in the modern age when droughts caused by global warming is a hot issue, Hungarian vetch is more resistant compared to other forage crops when planted in the winter season.

The vetch (*Vicia sativa* L.) plant that is used for its weed and seeds alike is a forage crop with a short vegetation period and can be cultivated in any type of soil and climate conditions, and, if offered to animals as a green weed, it causes no digestive issues. Vetch seeds with their protein content above 20% are also given to animals as a concentrate feed. In addition, for seed yield, the residual hay left from harvested plants is good animal forage (Acikgoz, 2001).

Forage peas (*Pisum sativum* L.) are annual forage legumes with a high nutritional value and taste. Its seeds also contain high ratios of crude protein (20-30%). Once broken, it can be mixed with forage, and over all of Europe, seeds of this type are used as protein feed in the forage industry. In the dry weeds of forage peas planted in favorable seasons, the ratio of crude protein is around 20%. As a forage crop, forage peas may be used green, as dry weeds, and as seeds can simultaneously be of benefit as a pasture plant and as a green manure crop (Ozkaynak 1980, Acikgoz 2001).

In this study, the aim was to analyze forage peas, Hungarian vetch, and common vetch, vital annual forage legumes for animals under the ecological conditions of Sanliurfa, with respect to their weed yield and quality in varied harvest seasons.

MATERIAL and METHODS

Conducted under the ecological conditions of the Harran lowlands near the city of Şanliurfa in 2018 during the second week of October in three repetitions, the main parcels were detected to form the annual different legume types while the lower parcels were designated to form harvest seasons according to a split parcels experimental design of randomized blocks. Obtained from Agricultural Credit Cooperative, in this research, a common vetch (Selçuk 99) form, 12 kg da^{-1}, of Hungarian vetch (*V. pannonica*) form, and a forage peas (Gölyazı) form in 8 kg da^{-1}, was manually planted in 30 cm rows during the second week of November. In my experiment, 4 kg da^{-1}, N, 10 kg P_2O_5 kg da^{-1}, were administered as the standard (Serin and Tan, 2001a).

Soil and Climatic Features of the Experiment Site

The soil composition in the experiment site was clay, and the total saline was measured as 0.098%, pH medium alkali as 7.70%, medium calcic as 5.4%, organic matter as low 1.23%, available phosphor (P_2O_5) in 3.60 kg da^{-1}, and potassium (K_2O) in 9.30 kg da^{-1}

Table 1. Vegetation period in Şanliurfa and climate data for long years (Anonymous, 2018-2019)*

Years	October	November	December	January	February	March	April	May
			Mean temp. (^{0}C)					
2018-19	21.6	13.0	8.6	6.1	8.3	10.7	14.4	25.2
Long years**	20.5	13.0	7.5	5.5	7.0	10.8	16.1	22.1
			Mean relative humidity (%)					
2018-19	45.6	72.5	84.9	76.4	71.7	69.5	67.0	35.8
Long years**	46.4	59.9	69.9	70.3	66.9	60.4	56.2	44.9
			Sum of precipitation(mm)					
2018-19	39.4	106.6	259.2	113.8	83.8	156.7	97.4	7.3
Long years**	4.6	26.5	44.6	87.6	69.5	62.8	49.8	26.7

* Sanliurfa Meteorology Directorate Climate Data **) Climate data for many years

As can be seen in Chart 1, during the period in which the experiment was conducted, a minimum mean temperature, 6.1 ºC, was recorded in January whilst a maximum mean temperature, 25.2 ºC, was recorded in May. With respect to mean relative humidity data related to the November-April months, obtained values exceeded long-term mean values. In regard to total precipitation, they scored much higher than the long-term mean values throughout the vegetation.

In the second week of October, the research was organized according to an experimental design of split parcels in randomized blocks and was set in three repetitions. In this experiment, the main parcels were formed with varied types of annual legume forages and lower parcels by harvest seasons. The total parcel number was 27, and the area of every single parcel was computed as 6m x 2.4m=14.4 m^2. In this research, common vetch and Hungarian vetch were planted as 12 kg da^{-1}, within 30 cm rows, and forage peas were planted in 8 kg da^{-1}, within 30 cm rows. Standard use in our experiment was 4 kg da^{-1}, N nitrogen and 10 kg da^{-1}, P_2O_5 phosphorous (Serin and Tan, 2001a). Throughout the cultivation process, irrigation, weeding and other required maintenance procedures were performed on the farm. After cutting out each parcel's first and last row and 50 cm-parts of the first and last lines as a side effect, the remaining site was designated as harvest territory 5m x 0.6m = 3m^2, and observations and measurements on their characteristics were performed in the site.

The first harvest season took place during a 50% flowering period season of forage peas on April 2 and Hungarian vetch and common vetch on April 15. The second harvest period for forage peas took place on April 29 when the low peas began to blossom while the harvest of Hungarian vetch and common vetch were conducted on May 2. For the forage peas, the third harvest season took place during the filling period of low peas on May 22 and on May 24 for the Hungarian vetch and common vetch.

In the experiment, the main stem length (cm), main stem thickness (cm), main stem number (piece), green weed and dry weed yields (kg da^{-1}), crude protein ratio (%), ADF (%) and NDF (%) values, the digestible dry matter ratio (DDMR) (%) and the relative feed value (RFY) were measured. Data obtained at the end of the research were used in JMP 11 statistical software to measure their variance analyses, and statistically significant mean scores were then grouped according to the Tukey (5%) multiple comparison test.

RESEARCH FINDINGS and DISCUSSION

Main Stem Length (cm)

It may be seen in Table 2 that, under the prevalent conditions in Sanliurfa, the detected character of the main stem length was as follows: in legume types, a 0.05 level of statistically significant difference; in harvest season, a 0.01 level of statistically significant difference; and in the interaction between legume x harvest seasons, a 0.05 level of statistically significant difference were detected. In terms of legumes, the mean main stem length was 163.23 cm, and, in terms of the Gölyazı form of the forage peas type based on harvest seasons, the low peas formation was measured as 161.70 cm. In terms of the legume x harvest season interaction, as for the Gölyazı form of forage peas, low peas formation, and during low peas filling season, they were computed to be higher, 184.93-185.70 cm. Relevant studies posited these findings: Yilmaz et al. (1996) in their Hatay-based study measured 91.56 cm for Hungarian vetch; Yucel et al. (2008) in their Cukurova-based study measured (97.8-122.3) cm; and Anlarsal et al. (1999) in their Cukurova-based study measured 76-106 cm. With respect to forage pea types, Seydosoglu (2013) in a Diyarbakır-based study measured 52.1-87.9 cm. The reason different findings in the literature may be related to climatic features and genotype variances in the research site.

Table 2. Main stem length (cm) and main stem thickness (mm) values and formed groups among different types of annual forage legumes and harvest seasons +

LEGUMES	**HARVEST SEASONS**				**HARVEST SEASONS**			
	Main stem length (cm)				Main stem thickness (mm)			
	50% Flowering	Low peas format-ion	Low peas filling	Mean	50% Flowering	Low peas format-ion	Low peas filling	Mean
Hungarian vetch (*V. pannonica* Crantz)	110.47**ef**	125.77 **cdef**	145.03 **cd**	127.09**b**	2.57	2.60	2.47	2.55 **b**
Common vetch (Selçuk 99)	101.33 **f**	139.67 **cde**	155.13 **bc**	132.04 **ab**	2.20	2.50	2.30	2.33 **b**
Forage peas (Gölyazı)	119.07 **def**	185.70 **a**	184.93 **ab**	163.23 **a**	3.60	2.57	2.47	2.88 **a**
Mean	110.29 **b**	150.38 **a**	161.70 **a**		2.79 **a**	2.56 **b**	2.41 **b**	
D.K. (%)	6.98				8.76			
Tukey (5%)								
Legumes			34.11*		Legumes			0.29*
Harvest seasons			12.36**		Harvest seasons			0.23*
Legumes x harvest seasons			29.88*		Legumes x harvest seasons			N.S.

+) Mean scores indicated by an identical letter group in the same column are, according to Tukey (5%), not different. +) *) 5% significance level, **) 1% significance level, N.S. statistically the difference is not significant.

Main Stem Thickness (mm)

Particularly in forage crops like forage peas, having a high main stem thickness, it is argued that when the drying period of the weed lags, plant quality could lower; hence, it is suggested that plants having a thin main stem thickness should be chosen. However, this preference leads to an effect that lowers the lodging of plants. With respect to main stem thickness, the character legume types and, with respect to harvest seasons, the statistical significance level was measured as 5%. The legumes x harvest seasons interaction, on the other hand, was determined to be statistically insignificant. Regarding the mean scores of the legume types, the maximum main stem thickness was measured in the Gölyazı form of forage peas by 2.88 cm, the minimum value was measured in Hungarian vetch's (*V. pannonica* Crantz) form by 2.55, and the minimum value was measured in the Selçuk 99 type of common vetch as 2.33 mm (Table 2). With respect to harvest seasons, the maximum mean main stem thickness was measured at 2.79 mm and 50% flowering, and the minimum mean values were respectively measured in low peas formation by 2.56 mm and by 2.41 mm during low peas filling season. In this study, the values obtained for the main stem thickness of forage peas were reported as follows: Bagci (2010) measured 2.07-2.27 mm in Ankara; with respect to local common vetch, Van de Wouw et al. (2003) measured 1.80-3.80 mm, and Unverdi (2007) measured 2.43-2.83 mm in Adana. In our research, the findings relevant to main stem thickness are compatible with findings of other scholars.

Table 3. Main stem number (piece) and green forage yield (kg da^{-1}) values and formed groups among different types of annual forage legumes and harvest seasons+

LEGUMES	HARVEST SEASONS				HARVEST SEASONS			
	Main stem number (piece)				Green forage yield (kg da^{-1})			
	50% Flowering	Low peas forma-tion	Low peas filling	Mean	50% Flowering	Low peas forma-tion	Low peas filling	Mean
Hungarian vetch (*V. pannonica* Crantz)	2.73	2.67	2.20	2.53 **a**	1681.89	1484.99	1070.39	1412.42 **b**
Common vetch (Selçuk 99)	3.03	2.97	2.13	2.71 **a**	1841.55	1551.89	1154.89	1516.11 **b**
Forage peas (Gölyazı)	1.83	2.33	1.80	1.99 **b**	2297.11	2173.00	1555.84	2008.65 **a**
Mean	2.53 **a**	2.66 **a**	2.04 **b**		1940.18 **a**	1736.66 **b**	1260.37 **c**	
D.K. (%)	10.77				11.32			
Tukey (5%)								
Legumes				0.39*	Legumes			202.51*
Harvest seasons				0.27*	Harvest seasons			191.33**
Legumes x harvest seasons				N.S.	Legumes x Harvest seasons			N.S.

+) Mean scores indicated by identical letter group in the same column are, according to Tukey (5%), not different. +) *) 5% significance level, **) 1% significance level, N.S. statistically the difference is not significant

Main Stem Number (Piece)

With respect to main stem number character, the statistical significance level of legume types and harvest seasons was measured as 5% while the legumes x harvest seasons interaction was measured as statistically insignificant. In terms of the main stem number of legume types, the maximum mean scores were observed in the Selçuk 99 form of common vetch and the (*V. pannonica* Crantz) form of Hungarian vetch by 2.53-2.71 piece s, and the lowest was measured in the Gölyazı form of forage peas by 1.99. In terms of the harvest seasons, the maximum low peas formation mean score and 50% flowering seasons were measured as 2.53-2.66 and the minimum mean value during low peas filling season by 2.04 (Table 3.). Accordingly, for common vetch, Seydosoglu (2014) calculated 1.6-2.6 in Diyarbakır; for Hungarian vetch, 2.73-3.07 in Diyarbakır; and for forage peas, Seydosoglu (2014) reported the main stem number piece as 1.2-1.9 in Diyarbakır. As can be seen, my findings are relatively paralleled with the findings of other researchers.

Green Forage Yield (kg da^{-1})

In terms of the green forage yield, the legume types had a 5% statistical significance level, and, in harvest seasons, a 1% statistical significance level whereas the legumes x harvest seasons interaction was measured to be statistically insignificant. Among the different harvest seasons of the legumes with respect to the yield character of green forage, it was explained that no statistically significant differences were observed in the yield sequences. In the legume types, the maximum green forage yield was computed as 2008.65 kg da^{-1}, the Gölyazı form of forage peas as 1516.11 kg da^{-1}, the Selçuk 99 form of common vetch, and the (*V. pannonica* Crantz) form of Hungarian vetch as 1412.42 kg da^{-1}. In the harvest seasons, the maximum values were measured in 50% flowering by 1940.18 kg da^{-1}, in the low peas formation, by 1736.66 kg da^{-1}, and in the low peas filling seasons, by 1260.37 kg da^{-1}. (Table 3.). For forage peas, Seydosoglu (2013) measured 1143.1-2417.6 kg da^{-1}, in Diyarbakır; for common vetch, Kaplan (2013) reported 1212.1-4386.0 kg da^{-1}, in Kahramanmaras; Seydosoglu (2014) measured 1522.0-3232.3 kg da^{-1}, in Diyarbakır, for Hungarian vetch, Sayar et al.,(2012) measured 1227-2336 kg da^{-1}; and in Mardin. Researchers reported that yield differences among these genotypes could stem from differentiation between their character and compatibility skills of genotypes (Bakoglu & Memis, 2002; Kokten, 2011).

Table 4. Dry weed (kg da^{-1}) and crude protein ratio (%) values and formed groups among different types of annual forage legumes and harvest seasons+

LEGUMES	HARVEST SEASONS				HARVEST SEASONS			
	Dry forage yield (kg da^{-1})				Crude protein ratio (%)			
	50% Flowering	Low peas format-ion	Low peas filling	Mean	50% Flowering	Low peas format-ion	Low peas filling	Mean
Hungarian vetch (*Vicia pannonica* Crantz)	366.27	296.35	272.69	311.77 **b**	26.65 **a**	26.71 **a**	21.34 **b**	24.90 **a**
Common vetch (Selçuk 99)	346.92	376.92	323.12	348.99 **b**	27.34 **a**	26.60 **a**	18.43 **c**	24.12 **a**
Forage peas (Gölyazı)	511.06	512.45	444.68	489.40 **a**	20.48 **bc**	19.76 **bc**	19.12 **bc**	19.79 **b**
Mean	408.09 **a**	395.24 **a**	346.83 **b**		24.82 **a**	24.36 **a**	19.63 **b**	
D.K. (%)	11.22				7.04			
Tukey (5%)								
Legumes			77.81**		Legumes		2.74*	
Harvest seasons			44.20*		Harvest seasons		1.66**	
Legumes x harvest seasons			N.S.		Legumes x harvest seasons		2.87*	

+) Mean scores indicated by identical letter group in the same column are, according to Tukey (5%), not different. +) *) 5% significance level, **) 1% significance level, N.S. statistically the difference is not significant

Dry Forage Yield (kg da^{-1})

The relationship of the forage yield statistical significance level of legume types was computed as 5%, and the statistical significance level of the harvest seasons was 1%, legumes x harvest seasons interaction was found to be statistically insignificant because, among the legumes examined in the research, no significant yield sequence changes were detected because the dry forage yield character varied across harvest seasons. Among the legume types, the maximum dry forage yields were respectively measured as 489.40 kg da^{-1} and 348.99 kg da^{-1} for the Gölyazı form of forage peas and the Selçuk 99 form of common vetch (*V. sativa* L.) and 311.77 kg da^{-1}, in the (*V. pannonica* Crantz) form of Hungarian vetch. During harvest seasons, the maximum values were measured in 50% flowering as 408.09 kg da^{-1}, as 395.24 kg da^{-1}, in low peas formation, and in low peas filling seasons as 346.83 kg da^{-1} (Table 4.). With respect to forage peas, Cakmakci et al. (1999) measured 227.0 kg da^{-1}, in Antalya, Uzun et al. (2012) measured 356.53-479.0 kg da^{-1}, in Bursa, Seydosoglu (2013) measured 292.9-553.1 kg da^{-1}, in Diyarbakir, and Karakose (2018) measured 264.0-580.8 kg da^{-1}, under Bingol conditions. For common vetch (*V. sativa* L.), Cacan et al. (2018) measured 122.8-227.4 kg da^{-1}, in Bingol; for Hungarian vetch (*V. pannonica* Crantz), Yilmaz et al. (1996) measured 405.33 kg da^{-1}, in Hatay; and Orak and Nizam (2003) measured 456.12-510.92 kg da^{-1}, in the Thracian region. Different findings recorded in the relevant literature may be related to the fact that experiments were conducted in different territories under different climatic features among different genotypes.

Crude Protein Ratio (%)

As can be construed from Table 4, in the research, statistically significant differences were identified between legumes and harvest seasons with respect to crude protein ratios (%). Legume x harvest seasons interaction was also found to be significant. In legume types, maximum crude protein ratios were obtained as 24.90% in the (*V. pannonica* Crantz) form of Hungarian vetch, as 24.12% in the Selçuk 99 form of common vetch, and as 19.79% in the Gölyazı form of forage peas. In harvest seasons, 24.82%-24.36% as well as 50% flowering and low peas formation seasons were detected. In the legume x harvest season, the interaction between 26.60%-27.34 values measured values were as follows: in Selçuk, the 99 form of common vetch, the (*V. pannonica* Crantz) form of Hungarian vetch were detected during the 50% flowering and low peas formation seasons. Indeed, it may be seen in Table 4 that, as cultivation periods lagged, there was a decrease in crude protein ratios. Although the same notion holds true in nearly all forage crops, it was reported by Uzun et al. (2012) that, as the cultivation period lagged, it is possible that the crude protein ratio of the seed could diminish. Similar findings were also reported by other researchers. For local common vetch, Yucel et al. (2013) reported 16.27%-24.25 in Diyarbakir, Kaplan (2013) reported 17.21%-24.76 in Kahramanmaras, for Hungarian vetch (*V. pannonica* Crantz), Ozturk (1996) reported 16.3% in Erzurum, Buyukburc and Karadag (2001) reported 17.36% in Tokat, Albayrak et al. (2004) reported 13.42%-13.86 in Samsun; for forage peas, Karakose (2018) reported 10.3-20.1% in Bingol, Timuragaoglu and Altınok (2004) reported 16-19% in Ankara, and Kandis (2019) reported 11.6-20.2% in Ordu.

Table 5. ADF ratio (%) and NDF ratio (%) values and formed groups among different types of annual forage legumes and harvest seasons+

LEGUMES	HARVEST SEASONS				HARVEST SEASONS			
	ADF ratio (%)				NDF ratio (%)			
	50% Flowering	Low peas formation	Low eas filling	Mean	50% Flowering	Low peas formation	Low peas filling	Mean
Hungarian vetch (*Vicia pannonica* Crantz)	31.94	32.53	24.25	29.57	39.39	40.60	34.83	38.27
Common vetch (Selçuk 99)	33.30	36.57	30.59	33.48	36.79	38.63	41.94	39.12
Forage peas (Gölyazı)	38.44	25.93	22.71	29.03	38.30	30.45	37.40	35.38
Mean	34.56 **a**	31.68 **a**	25.85 **b**		38.16	38.05	36.56	
D.K. (%)	14.39				15.24			
Tukey (5%)								
Legumes			I.S.		Legumes		I.S.	
Harvest seasons			4.54*		Harvest seasons		I.S.	
Legumes x Harvest seasons			I.S.		Legumes x Harvest seasons		I.S.	

+) Mean scores indicated by identical letter group in the same column are, according to Tukey (5%), not different. +) *) 5% significance level, **) 1% significance level, N.S. statistically the difference is not significant

ADF Ratio (%)

It may be seen in Table 5 that harvest seasons forming the lower parcels had a 5% significance level, and. in main parcels, the legume types and legume types x harvest seasons interaction was found to be at an insignificant level. Although in legume types no difference existed with respect to mean values, the maximum numeric ADF value was measured as 33.48% in the Selçuk 99 form of common vetch, and with respect to harvest seasons, maximum values were identified as 31.68%-34.56 and 50% during flowering and low pea formation seasons. Although in the legume x harvest season interaction, no difference existed in terms of mean values while the numeric maximum value gathered attention in the 50% flowering season of Gölyazı form of forage peas. At the end of studies conducted with different genotypes and different ecologies, the ADF value of forage peas was measured as 21.7%-36.4 by Karakose (2018) under Bingol conditions and as 27.6%-34.9 by Cacan (2019) in Bingol, ADF ratio's vegetative growth season was reported by Ozkan (2006) as 30.54% in Kahramanmaras, and, in flowering season, it was measured as 37.35%, and, in seed binding season, it was measured as 44.05%. Bingol et al. (2007) stated that the ADF ratio of Hungarian vetch, in the ecological conditions of Eastern Anatolia, varied between 30.35%-31.80. Badrzadeh et al. (2008) reported that, in vetches as the ripening period extended, NDF and ADF values increased and quality decreased, and these values are partially compatible with the findings of researchers.

NDF Ratio (%)

In terms of the neutral detergent-insoluble fiber ratio legume types, the harvest seasons, and the legumes x harvest seasons interaction, the effect was found to be statistically insignificant. Although among legume types, no difference existed with respect to mean values, the maximum numeric value of 39.12% was measured in the Selçuk 99 form of common vetch while during the harvest seasons by 50% flowering and 38.16% and legumes x harvest seasons interaction, it was measured as 41.94%; and in the Selçuk 99 form of common vetch, the maximum numeric value was obtained in the low peas filling season (Table 5). In general, NDF in animals is closely related to feed consumption. Sahar (2017) stated that, as the harvest season lags, the lignin quantity in the feed rises, and, as lignin forms a bridge between cellulose and hemicellulose, it can lower' the digestion of feed. In similar studies, the common vetch NDF ratio was detected by Caballero et al. (1995) as 38.1% in Spain, Yucel et al. (2013) reported 32.84%-40.66 in Diyarbakir, Kaplan (2013) reported 32.32%-49.56 in Kahramanmaras, and Temel and Keskin (2015) identified 40.63%-47.27 in Iğdır. As the ripening period enhanced among vetches, the corresponding escalation was seen in NDF and ADF values while the quality reduced (Badrzadeh et al., 2008). These values are partially compatible with other researchers' findings.

Table 6. Digestible dry matter (%) and relative feed values and formed groups among different types of annual forage legumes and harvest seasons+

LEGUMES	**HARVEST SEASONS**				**HARVEST SEASONS**			
	Digestible dry matter ratio (%)				Relative feed value (RFV)			
	50% Flowering	Low peas formation	Low peas filling	Mean	50% Flowering	Low peas formation	Low peas filling	Mean
Hungarian vetch (*Vicia pannonica* Crantz)	64.02	63.56	70.01	65.86	160.10	148.10	189.43	165.88
Common vetch (Selçuk 99)	62.96	60.41	65.07	62.81	161.86	148.95	145.07	151.96
Forage peas (Gölyazı)	58.95	68.70	71.21	66.29	146.78	211.14	183.22	180.38
Mean	61.98 **b**	64.22 **b**	68.76 **a**		156.25	169.40	172.57	
D.K. (%)	5.29				16.19			
Tukey (5%)								
Legumes			N.S.		Legumes		N.S.	
Harvest seasons			4.32*		Harvest seasons		N.S.	
Legumes x harvest seasons			N.S.		Legumes x harvest seasons		N.S.	

+) Mean scores indicated by identical letter group in the same column are, according to Tukey (5%), not different. +) *) 5% significance level, **) 1% significance level, N.S. statistically the difference is not significant

Digestible Dry Matter Ratio (%)

It may be seen in Table 6 that, in relation to digestible dry matter, yields a statistically significant difference between genotypes was detected; in seasons, a significance level was measured as 5%; and, in legumes and the legumes x harvest seasons interaction, the difference was insignificant. In relation to harvest seasons, the maximum value detected during low peas filling seasons was 68.76%. In similar studies, Cacan et al. (2019) measured 61.7-67.4% in forage peas in Bingol, and Engin (2019) measured 47.72%-54.18 in Canakkale and reported that digestible dry matter ratio had a vital effect on animal feeding and should be high. The difference between harvest seasons could be explained by the ripening during the cultivation time of genotypes.

Relative Feed Value (RFV)

The research depicted in Table 6 indicate that, in terms of relative feed value (RFY) legumes, harvest seasons and the legumes x harvest seasons interaction was statistically insignificant. Although with genotypes, no difference was measured with respect to mean values, and a maximum numeric value was detected during low peas formation season of Gölyazı form of forage peas where the value was 211.14. When compared with 100 RFY taken as normal clover value, it was determined that forage peas employed in the research were high-quality plant. In previous studies, in terms of RFY, Canbolat and Karaman (2009) measured legume dry weeds as 120.3-159.9 in Bursa, Ozturk (2009) measured 315.0 value in Aydın, and Karakose (2018) measured 136.6-202.1 value in Bingol. The reason for the differences detected in the literature could be related to different types used in the experiment and variances in environmental conditions.

CONCLUSION

It was concluded that differences that stemmed from legume types and harvest seasons discussed in the experiment were not only reflected in yield and quality but also climate conditions and the genotypes in which they were produced also played critical roles in the ripening and cultivation seasons. In the city of Sanliurfa and similar ecological conditions, with respect to high green weed, dry weed and crude protein yields, low ADF and NDF ratios, and high DDMR and RFV values. It is suggested that the Gölyazı form of forage peas should be cultivated during low pea formation season.

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CHAPTER 5

EFFECTS OF TRACE ELEMENTS ON FORAGE CROPS

INTRODUCTION

Today, one of the first concepts that we come across about environmental pollution is the term "heavy metal". The term called heavy metal is basically used for metals whose density is higher than 5 g in terms of physical properties. Among these, there are more than 60 metals including cadmium, chromium, copper, nickel, mercury and zinc (Kahvecioglu et al., 2007). On the other hand, Duffus (2002) stated that although the term "trace element" was never fully defined, it preferred to use the term "heavy metal". Recently, there has been a tremendous increase in research on heavy metal risks encountered in the earth. The inclusion of trace elements in the food chain is a situation we naturally encounter. However, some anthropogenic factors have changed the normality of trace elements in forage and food. Forage crops can be intermediate materials that prevent heavy metals from being directly involved in the food chain. A considerable amount of research has focused on conserving natural resources for a safe and risk-free environment. In this review, information from 12 forage plants and 16 trace elements, selected from more than 20 contemporary sources, from the twenty-first century has been compiled.

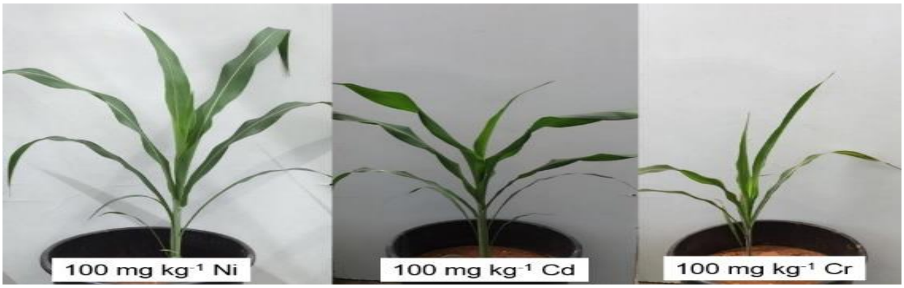

Figure 1. The Effect of Different Trace Elements in the Same Dose Applied to a Forage Plant *(Sorghum bicolor* L.) (Yılmaz, 2017)

Table 1. Forage Crops and Their Latin Names Mentioned in This Review

Alfalfa, *Medicago sativa* L.	White clover, *Trifolium repens* L.
Red clover, *Trifolium pratense* L.	Sorghum, *Sorghum bicolor* L.
Grass, *Agrostis tenuis*	Fescue, *Festuca arundinaceae* L.
Clover, *Trifolium* sp.	*Dab* grass (*Desmostachya bipinnata*)
Ryegrass, *Lolium perenne* L.	Maize, *Zea mays* L.
Soybean, *Glycine max* (L.) Merr.	Perennial ryegrass, *Lolium perenne* L.

Table 2. Trace Elements and Symbols Mentioned in This Review

Arsenic: As	Mercury, Hg
Boron, B	Molybdenum: Mo
Cadmium: Cd	Nickel: Ni
Cesium: Cs	Palladium: Pd
Chromium: Cr	Platinum, Pt
Lead, Pb	Rhenium, Re
Lithium: Li	Selenium: Se
Manganese: Mn	Zinc, Zn

Se taken by the ryegrass plant grown in soil contaminated with Se, which was included in the insoluble proteins. This rate can be up to 75%. Increasing Se concentration in the plant increased GSH-Px activity, but decreased SOD activity and vitamin E concentration (Hartikainen et. al., 1997).

Malan and Farrant (1998) conducted a study in greenhouse conditions to determine the effects of different concentrations of Cd and Ni on the growth of soybeans. They have observed that Cd and Ni have a negative effect on plant growth and product amount. They stated that heavy metal accumulation in the plant is concentrated in the roots. They determined that Ni is more mobile than Cd and is transported to all parts of the plant and has a high density.

Toxic Se concentrations in nonaccumulative plants, which are 330 mg kg^{-1} in white clover, cause a 10% yield reduction without any symptoms. Se levels in accumulator plants can reach 4000 mg kg^{-1} without any negative effects. The exclusion of the effects of the proteins of the Se amino acids explains the tolerance mechanism of the process, thus avoiding the binding of Se with proteins and its negative effect on the plant (Terry et al., 2000).

Recently, Pb in soils has been investigated. Lime and $CaCO_3$ were added to the Fe-rich soils and the soil pH was raised to 7, and thus the Pb uptake of the *Festuca aurundinacea* plant was reduced (Adriano, 2004).

Rellan-Alvarez et al. (2006), reported that the amount of glutathione in the corn plant decreased under Cd stress.

Dan-Badjo et al. (2007) investigated the accumulation of Pt, Pd and Rh elements produced by vehicles in traffic on the highway in ryegrass (*Lolium perenne*) and soil and their effect on the food chain. The researchers stated that the concentration of Pd, Pt and Rh increased in the first weeks of exposure, and that the exposure time of ryegrass increased in direct proportion to the Pd and Rh levels. The authors noted that although ryegrass was transferred over the road 5 weeks after exposure, there was no significant reduction in the concentrations of the elements, which posed a risk of contamination for ruminants.

Lopez et al. (2007) stated that nitrogenase enzyme activity and nodules increase in red clover with the increase in the amount of Mo available in the soil.

Vernay et al. (2007) reported that with the increase of Cr^{6+} level in nutrient solution, CO_2 assimilation and other parameters related to photosystem in leaves of *Lolium perenne* plant decreased.

As uptake of *Lolium perenne* plant under greenhouse conditions was evaluated. Among the various mixtures applied, the high proportion of compost (15%), zeolite (5%) and iron oxide (5%), were effective in reducing the As uptake of the plant and regenerating vegetation on contaminated soils (Gadepalle et al., 2008).

Zhou et al. (2008) reported that application of up to 40 mg kg^{-1} $HgCl_2$ promoted antioxidant enzyme activity in alfalfa, but showed toxic effects at higher concentrations.

The mean B level in grasses is 5.7 mg kg^{-1}, whereas the concentration of alfalfa and clover is 37 mg kg^{-1} (Davies, 1980; Kabata-Pendias, 2011). Chapman, (1972); Kabata- Pendias, (2011) stated toxic B levels for alfalfa to be from 283 to 333 mg kg^{-1}.

Worldwide, the manganese concentration in grasses is 17-334 mg kg^{-1} and 25-119 mg kg^{-1} in clover. While the average concentration of Ni in clover obtained from different countries is 1.2-2.7 mg kg^{-1}, this ratio is 0.13-1.7 mg kg^{-1} in grass. (Kabata- Pendias, 2011). Contrary to these average values, Ni concentrations of 13-75 mg kg^{-1} in meadow grasses and 10-100 mg kg^{-1} in forest grasses were determined from Western Siberia (Niechayeva, 2002; Kabata- Pendias, 2011).

Generally, Li concentrations are investigated in the root regions of plants. While this level is 4.4 mg kg^{-1} Li in the roots of the ryegrass plant, it is 20 mg in the white clover (Wells and Whitton 1972; Kabata-Pendias, 2011).

Festuca ovina collects more Cd to its roots than *Secale cereale* and carries more Cd to its above-ground organs (Majewska and Kurek 2008; Kabata- Pendias, 2011).

Soudek et al. (2014) the answer of hydroponic culture in grown sorghum plants to Cd and Zn stress was followed. Cd and Zn were accumulated first in the roots of *Sorghum bicolor* L. Incrising of metal levels in the media suplied their transfer to the shoots. Toxic effects of elements treatmented at lower levels were less important in the shoots in check with their impact to the roots. When practiced at higher densities, transmission of the metals into the leaves of plant rised, causing development decrease and leading to chlorophyll loss and chlorosis. Support of antioxidant system by supplement of GTH importantly rised the accumulation of Cd in the roots as well as in the shoots at the highest Cd level practiced.

Sorghum (*Sorghum bicolor*), sunflower (*Helianthus annuus L.*), buckwheat (*Fagopyrum esculentum*) and amaranth (*Amaranthus L.*) plants were grown in the field to evaluate the ^{137}Cs (radiocesium) element for phytoremediation. Sorghum had the most biomass in 2 different soils compared to other plants. Removal of radiocesium from surface soils by plant cultivating (sorghum, sunflower, amaranth and buckwheat) was at a low rate. It has been determined that the phytoremediation method is difficult in soils contaminated with radiocesium (Saito et al., 2014).

Latif et al. (2015) made silage by adding 2%, 4% and 6% molasses to corn and dab grass (*Desmostachya bipinnata*) grass and aimed to determine the physical and nutritional properties of silage. In general, each increasing molasses dose indicates increasing heavy metal content. Control, concentrations in feed containing 2%, 4% and 6% molasses, respectively, 3- 5- 4.2- 9.8 ppm Ni, in the same order 5.6-

5.8- 2.8- 5.2 ppm Cr, it contains, in the same order, 1.2- 1.2- 2.2- 3.3 ppm Cd and the same order 2.6- 7.6- 28- 53.4 ppm Pb. While dry matter and ash content increased, crude fiber, ADF and NDF content decreased with increasing molasses ratio in silage. They stated that there was no change in the crude protein level with increasing molasses levels.

Vatehova et al. (2016) examined some physiological parameters after two hybrid maize (sensitive and tolerant) exposed to Cd stress. After 10 days of stress Cd^{2+} plant growth was limited in both varieties, while significant changes were observed in the root structure and pigment content of the sensitive variety. They reported that the Cd concentration in the roots was 10 times higher than in the shoots, and the protein content decreased in both varieties. The Ca^{2+} content in both varieties decreased due to the replacement of Ca^{2+} in the cell walls with Cd^{2+}. They reported that cellulose ratio decreased and lignin ratio increased with Cd stress.

CONCLUCSION

Phytoremediation is a green technology that removes heavy metals from soils contaminated with heavy metals using plants. However, it has been determined that very few plants have been both hyperaccumulator and fast growing until now (Bian et al., 2020). If forage plant species are used for phytoremediation technique, the soils will be cleared of heavy metals, and the direct entry of heavy metals into human food is prevented. In this direction, with the increase of studies investigating the effects of trace elements on feed plants, it will make forage plants, which are already extremely important for animal nutrition, also important for the environment and human health.

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CHAPTER 6

WEED MANAGEMENT IN FORAGE CROPS

INTRODUCTION

The term 'weed' can be broadly applied to any plant that is undesirable at any given time and place based on certain criteria. While most forage crops are a problem in agricultural areas as weeds, some unwanted plants are also a problem in forage crop areas. In this context it is necessary to approach the weed problem in forage plants differently from other field crops. Weeds in forage crops affect the profit margin by affecting feed quality, pasture life and animal performance, reducing yield, palatability and grazing area. The livestock sector must have a growing awareness that weeds can affect forage crops and ultimately livestock. Common weeds in forage crops included are docks, thistles - creeping and spear, chickweed, ragwort, buttercup, bracken, nettles, charlock, fat hen, redshank, etc. Weeds compete with forage crops for water, minerals, light and space, resulting in a loss of yield and quality. In general, when the weed coverage area is 1%, it reduces the yield of the forage plant by 1%. If 1/4 of the forage crop field is infested by weeds, quality forage cannot be obtained from the forage field. It causes indirect damages by hosting foreign diseases and pests, also. In addition, it can hinder harvest and reduce feed (such as an unpleasant, prickly or poisonous stranger), poisoning (e.g. bracken fern, buttercups, coclebur, horsetail, horseweed, lambsquarters, jimsonweed, nightshades, pigweeds, poison hemlock), hostel for pathogens and insects. Preventive measures against troublesome weeds, physical and mechanical methods should be given priority. Chemical application should be preferred as a last choice. Biological and biotech tactics should be applied if possible. In general, the weed problem is less in perennial forage plants according to annuals. The things to be done against weeds, which are a problem in forage plants, are given below. a) Choosing a non-weedy field to plant forage crops, b) Using certified seeds, c) Sow competitive and adaptable varieties, d) Resistance and tolerant species should be cultivated, e) Turn to perennial feeds, f) Fertilize the fields according to the soil test recommendation, g) The burnt exterior of animal manure should be paid attention to, h) Drip irrigation (instead of sprinkler and flood irrigation), i) Suitable harvesting and shearing/cutting j) Partial flame burning is applicable, k) Hand picking, l) Hand and tractor hoeing, m) Crop rotation, n) Herbicide rotation, o) Using herbicides according to label information. A limited number of herbicides (e.g. glyphosate, imazamox, bentazone, propyzamide, 2,4-D, MCPA, metsulfuron methyl, flumetsulam, thifensulfuron, and fenoxaprop) are available for use in weed control. There are growing concerns over herbicide use from producers and consumers based on environmental impacts and herbicide-resistant weeds. Unfortunately, effective control methods for weeds that are a problem in forage crops are still not available. For this reason, there is a need for scientific research on weed species that are problematic in forage plants and the development of alternative methods to control them. Consequently, for the long-term sustainable management of weeds in forage crops, integrated weed control tactics should be applied as a whole.

1. The Effect of Weeds on the Yield of Forages

Weeds tend to fill gaps between rows and rows in forage crop production areas (Meiss et al., 2010). Therefore, eliminating these weeds may reduce feed production in the first stage (Schuster et al., 2019). Many weeds are known to produce less grass than forage crops cultivated (Putnam and Orloff, 2014). If weeds were as productive as forage crops, they could be cultivated as fodder on their own (Chatterjee and Das, 1989). However, studies have shown that competitive weeds such as quackgrass and barnyardgrass have less yield potential than forage crops (Sardana et al., 2017).

Weeds have a high ability to reproduce, spread, and infest (Panetta and Cacho, 2014). Weeds can reproduce generativity (by seeds) and vegetatively (such as rhizomes and stolons) (Klimešová et al., 2008). Weeds production materials can be spread by different ways such as wind, water, rainfall, crop, agricultural tools and machinery, people, and animals (Thill and Mallory-Smith, 1997). Weed species with high adaptation ability benefit from weaknesses in field crops such as forage crops and settle in these areas (Batello et al., 2008; Kaur et al., 2018). Plant breeders tend to develop productive forage plant species that are resistant to disease and insects. However, weeds develop their areas of influence because they are the native child of the soil and their adaptability is high (Swanton and Weise, 1991). Many weeds have allelopathic potentials (Li et al., 2019) . For example, quackgrass secretes substances relating to allelopathy that can suppress the germination and maturity of forage crops in the forage plant production area and suppress the forage plants. This helps this weed slowly dominate the forage crop production areas (Dahiya et al., 2017; Jabran et al., 2015; Nimisha 2019; Tesio and Ferrero, 2010). On the other hand, parasitic weeds such as broomrapes (*Orobanche* spp.)

dodder (*Cuscuta* spp.) can parasitize especially legume forage plants (Rubiales et al. 2009; Parker, 2013; Seydosoglu, 2019). Weeds can provide area dominance and reduce yield and quality in forage crops (Cinar et al., 2013; Yadav et al., 2016).

As it turns out, weeds can cause problems (Holm et al., 1977). Alfalfa stages have been informed to drop up to 30% of the stand from infestations of chickweed. If chickweed emerges throughout the autumn and within spring it grows a solid ornate cover that manages completely with the alfalfa till first cutting forage is formed. Purple deadnettle and henbit can create an identical obstacle. If those plants (weeds) continue and later vanish, summer seasonal weeds such as foxtails, lambs quarter, pigweed, or others usually carry over. Permanent (long life) weeds like dandelion or Canada thistle can also creep into parts of the developing field to decrease yields and quality even more (PennState, 2020).

In research on a station of orchardgrass with 10 - 20% dandelion, manually ejecting the weed enhanced forage crops yield by just 7%. Application of 2,4-D for dandelion management would possibly result in some financial gain. But, the biggest profit of managing encroaching weeds may be postponing the drop of the host forage that the weeds would oppositely support to carry about. Because weed and forage crop intercommunications are complicated, we have little data on financial entrances for managing weeds in forages (Bittman et al., 1999).

2. The Effect of Weeds on Forage Quality

Farmers with a small number of animals and small fields cultivate forage crops for their own feed, while commercial production is carried out on large agricultural lands (Oruk et al., 2019). Small farmers tend to treat weeds as forage crops. While the largest weeds can decrease the nutritional status of forages, some weeds can increase forages character (Khan et al., 2013: PennState, 2020).

Many seasonal (year-end) weeds (including lamb's quarters and redroot pigweed) and permanent weeds (such as sow-thistle and dandelion) have a nutritional quality similar to alfalfa when cut at the meanwhile (Sweetser, 2020; Bittman et al., 1999). Weeds are collected concurrently with the forages, it can increase the forage character of the silage (Rotz et al., 2003). Investigations have confirmed that weeds had broadleaf have a more favorable scale of copper (Cu) and molybdenum (Mo) than cultivated or optional grass samples in hayfields, thus cows are few possibilities to feel a Cu insufficiency in weed hayfields (Clements et al., 2003; Oates et al., 2011).

Initial harvest dandelions that are in blossom typically include approximately 3% points less protein than orchardgrass, only dandelions that are often in a vegetative scene in following harvests have alike protein content to that of orchardgrass (FoodPrint, 2020). In feeding experiments, dandelions usually match orchardgrass in flavor, both in the hayfield and as well kept hay. The overall digestibility and the digestibility of the plant protein are alike in alfalfa and dandelions (Bittman et al., 1999). Quackgrass, similar to dandelions, has fairly excellent nutritional worth (Neverman, 2013). While quackgrass is accused as a weed, the grass is used as a parent in grass producing arrangements for its nutritious worth and flavor. The protein ingredient and flavor of quackgrass and timothy are alike according to some articles in the paper. Other examinations have explained that quackgrass has 3% marks of fewer raw protein contents than orchardgrass at the flowering step (Bittman et al., 1999).

Unlike, different popular weeds like foxtail, curled dock, shepherd's-purse, and smartweed are normally below in nutritious worth than forage greens and since useless as a forage part (Bittman et al., 1999; Lima, 2017). Weeds in agricultural products are more of a result than a reason (Leghari et al., 2015). Weeds easily locate areas affected by such environmental circumstances as weak drainage, poor fertility, high or low pH, applying force to the soil so that it becomes denser, pathogens and bugs attack, and weak cutting and grazing methods (Greenwood and McKenzie, 2001). Damaging dandelions show the decay of the forages by circumstances like winter damage, pathogens, and bugs. Bog rush and buttercups favor moist earth, so are symbolic of weak drainage. Bracken develops most suitable beneath low pH (acid soil forms) while foxtail barley fancies high pH (basic soil forms). Permanent bluegrass varieties and bentgrasses symbolize overgrazing, and yearly bluegrass seems on compacted earth. Horsetail frequently shows lightning, dry earth with a coarse surface and low organic matter (Hill and Ramsay, 1977; Bittman et al., 1999; Carlesi and Barberi, 2017).

Weeds usually show unsatisfactory nutritional parts in forage products and cattle reproduction (Iqbal et al., 2020). Excess dampness:

Dandelions hold up to 7% more damp than alfalfa and need at least a more day to drain ere baling. Hay bales containing broad-leaved weeds such as dandelions will become moldy and black (Bittman et al., 1999; PennState, 2020). Staining taste of milk: Some weeds from the Brassicaceae family such as stinkweed and wild mustard have quality spoiling ingredients that will reduce the quality of the milk (Best Mclntyre, 1975; Rice at al., 2007). Nitrates: Some weeds such as barnyard grass, redroot pigweed, lamb's quarters, smartweed, and Canada thistle contain toxic nitrate substances (Dowling et al., 2000; Chambers et al., 2001). Toxins: Since some weeds such as buttercup, field horsetail, tansy ragwort, and bracken fern contain toxics, excessive animals should be grazed in areas where these weeds are present and they should not be fed to animals too much (Panter et al., 2012).

Table 1. Common weeds that are capable of affecting animal health

Species	Toxin	Comments
bracken fern	thiaminase	woods and open areas; all part poisonous
buttercups	protoanemonin	pastures, esp. wet areas; causes sharp drop in milk production; toxin lost on drying forage
chokecherry	prussic acid	common in fencerows and woods
cocklebur	hydroquinone	cultivated fields, pastures; esp. sandy soils; seedlings and seeds toxic
hemp dogbane	apocynin & other glycosides	all plant parts have milky sap; fields and roadsides
hoary alyssum	unknown	horses are particularly sensitive
horsetail	thiaminase	wet or dry areas of pastures and roadsides; all parts toxic
horse nettle	alkaloids	seldom eaten because of spines
jimsonweed	alkaloids and others	all plant parts toxic
lambsquarters	nitrate and oxalate	common field weed; high in feed value
nightshades	solanine and other glycoalkaloids	all parts poisonous under certain condition; ripe berries almost nontoxic
oaks	gallotannins	acorns and young leaves and shoots are of concern
pigweeds	oxalate and nitrate	common field weed; many species; prostrate and tumble pigweed common in pastures
poison hemlock	many alkaloids	roadsides, edges of fields and waste areas where soil is moist; all parts highly toxic

Livestock can be poisoned or injured by certain weeds while grazing or being fed stored feed. Many common weeds in the forage crops can poison livestock.

3. The Effect of Weeds on Forage Crops Trade

Forage crops lose 1% sales value for each 1% weed that is a problem in their fields and is mixed with the harvested crop (Bittman et al., 1999; Colbach et al., 2019). Generally, since the forage plants are mixed with 1/4 weed, approximately 20-25% value loss is applied in the sold feed (Bhagmal et al., 2009). Weeds in feeds are one of the important factors limiting feed sales. The market value of feeds containing more than a quarter of weeds is very low. The use of herbicides for a sustainable feed production is a preferred method because it is practical and cheap (Bittman et al., 1999; Abouziena and Haggag, 2016). Since the control of weeds using only herbicides is insufficient in a forage crop production that is infested with weed, preventive measures should be integrated with cultural measures, physical and mechanical tactics, biological and biotechnical strategies (Popay and Field, 1996). Despite the management, there may be weed contamination in the forage plant production area. Therefore, long-term sustainable weed control should be implemented in commercial feed production areas. Crop and herbicide rotations are important tactics (Meiss, 2010).

Weed Life Cycles

Weeds rank as one of the major factors that limit the productivity of forage crops. Perhaps the best definition of a weed is simply "a plant out of place." Most hayfields, and especially most pastures, contain many plant species that are out of place and are unwanted.

Table 2. Noxious weed species in forage crops (Inside SDDA, 2020)

Common and scientific names of weeds in forages	
Absinth wormwood (*Artemisia absinthium*)	Multiflora rose (*Rosa multiflora*)
Black henbane (*Hyoscyamus niger*)	Orange hawkweed (*Hieracium aurantiacum*)
Buffalobur (*Solanum rostratum*)	Oxeye daisy (*Leucanthemum vulgare*)
Bull Thistle (*Cirsium vulgare*)	Perennial pepperweed (*Lepidium latifolium*)
Canada thistle (*Cirsium arvense*)	Perennial sowthistle (*Sonchus arvensis*)
Chicory (*Cichorium intybus*)	Phragmities (*Phragmites australis*)
Common burdock (*Arctium minus*)	Plumeless thistle (*Carduus acanthoides*)
Common crupina (*Crupina vulgaris*)	Poison hemlock (*Conium maculatum*)
Common mullein (*Verbascum thapsus*)	Puncturevine (*Tribulus terrestris*)
Common tansy (*Tanacetum vulgare*)	Purple loosestrife (*Lythrum salicaria*)
Common teasel (*Dipsacus fullonum*)	Quackgrass (*Agropyron repens*)
Cutleaf teasel (*Dipsacus laciniatus*)	Skeletonweed (*Chondrilla juncea*)
Dalmation toadflax (*Linaria dalmatica*)	Russian knapweed (*Centaurea repens*)
Damesrocket (*Hesperis matronalis*)	Saltcedar (*Tamarix Species*)
Diffuse knapweed (*Centaurea diffusa*)	Scentless chamomile (*Anthemis arvensis*)
Dodder (*Cuscuta genus*)	Scotch thistle (*Onopordum acanthium*)
Dyers woad (*Isatis tinctoria*)	Sericea lespedeza (*Lespedeza cuneata*)
Field bindweed (*Convolvulus arvensis*)	Spotted knapweed (*Centaurea maculosa*)
Field scabious (*Knautia arvensis*)	Squarrose knapweed (*Centaurea vigata*)
Knotweed (*Fallopia sachalinensis*)	St. Johnswort (*Hypericum perforatum*)
Hoary alyssum (*Berteroa incana*)	Sulfur cinquefoil (*Potentilla recta*)
Hoary cress (*Cardaria* spp.)	Tall Buttercup (*Ranunculus acris*)
Horsenettle (*Solanum carolinense*)	Tansy ragwort (*Senecio jacobaea*)
Houndstongue (*Cynoglossum officinale*)	Vipers bugloss (*Echium vulgare*)
Johnsongrass (*Sorghum halepense*)	White horehound (*Marrubium vulgare*)
Jointed goatgrass (*Aegilops cylindrica*)	Wild oats (*Avena fatua*)
Leafy spurge (*Euphorbia esula*)	Wild proso millet (*Panicum miliaceum*)
Meadow knapweed (*Centaurea pratensis*)	Yellow hawkweed (*Hieracium pratense*)
Medusahead (*Centaurea pratensis*)	Starthistle (*Centaurea solstitialis*)
Musk thistle (*Carduus nutans*)	Yellow toadflax (*Linaria vulgaris*)

It is important to know the life cycles of weeds and to determine the control methods (Bhowmik, 1997). Weeds are divided into 3 basic groups as annual, biennial and perennial. One-year weeds are also divided into two groups as winter and summer annual weeds (UMassAmherst, 2020). One-year weeds complete their life cycle within the year. In other words, they germinate, grow, bloom and dry completely after spilling seeds. Perennial weeds do not completely dry out and die during the year and they can survive for many years. One-year and perennial weed samples are given in the table below (OregonState, 2020).

Table 3. Life cycles of weeds (OregonState, 2020)

Life Cycle	Definition	Examples
annual	Weeds that complete their seed-forming life cycle in a growing season	Kochia, redroot pigweed
summer annual	Summer weeds are annual plants that germinate in hot or humid conditions in spring and summer after winter passes, and form flowers and seeds in summer and autumn.	common lambsquarters, Russian thistle, green foxtail, redroot pigweed
winter annual	They are one-year weeds that germinate in autumn and form flowers and seeds in spring and summer, which spend the winter in dormancy.	downy brome shepherd's-purse
biennial	Germinate and form rosette leaves in the first year and form flowers and seeds in the second year and complete their life cycle in two years.	common mullein, wild carrot, musk thistle
perennial	They are weeds whose life cycle continues for several years.	buckhorn plantain, sagebrush, johnsongrass
creeping perennial	They are perennial weeds that have the ability to reproduce asexually or without seeds, such as rhizome and stolon.	quackgrass, Canada thistle, field bindweed

Annual forage crops (single year hay or silage crops such as brassicas, maize, forage peas) can also provide weed control. In one study, cereal silage crops provided wild oat control comparable to in-crop wild oat herbicide use. Forage crop mixtures that provided season-long competition with weeds also tended to have fewer broadleaved weeds (Schoofs and Entz, 2000). Similar results have been found in a western Canadian study, where barley was grown as a grain crop, harvested for silage at the soft dough stage or harvested for silage one week after heading. The early-harvest barley provided better wild oat control than herbicides in the barley grain crop (Harker et al., 2003).

Perennial forage crops are effective at controlling some types of weeds, but not others. a) Perennial hay crops provide excellent control of wild oat, canada thistle, perennial sowthistle, b) Perennial hay crops provide only partial control of: green foxtail, quackgrass, c) Perennial hay crops result in higher populations of: dandelion, volunteer forage species. Results of one on-farm study highlight the positive effects of alfalfa in rotation on wild oat and Canada thistle and the negative effect of alfalfa on dandelion populations (Ominski et al.,1999).

3.1. Annual weeds in forages

They are annual weeds that grow in warm and hot regions. Since these weeds are in the C-4 group, they have adapted to hot environments. They are dryness tolerant. It germinates since May and continues to develop in the hot summer period. This increases the competitiveness of their feed plants with other organisms. Examples of summer annual grasses include red root hogweed, lamb's quarters, annual smart grass, prairie grass, and yellow or green foxtail. They are annual plants adapted to cold and humid conditions. They germinate in autumn or winter. They spend the winter dormant and grow vegetatively in the spring, and when they enter the summer they flower and plant seeds. Examples of winter annual grasses include shepherd’s purse, annual bluegrass, and corn spurry.

One-year weeds constitute the most important weed problem in the field of forage crop production. Invasive species in particular have come to the fore in recent years. These weeds reduce the germination and competitiveness of small seed weeds. Weed-free areas should be selected for a good forage production area establishment and contamination should be prevented. For example, forage crop production is recommended in areas where the previous crop was maize. This is because the corn plant leaves a clean field after itself due to its superior competitive power (FarmWest, 2020).

One-year weeds have been adapted to the annual cultivation plants production areas. Looking in more detail, winter weeds become a problem in winter culture plants, summer weeds in summer culture plants. Before the forage plant is planted, a good seed bed is prepared by plowing the soil or by destroying weeds with herbicide application. Weed control should be provided before the critical period in maintenance operations during the year. Especially weeds should not be allowed to spill seeds. Ideally, the best way to control annual weeds in forages is to not allow them to become established in the first place. The use of weed free seed and/or crop rotation are important steps in achieving this goal. Realistically though, even with the use of these techniques, annual weeds may still be a problem.

EPTC and Glyphosate are the most commonly used herbicides for the control of weeds germinated before planting. The chemical control method should be supported by cultural measures. For example, if summer weeds are the main problem, forage crop cultivation can be performed in autumn. Another cultural practice is planting the fodder crop after the companion crop (e.g. wheat or barley) is planted and harvested in areas where forage production is decided.

The control of annual weeds in perennial forage crop production areas is based on tillage and herbicide use. While deciding on the herbicide selection, licensed active substances in the Plant Protection Products Database of the Ministry of Agriculture and Forestry should be used (OregonState, 2020).

3.2. Biennial weeds in forages

Two-year weeds germinate in the first year and drop seeds in the second year and complete their life cycle in two years (e.g. common burdock, bull thistle, wild carrot) (FarmWest, 2020). Two-year weeds are less of a problem than annual weeds in forage crop production. Because whether you have been an annual forage crop or a perennial forage plant, we can say the following for both: Since the mechanical and chemical control for weed control is carried out during the year, seeding and shedding of two-year weeds can be prevented. Thus, two-year-old weeds can be suppressed. The application of herbicides as surface spraying is one of the most effective ways to prevent the growth of weeds for two years. However, herbicide application time should be determined carefully. For this reason, application of herbicides according to label information is important in terms of preventing damage to forage plants (OregonState, 2020).

3.3. Perennial weeds in forages

Perennial weeds have storage structures such as rhizome, stolon, tuber, onion. As a general rule, perennial weeds such as quackgrass, velvetgrass, bluegrass, curled dock and Canada thistle in established forage stands are best controlled by maintaining a healthy, dense, well-managed stand of the desired crop. This makes it very competitive against weed invasion. As a pasture or forage crop stands, it tends to naturally thin out, which provides weeds with an opportunity to encroach into the stand. When a thinning stand is the primary cause of weed invasion, the grower must make a decision whether to establish an entirely new stand, rotate to another crop, or simply renovate the existing stand. Each approach has advantages and disadvantages (FarmWest, 2020).

Perennial forage crop production areas are open to all crops invasion since early plant growth is weak. Another critical period is that in the following years, towards the last stages of the perennial forage plant, the fodder plant becomes thin again and becomes suitable for weed contamination and development as its competitiveness decreases. It is recommended to do intensive weed control in the first periods. However, the fodder area can be changed by analyzing the economic situation for the last years or periods.

Gaps or scrawny areas in forage lice areas can be strengthened by renewal, that is, by planting forage seeds in those that are. Thus, weed infestation can be prevented. One of the most effective control methods in the control of perennial weeds, which is a problem in perennial forage crop production areas such as alfalfa, is cutting. When the forage plant is harvested, both its generative reproduction is prevented and the carbohydrate reserve accumulated in the underground roots or rhizomes of the weed in all forms is depleted.

The use of selective herbicides is one of the effective control methods of controlling perennial weeds, which is a problem in perennial forage crop production. It should be considered here to choose a licensed herbicide for the relevant feed plant and use it according to the label information. However, it is overlooked that the use of herbicides increases the cost of forage crop production.

Biological monsters (sheep and goats) can be used to control perennial weeds in perennial forage production areas. Especially local places where weeds are dense can be grazed for 23-3 weeks and weeds can be partially suppressed (OregonState, 2020).

3.4. Weed seeds

Weeds are plants with high generative or vegetative reproduction ability. Knowing the reproductive ability of weeds is important in deciding the strategies to prevent their contamination and reproduction (FarmWest, 2020). The Table below shows the growth and dormancy of weeds.

Table 4. Seed production and dormancy of weeds (FarmWest, 2020)

Weed	Number of seeds produced per weed	Dormancy period of weed seed (year it can survive in soil)
canada thistle	630/stem	11-20
chickweed	-	10
dandelion	15.000	-
curled dock	29.500	80+
barnyardgrass	7.160	-
green foxtail (millet)	34.000	-
lamb's quarters	72.450	21-40
redroot pigweed	129.000	21-40
lady's thumb	19.000	-
shepherd's purse	33.500	35
tansy ragwort	150.000	-

3.5. Bioindicator weeds

Some weeds provide information about the soil in which forage crops are cultivated. Various weeds live in different types of soil. The purpose of this method is to learn about the soil. Some weeds and soil types that are a problem in forage crops are given in the table below.

Table 5. Weeds as soil bioindicators (Carlesi and Bàrberi, 2017)

Species	Family	Typology	Trustability
Soil reaction			
Chrysanthemum leucanthemum	Asteraceae	Acidic soil	M
Gnaphalium uliginosum	Asteraceae	Acidic soil	M
Hieracium aurantiacum	Asteraceae	Acidic soil	H
Hieriacium pratense	Asteraceae	Acidic soil	H

Polygonum aviculare	Polygonaceae	Acidic soil	M
Polygonum persicaria	Polygonaceae	Acidic soil	M
Portulaca oleracea	Portulacaceae	Acidic soil	M
Potentilla argentea	Rosaceace	Acidic soil	M
Potentilla monspeliensis	Rosaceace	Acidic soil	M
Rumex acetosella	Polygonaceae	Acidic soil	H
Rumex crispus	Polygonaceae	Acidic soil	M
Sonchus spp.	Asteraceae	Acidic soil	H
Spergula arvensis	Caryophyllaceae	Acidic soil	H
Verbascum spp.	Scrophulariaceae	Acidic soil	M
Viola arvensis	Violaceae	Acidic soil	H
Anagallis arvensis	Primulaceae	Alkaline soil	H
Anthemis nobilis	Asteraceae	Alkaline soil	M
Chenopodium spp.	Chenopodiaceae	Alkaline soil	M
Daucus carota	Apiaceae	Alkaline soil	M
Lepidium virginicum	Brassicaceae	Alkaline soil	M
Water availability			
Amaranthus retroflexus	Amaranthaceae	Dry soil	M
Euphorbia maculata	Euphorbiaceae	Dry soil	M
Medicago lupulina	Fabaceae	Dry soil	M
Althaea officinalis	Malvaceae	Humid soil	M
Apios americana	Fabaceae	Humid soil	M
Carex lasiocarpa	Cyperaceae	Humid soil	H
Echinochloa crus-galli	Graminaceae	Humid soil	M
Equisetum arvense	Equisetaceae	Humid soil	H
Impatiens pallida	Balsaminaceae	Humid soil	M
Lychnis flos-cuculi	Caryophyllaceae	Humid soil	M
Poa annua	Graminaceae	Humid soil	H
Podophyllum peltatum	Berberidaceae	Humid soil	M
Polygonum pensylvanicum	Polygonaceae	Humid soil	M
Polygonum persicaria	Polygonaceae	Humid soil	H
Ranunculus spp.	Ranunculaceae	Humid soil	H
Rumex acetosella	Polygonaceae	Humid soil	M
Tussilago farfara	Asteraceae	Humid soil	H
Typha latifolia	Typhaceae	Humid soil	M
Soil compaction			

Euphorbia maculata	Euphorbiaceae	Compaction	H
Galium aparine	Rubiaceae	Compaction	H
Plantago major	Plantaginaceae	Compaction	H
Poa annua	Graminaceae	Compaction	H
Polygonum aviculare	Polygonaceae	Compaction	H
Soil texture			
Allium vineale	Liliaceae	Clayey soil	M
Bellis perennis	Asteraceae	Clayey soil	M
Plantago major	Plantaginaceae	Clayey soil	H
Ranunculus spp.	Ranunculaceae	Clayey soil	M
Ranunculus repens	Ranunculaceae	Clayey soil	M
Rumex obtusifolius	Polygonaceae	Clayey soil	H
Taraxacum officinale	Asteraceae	Clayey soil	M
Centaurea cyanus	Asteraceae	Sandy soil	M
Centaurea melitensis	Asteraceae	Sandy soil	M
Convolvulus arvensis	Convolvulaceae	Sandy soil	M
Eupatorium capillifolium	Asteraceae	Sandy soil	M
Lactuca tatarica var. Pulchella	Asteraceae	Sandy soil	M
Linaria vulgaris	Scrophulariaceae	Sandy soil	M
Urtica dioica	Urticaceae	Sandy soil	H
Viola arvensis	Violaceae	Sandy soil	H
Soil fertility			
Arctium minus	Asteraceae	High fertility	M
Chenopodium album	Chenopodiaceae	High fertility	H
Phytolacca americana	Phytolaccaceae	High fertility	M
Poa annua	Graminaceae	High fertility	M
Portulaca oleracea	Portulacaceae	High fertility	M
Stellaria media	Caryophyllaceae	High fertility	H
Taraxacum officinale	Asteraceae	High fertility	H
Andropogon spp.	Graminaceae	Low fertility	M
Linaria vulgaris	Scrophulariaceae	Low fertility	M
Lotus corniculatus	Fabaceae	Low fertility	M
Rumex acetosella	Polygonaceae	Low fertility	M
Verbascum spp.	Scrophulariaceae	Low fertility	M

H: high reliability (information from > 3 bibliographic sources)
M: medium reliability (information from at least 2 sources)

In forage crops, the weed species in their fields provide us with practical information about the soil (e.g. purslane for low pH soil, pigweed for dry soil, barnyardgrass for humid soil, spurge for compaction soil, creeping buttercup for clayey soil, bindweed for sandy soil, lambsquarters for high fertility, curled dock for low fertility).

4. Applicable Weed Management in Forage Crops

Weed management strategies in forages should focus first on cultural practices and then on chemical weed control practices. Vigorous, dense-growing forage stands have fewer weed problems. Thus, cultural and management practices that promote a highly competitive forage stand may prevent many weed problems. These practices include: a) fertilizing fields based on soil test recommendations, b) seeding well-adapted, vigorous, long-lived varieties, c) buying weed-free seed, d) cutting forage at proper timing intervals or growth stages, e) timely control of insect and disease problems, f) rotating fields with other crops to interrupt the buildup of certain forage related weed species.

Productive and high quality forage crop species should be preferred. Durable, tolerant forage crops should be selected. The cultivation of competitive and high-covering species should be done. Certified feed crop seeds should be used. Forage crop production should be started in a field without weeds. Before planting, weeds should be destroyed by tillage or herbicides. A good seed bed should be prepared. The transplantation norm should be observed. Planting should be done early. By making weed observations, manual collection, hoeing and herbicide applications should be done to keep them below the economic damage threshold.

4.1. Weed control before seedbed preparation

One-year weeds should be destroyed before planting. Since perennial weeds such as quackgrass, curled dock or Canada thistle are difficult to control when they infect forage areas, it is important to prevent transmission of these species. The vegetative propagation materials of these species are especially contaminated by tillage tools. If forage plants will be produced in the area contaminated with perennial weeds, active substances such as Glyphosate should be applied when these weeds are at least 20-25 cm during the active growth period in the spring. Autumn application provides excellent effect for perennial weed control. Because in this period, it actively uses transmission means to store perennial weed carbohydrates.

The herbicide applied in this period reaches the storage areas and roots of the plant and enables them to be controlled. This provides a clean field for forage crop cultivation in the spring. A single herbicide application is insufficient for the management of perennial weeds.

Table 6. Survival of weed seeds after grazing/feeding

Weed Name	Horses	Cattle	Swine	Sheep
canada thistle	-	No	Yes	Yes
chickweed	Yes	Yes	Yes	Yes
curly dock	Yes	Yes	Yes	Yes
dandelion	No	No	Yes	Yes
green foxtail	Yes	Yes	Yes	Yes
smartweed	-	-	Yes	No
lamb's quarters	Yes	Yes	Yes	Yes
quackgrass	Yes	Yes	No	No
tall buttercup	Yes	Yes	Yes	Yes

Therefore, several herbicide applications per year may need to be repeated for several years. In addition to chemical application, preventive measures, grazing and mechanical control are also important for the suppression of foreign grass. The survival of weed seeds after grazing is given in the table below.

Tillage in moist soils is more effective against perennial weeds than dry soils. Because in dry soils vegetative parts remain immobile, a kind of dormancy. Herbicide application at the time of tillage increases the weed control rate in both dry and heme soils.

4.2. Control of weeds during seeding and establishment

Germinated weeds are unable to compete with many weed species that germinate with them. A newly established forage area should be controlled at early germination to prevent infestation by weeds. Slow-growing forage crops (e.g. tall fescue, reed canary-grass, timothy) are sensitive to highly competitive weed species (notably the ryegrasses). In contrast, competitive forage crops such as rye can compete against weeds. The infestation of weeds in newly established forage plants is given in the table below.

Table 7. Seedling viability affects weeds infestation in new perennial forage stands

Type	Weed Content (%)
perennial ryegrass	30
orchardgrass	30
mix (orchard + ryegrass)	39

4.2.1. Nurse (companion) crops

Cereal companion or nurse crops (either perennial ryegrass, orchardgrass, or a mixture of the two) can be used to increase the competition of the forage plant with weeds or to reduce the need for herbicides. Cereal companions can be mixed in half the amount of feed plant. If planted at a higher rate, it may suppress the fodder plant.

A short-lived vigorous grass (such as Italian or perennial ryegrass) can be used to increase competition of the forage plant. These short-lived herbs inhibit the growth and spread of weeds. Here, attention should be paid to the mixing ratio. Otherwise, these plants can overwhelm the fodder plant and compete. Information on companion crops is given in the table below.

Table 8. Information on companion crops

Establishment Method	**Weed Content (%)** Initial Harvest
No weed control	65
Herbicide	41
Barley companion crop	22
Oats companion crop	24

4.2.2. Clipping and grazing

Harvest time in annual forage plants, mowing time and number of many years in forage plants are the most effective methods in foreign control. Biological monsters are an effective method for the control of weeds that are problematic in forage plants. Grazing can be done at appropriate time for weed control, which is a problem in local sheep and goats. A situation that should not be ignored is the formation of mowing and grazing tracks and hoof marks that will cause damage. Mowing and grazing suppress some weeds, but there are some problems this brings about. For example, while tall plants decrease, shorter plants increase. In addition, grazing in some weeds has an effect of taking tips and causes the weed to grow better. There is a need for scientific studies on weed control by mowing or grazing forage crops.

The blades of the harvester used during the harvest must be sharp enough not to cause injury to the forage plant. It should not be ignored that there are weeds in the weed cut and some of them are harmful. Mowing residues must be removed from the field. This situation will positively affect forage crops receiving light and performing photosynthesis. It will ensure that the spilled weed seeds or vegetative reproduction parts are removed from the field.

4.2.3. Herbicides

Before the forage crop is planted, total herbs such as glyphosate and paraquat can be used to dry all green weeds. In an established forage field such as alfalfa, herbicides such as imazamox, bentazone and propyzamide are available, which provide superior performance in wide and some grass weeds in Turkey (BKÜ, 2020). Also 2,4-D, MCPA, metsulfuron methyl, flumetsulam, thifensulfuron (for broadleaf weeds), and fenoxaprop (for grass weeds) are some of the important herbicides used in the field of pasture and forage plants in the other countries (Ghanizadeh and Harrington, 2019). It controls weeds such as dodder, lamb's quarters, barnyard grass, purslane, black nightshade, rough cocklebur, chamomile, common nettle, wild mustard, shepherd's wand and shepherd's purse. Imazamox and Bentazone: Used after weed emergence (when weeds are in early growth period). The application time is determined according to the growth period of the weeds, and it is generally the period from the first true leaf period to before flowering. However, the period when the weeds have 2-4 leaves is the ideal application time to achieve the desired effect. It is applied with 20-40 L water per decare. Most forage crops do not have a registered herbicide in Turkey (BKÜ, 2020).

Table 9. Chemical weed control in forage crops (CornellCALS, 2020).

Situation	Amount of Product(s) per Acre	Remarks and Limitations
Legume seedings without small grain companion crop		
Quackgrass	22-44 fl. oz. Roundup PowerMax **or** 24-48 fl. oz. Durango DMA **or** 24-48 fl. oz. Touchdown Total	**GROUP 9 HERBICIDES•** Apply these or other glyphosate products as preplant foliar sprays in the fall or spring when quackgrass is at least 8 in. tall (4- to 5-leaf stage) and actively growing. Fall applications should not be made in fields that have been tilled during the summer or mowed after August 15. Delay tillage for at least 3 days after spraying. Will not control weeds germinating after application. The low rates may not provide long- term quackgrass control. Labels include all forage grasses and forage legumes. Do not graze or harvest forage within 8 weeks after application.
Nutsedge, annual grasses, and broadleaf weeds	3.5–4.5 pt. Eptam 7-E	**GROUP 8 HERBICIDE•** Preplant only. Apply to a dry soil surface and incorporate immediately. Will not control wild mustard, wild radish, or ragweed.
Annual grasses and broadleaf weeds	4 oz. +Pursuit **or** 5 oz. Raptor	**GROUP 2 HERBICIDES•** Apply postemergence when seedling alfalfa is in the second trifoliolate stage or larger and when weeds are 1-3 in. tall. Use crop oil concentrate or nonionic surfactant and add 1-2 qt./A of liquid fertilizer to spray solution. **Add 1-2 pt. Butyrac 200 if ragweed or lambsquarters are a problem.**
	2–2.5 lb. Balan DF	**GROUP 3 HERBICIDES•** Apply preplant and incorporate within 8 hr. Use 2 lb. on coarse and medium soils and 2-1/2 lb. on fine soils. Will not control quackgrass, nutsedge, wild mustard, wild radish, and ragweed.
Annual grasses	1.5 pt. Poast Plus	**GROUP 1 HERBICIDE•** Labeled for alfalfa only. Apply when annual grasses are 2–4 in. tall. Add 1 qt./A of an oil concentrate-surfactant blend. Do not apply Poast Plus within 7 days of grazing, feeding, or cutting for undried forage, or within 14 days of cutting alfalfa for dry hay.
	9-16 fl. oz. *Select Max	**GROUP 1 HERBICIDE•** Apply when annual grasses are 2–4 in. tall. Add adjuvants according to label instructions. Do not apply *Select Max within 15 days of grazing, feeding, or harvesting (cutting) alfalfa for forage or hay.
Annual broadleaf weeds	1-1.5 pt. of 2 lb./gal. Buctril	**GROUP 6 HERBICIDE•** Labeled for alfalfa only. Apply when alfalfa has a minimum of 4 trifoliolate leaves. Weeds should not exceed the 4-leaf stage or 2 in. in height, whichever comes first, or apply before rosettes are 1 in. in diameter. Applications should not be made when temperatures exceed 70° F at, and 3 days following application. Do not cut alfalfa for feed or graze within 30 days following treatment.

	2 qt. Butyrac 200	**GROUP 4 HERBICIDE•** Apply postemergence when weeds are no more than 2–3 in. high or rosettes are less than 2 in. across. Will not control wild radish. Do not graze or feed seedling alfalfa, clover, or birdsfoot trefoil within 60 days after application. There is no preharvest interval for haylage or dry hay; however, harvested forage should not be fed within 60 days after application.
Annual grasses and broadleaf weeds in **Roundup Ready Alfalfa**	22-44 fl. oz. Roundup PowerMax	**GROUP 9 HERBICIDE• For use with Roundup Ready alfalfa only.** Apply 22 to 44 fl. oz. up to 4 trifoliolate leaves. Apply up to 44 fl. oz. from 5 trifoliolate leaves up to 5 days before first cutting. Up to 10 percent of the alfalfa seedlings might not contain the Roundup Ready gene and will not survive after the first application of this product.
Legume seedings with small grain companion crop		
Quackgrass	22-44 fl. oz. Roundup PowerMax **or** 24-48 fl. oz. Durango DMA **or** 24-48 fl. oz. Touchdown Total	**GROUP 9 HERBICIDES•** Apply these or other glyphosate products as preplant foliar sprays in the fall or spring when quackgrass is at least 8 in. tall (4- to 5-leaf stage) and actively growing. Fall applications should not be made in fields that have been tilled during the summer or mowed after August 15. Delay tillage for at least 3 days after spraying. Will not control weeds germinating after application. The low rates may not provide long- term quackgrass control. Labels include all forage grasses and forage legumes. Do not graze or harvest forage within 8 weeks after application.
Nutsedge and annual grasses	-	No herbicides currently available
Annual broadleaf weeds	1 pt. of 2 lb./gal. Buctril	**GROUP 6 HERBICIDE•** Labeled for alfalfa only. Apply when alfalfa has a minimum of 4 trifoliolate leaves. Weeds should not exceed the 4-leaf stage or 2 in. in height, whichever comes first, or apply before rosettes are 1 in. in diameter. Applications should not be made when temperatures exceed 70° F at and 3 days following application. Do not cut for feed or graze within 30 days following treatment.
	1/4-1/2 pt. *MCP Amine 4 **or** 1/2 pt. Rhomene MCPA	**GROUP 4 HERBICIDES•** Recommended for red clover seedings only. Small grain should form a protective canopy over the red clover seedlings. Do not use more than 6 gallons of water per acre unless injury can be tolerated; higher spray volumes may injure red clover.
Established alfalfa		
Bluegrass[1] and many broadleaf weeds including yellow rocket and common dandelion	2-6 pt. Velpar L	**GROUP 5 HERBICIDE•** Apply to dormant alfalfa in spring before new growth exceeds 2 in. in height or to stubble after cutting before regrowth exceeds 2 in. in height. Treat only stands established 1 yr. or for one growing season. Adjust rate according to soil texture and organic matter. Do not use on alfalfa-grass mixtures or other mixed stands. Do not graze or harvest within 30 days after application.

Chickweed, henbit, yellow rocket, and other broadleaf weeds	4-6 oz. +Pursuit	**GROUP 2 HERBICIDE•** Apply in fall or spring to dormant, or semi- dormant alfalfa, or between cuttings before 3 in. of growth or regrowth. Will reduce growth and competitive effect of perennial grasses such as bluegrass, orchardgrass, and timothy.
Chickweed, bluegrass[1], and other annual grasses and broadleaf weeds	2-3 pt. *Gramoxone SL 2.0	**GROUP 22 HERBICIDE•** Apply to established (at least 1 yr. old) alfalfa stands in the spring before new alfalfa growth starts. Add a nonionic surfactant to spray tank. Do not cut or harvest within 42 days of application.
	1 pt. *Gramoxone SL 2.0	**GROUP 22 HERBICIDE•** Apply to alfalfa stands within 5 days after cutting. Add a nonionic surfactant to spray tank. Do not cut or harvest within 30 days of application.
Grass and broadleaf weeds in Roundup Ready alfalfa	22-44 fl.oz. Roundup PowerMax	**GROUP 9 HERBICIDE• For use in Roundup Ready alfalfa only.** Apply up to 44 fl. oz. per cutting up mto 5 days before cutting.
Sorghum or sorghum-sudangrass hybrids		
Nutsedge and annual grasses	—	No herbicides currently available
Broadleaf weeds	2 qt. *AAtrex 4L **or** 2 qt. *Atrazine 4L	**GROUP 5 HERBICIDE•** Apply after sorghum or hybrid has completely emerged and weeds are less than 1-1/2 in. tall. Do not apply to straight sudangrass. Do not graze or feed forage from treated areas for 21 days following application.

* Restricted-use pesticide; may be purchased and used only by certified applicators or used by someone under the direct supervision of a certified applicator

\+ Not for use in Nassau and Suffolk Counties; pesticide labels that indicate “Not for use on Long Island, N.Y.” mean that use is prohibited in Nassau and Suffolk Counties only.

•Refer to Section 4.11.1 for information on herbicide resistance management and site of action groups.

[1]See comments about cultural control of bluegrass in Section 4.11.

Several herbicide options are available for established forage stands. You can use many of the same herbicides available for new seedings. Furthermore, the deep root system of established plants such as alfalfa enables them to tolerate certain herbicides that are not suitable for new seedings. When selecting herbicides for forages, you should consider such factors as: whether the herbicide can be applied as a dormant season, non-dormant, or between cutting treatment; effectiveness on weed species to be controlled; feeding and grazing limitations; rotational crop restrictions; and cost of treatment.

4.3. Weed Control in Established Forages

Identification of the problematic weed species in forage crop fields is necessary for the selection of appropriate herbicides. In terms of the weed method, it is important that all agricultural production practices (such as weed control) in forage production are integrated with other maintenance processes. Grass weeds are the most important group limiting feed production. They are partly easier to control because they are registered for parasitic weed seedlings and other broadleaf weeds. In order for the right herbicide to be used in the right forage plant at the right dose at the right time, the herbicides registered in the Ministry of Agriculture and Forestry Plant Protection Products Database should be used according to the label information.

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CHAPTER 7

PERENNIAL WARM SEASON GRASS; CULTIVATION OF DALLISGRASS (*Paspalum dilatatum* Poir.)

INTRODUCTION

Paspalum dilatatum Poir., commonly known as dallisgrass, is a perennial warm-season grass native to South America especially to Southeast Brazil, Uruguay and Northern Argentina and recommended to improve pastures. *Paspalum* has been moved from its natural range to tropical and subtropical areas. The *Paspalum* L. is a genus belongs to the Paniceae family of the Panicoideae subfamily. The *Paspalum* L. consists of approximately 400 species including important forage grasses and widespread invasive weeds. The word Paspalum originated from the Greek word Paspalos denoting a variety of millet (CRC, 1999). The common name of *P. dilatatum* is dallisgrass which comes from AT Dallis, who extensively cultivated the *P. dilatatum* in Georgia, USA (Hitchcock and Chase, 1951). The dallisgrass an economically important and widely cultivated forage crop for livestock feeding in the tropical, subtropical, and warm temperate regions. Dallisgrass is also included in the natural vegetation of the Çukurova Region (DAISIE, 2017). This warm season fodder plant has a good potential to meet the green fodder need in summer months of livestock farms located in the Mediterranean and Aegean regions of the Turkey (Moore and Gerald, 1975).

Figure 1. Dallisgrass (*Paspalum dilatatum* Poir.) (Bilgin et al., 2012-2020)

Global temperature increase, which is the obvious indicator of climate change, requires new strategies and the presence of germplasm resources to increase the resilience of artificial grasslands, as well as other agricultural systems. Understanding of the germplasm structure for the potentially beneficial wild species is required for the efficient use of wild germplasm in domestication and breeding. *Paspalum dilatatum* subsp. *flavescens* Roseng., Arrill. & Izag. (Poaceae) is a sexual, autogamous member of the species complex containing the highly valued apomictic forms of *P. dilatatum* (*Dilatata group*) (Sandro et al., 2019).

The dallisgrass, known as a warm season forage plant, is resistant to grazing; thus is widely used in the establishment of artificial pastures. The plant is palatable before flowering, but ergot fungus emerging after flowering reduces the attractiveness of plant to animals. The plant is not toxic, however the ergot fungus, Claviceps paspali, infects the flowers of Dallisgrass and is toxic to animals.

P. dilatatum has been used for a long time for the establishment of artificial pastures due to flavor, productivity and ability to resist for heavy grazing (Tropical Forages, 2017). Many varieties, registered in the USA, New Zealand, Australia, Brazil, Japan and Uruguay, are also recommended for the seed mixtures used in the Mediterranean coast of Turkey. High meat and milk yields are obtained from animals fed with *P. dilatatum* used as hay and silage feed. *P. dilatatum*, which is also used as a source of vitamins and minerals, is also widely used in erosion control and restoration of mine habitat (PROTA and USDA-ARS, 2017).

P. dilatatum is often used as a forage or hay and is preferred because of the high productivity of livestock fed with dallisgrass (Miz et al., 2006). However, spreading of dallisgrass to the larger areas is restricted by the problems such as low sexual reproduction, low germination rate and slow establishment and susceptibility to infection with ergot fungi (*Claviceps paspali*). Researches continue to develop genotypes that will increase the use of dallisgrass as a forage crop in wider areas (Glison et al., 2015).

Figure 2. Ergot-infected flowering in Dallisgrass (Bilgin et al., 2012-2020)

CHARACTERISTICS

Paspalum is a perennial forage plant that produces abundant shoots from short rhizomes with a diameter ranging from 4 to 8 mm (Hatipoglu and Tukel, 2009). Clums of the paspalum, which has thick fibrous roots that penetrate down to a depth of 1 m, form a coarse, spreading tuft, varying from 50 to 150 cm in length, 5 mm in diameter and glabrous. Leaf sheaths are glabrous or pilose in the lower part. The leaf blades are linear with a size of 10-45 x 0.3-1.2 cm, glabrous and apex attenuate. Ligule, which is a membranous scale on the inner side of the leaf sheath at its junction with the blade, is 2-4 mm. Inflorescence axis of paspalum is between 2 and 20 cm. The number of flowering stalk ranges between 2 and 10 with the length of 5 to 12 cm (CABI, 2018).

Figure 3. Rhizomes (Dallisgrass) (Bilgin et al., 2012-2020)

Figure 4. Dallisgrass a) Root state b) Shoots state (Bilgin et al., 2012-2020)

Figure 5. Culms tall (Dallisgrass) (Bilgin et al., 2012-2020)

The number of chromosomes for P. dilatatum are 2n = 40, 50 and 60, of which 2n = 50 chromosomes and apomictic is the most common biotype (Hatipoglu and Tukel, 2009). The dallisgrass blooms from the late spring through the end of fall season. The flowers in the form of a paired spikelet, which arise from different points at the upper part of the flower stalk. Each spikelet has two rows of flat, egg-shaped seeds along the entire length of flower stalk. The color of spikelets ranges from pale green to purplish (Dallisgrass, 2008).

 

Figure 6. Flowering state (Dallisgrass) (Bilgin et al., 2012-2020)

ENVIRONMENTAL REQUIREMENTS

Dallisgrass is a C4 gramineae that is classified as moderately tolerant to cold. Dallisgrass requires high temperatures, sufficient amount of available water and soil nitrogen content for development. *P. dilatatum* grows easily in regions where annual temperatures vary between 15 and 20 °C and annual precipitation is approximately between 750 and 1700 mm. However, the plant is resistant to drought and low temperatures down to -4 °C due to the deep root system, while it is not resistant to shade and salinity. The dallisgrass grows in irrigate pastures. The plants tolerate flooding conditions for a week (Hatipoglu and Tukel, 2009).

Dallisgrass can grow in a wide variety of soils, but is more commonly found in loam and clay soils where drainage is poor (Evers and Burson, 2004). The quality of Dallisgrass seeds varies greatly depending on the type of soil where it grows. The available soil water content is often a limiting factor for yield and high quality seed production. Long-term droughts and poorly drained soil conditions also negatively affect the seed formation and seed quality (Owen, 1951). Dallisgrass is grown in moderate to high-yielding lowland and highland soils, usually along with other pasture grasses and legumes.

ESTABLISHMENT

Establish of dallisgrass is difficult due to poor seed quality and slow germination rate. Recent studies indicated that poor seed quality and improper planting dates are the most important factors that make the establishment difficult.

Therefore, dallisgrass seeds should be tested for germination prior to planting and seeding rates should be adjusted according to the quality of the seed. Seeds of unknown or untested quality must be tested just before planting (Lewis, 1956).

Figure 7. Germination test (Dallisgrass) (Bilgin et al., 2012-2020)

The dallisgrass is usually planted in early spring, and seeds germinate 10 to 15 days after the planting. Care should be given to control the weeds in the newly established pasture. Weed control is very important in the early stage of the dallisgrass establishment as weeds will compete for water and nutrients with the dallisgrass. Since seedlings are weak at this stage, weed control will contribute to the decrease of competition and facilitates the establishment. Therefore, the land should be cleared of weeds before planting, and then seedbed should be prepared to provide the best soil-seed contact. The interrow distance should be set as 50 cm and the seed amount for planting should be around 10 to 15 kg ha^{-1}. The seeds are very small; thus, the sowing depth should be between 0.7 and 1.3 cm, and after planting, a harrow or roller should be used to obtain a minimum soil cover above the seeds (Hatipoglu and Tukel, 2009).

Paspalum dilatatum can be cultivated vegetatively. Cultivation of dallisgrass using sprigs should be carried out at the beginning of the rainy season when the soil gets moist. In addition, the land should be prepared well before planting. Dallisgrass sprigs are obtained by separating the plant, which is uprooted from the old vegetation, into pieces with rhizomes. When these sprigs are planted in the soil, they can be established easily and quickly.

Figure 7. Cultivation of dallisgrass using sprigs (Bilgin et al., 2012-2020)

Figure 8. The land planted of dallisgrass using sprigs (Bilgin et al., 2012-2020)

FERTILIZER APPLICATION

The chemical composition or nutritional value of the forage obtained from Dallisgrass varies depending on many factors such as the variety planted, the growth stage at the time of harvest, the type and productivity level of the soil cultivated, plant available soil moisture and the season. Protein and phosphoric acid contents are the two most important components of the forage. Forage containing less than 6.0% protein and less than 0.33% phosphoric acid is considered insufficient for cattle feeding. The protein content of the forage obtained from Dallisgrass varies with the season of harvest and fertilizer application. Appropriate fertilization is effective in maintaining an adequate protein level (Lewis, 1956). Dallisgrass responds well to fertilization, and fertilizer application should be carried out based on the soil analysis. The results of studies carried out to determine the response of fertilizers on growth and growth parameters of dallisgrass revealed that fertilizer application at 134 kg N ha^{-1} rate significantly increased the yield and yield components of dallisgrass. In addition, fertilizer application increases the tolerance of dallisgrass to frequent defoliation and preserves feed quality longer throughout the growing season compared to other perennial C4 grasses (Davies and Forde, 1991; Evers and Burson, 2004).

FORAGE YIELD AND QUALITY

The nutritional value of dallisgrass decreases with the blossoming. Crude protein content varies with the age of plant and the available nitrogen content of the soil. The average crude protein ratio of forages obtained from dallisgrass grown in the Çukurova Region was between 11.81 and 14.10%. In addition, the highest forage green yield was recorded as 45.78 t ha^{-1} and the highest forage hay yield was 13.12 t ha^{-1} (Bilgin et al., 2019).

Figure 9. The regional yield test in the breeding program (Dallisgrass) (Bilgin et al., 2012-2020)

Grass-legume mixtures are widely preferred due to their higher total forage and protein content compared to pure grass cultivation. The mixtures offer several potential advantages over pure grass or pure legumes stands. The legumes-grasses mixtures offer a balanced diet for animals due to the higher forage and protein content. Some researchers reported that growing warm-season grasses with legumes resulted in higher dry matter yields than pure plantings (Aganoglu and Tansı, 1985; Gökkus et al. 1999; Tessema and Baars, 2006; Çınar et al. 2014). The average green forage yield for *Paspalum dilatatum* in pure standings and alfalfa + *Paspalum dilatatum* mixtures were reported as 34.30 t ha^{-1} and 60.03 t ha^{-1}, respectively (Çınar et al., 2012).

Figure 10. Dallisgrass-alfalfa (*Medicago sativa* L.) mixtures (Bilgin et al., 2012-2020)

Harvesting, Threshing and Post-Harvest Handling

P. dilatatum is resistant to overgrazing due to the improved root system. The grazing should be carried out at the beginning of flowering so that the stem height remains approximately 7.5-10 cm. After flowering, *P. dilatatum* can be infected with the ergot fungus, *Claviceps paspali*, which is toxic to animals; in this case, the nutritional value of the forage decreases rapidly (Owen, 1951).

Figure 11. The beginning of flowering (Dallisgrass) (Bilgin et al., 2012-2020)

The average quality and yield of dallisgrass is sufficient, however, it is not widely used for hay production in general. However, the plant should be cut for straw just before seed is formed to avoid the ergot fungi infection. The dallisgrass can be harvested manually using a rotary mower or a sickle. Before baling and storing the straw, the seeded dallisgrass should be threshed to remove the ergot contaminated seed. This practice enables the removal of seeds contaminated with ergot fungi and reduces the risk of animal poisoning due to the ergot fungi infection. In addition, clean seeds can be separated and some seeds can be stored to be used for planting in the next season (Owen, 1951).

Figure 12. Harvesting (Dallisgrass) (Bilgin et al., 2012-2020)

P. dilatatum can produce a large number of seeds, but the mature seeds fall off immediately, as the seeds are not homogeneous in maturity. Seed harvest is carried out when 60 to 80% of spike clusters are light brown in color (Owen, 1951).

The harvest in fields used entirely for seed production can be carried out three or four times during a growing season.

Figure 13. The suitable time for seed harvest (60-80% of the spike bunches light brown) (Bilgin et al., 2012-2020)

Harvesting can be accomplished by various methods. The most common harvesting methods are directly combining or mowing, clustering and combining from heaps. Combinerun seed contains an abundant green seeds and should be dried before storing. Drying can be carried out by spreading the harvested plants under sun light or by artificially drying them at 43 to 48 °C until the moisture content decrease to 10 to 12%. Seed yield of dallisgrass varies between 90 and 50 kg ha-1. Dallisgrass seed is short-lived, therefore, half of the stored seeds lose the vitality in the second year and 80% of the seeds loses the vitality in the next year. The studies revealed that that seeds stored for more than three years completely lose their germination ability (Owen, 1951).

Figure 14. Seed (Dallisgrass) (Bilgin et al., 2012-2020)

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CHAPTER 8

PERENNIAL WARM SEASON GRASSES; CULTIVATION OF RHODES GRASS (*Chloris gayana* L.) AND DALLISGRASS (*Paspalum dilatatum* Poir.)

INTRODUCTION

Warm-season (C4) grasses, including Rhodas grass (*Chloris gayana* L.) and dallisgrass (*Paspalum dilatatum* Poir.) are the important forage crops for ruminant livestock feeding in the tropical and subtropical regions of the world. Many C4 grasses spread from their origin to other regions of the world and now used forage, grain, turf, or conservation plants. The C4 grasses are photosynthetically efficient at higher temperatures, therefore well adapted and produce high yield under warm climate condition. Most of C4 grasses can also be grown under temperate climate zone and produce higher biomasses.

Chloris gayana originated from South Africa was discovered by Rhodes following the well-known Cecil Rhodes, who popularized the plant (Moore, 2006). The Rhodes grass is used both as green forage or hay, and gladly consumed by animals due to the taste and high nutritive value. Rhodes grass harvested at the beginning of flowering or a little earlier is commonly used as hay (Yenesew et al., 2015). The Rhodes grass currently cultivated in most of the tropical and subtropical countries such as India, Pakistan, Australia and the USA. After introducing by soldiers at the beginning of the 20th century, Rhodes grass become the most widely grown warm season grass in the Western Australia (Moore, 2006).

Figure 1. Rhodes grass (*Chloris gayana*) (Bilgin et al., 2012-2020)

The Rhodes grass can use up to 80% of available sunlight and utilizes available soil moisture to accumulate biomass. The Rhodes grass grows well under sunlight; thus does not grow well under shade. Therefore, Rhodes grass is considered a suitable cover crop to sequester atmospheric carbon in regions with abundant sunlight. In addition, Rhodes grass is used as intercropping in orchards such as macadamia, coffee, and papaya (Hector and Jody, 2002). Intense horizontal rooting system and ability to bind soil particles forming stable soil aggregates help conserving lands from soil erosion (Tewodros et al., 2012, Yayock and Owonubi, 1986).

CHARACTERISTICS

Rhodes grass, a perennial or annual C4 leafy grass widespread in subhumid tropical and subtropical regions. The culms are stoloniferous, tufted or creeping, and the stem is fine and grows up to

0.5 to 2 m height depending on the habitat. The leaves are linear, with smooth or folded glabrous blades, 12–50 cm long and 10–20 mm wide (Na Allah and Bello, 2019).

Figure 2. Rhodes grass, stolon state (Bilgin et al., 2012-2020)

The Rhodes grass has plenty of leaves, which are light green in color, soft and slightly hairy. Three to 20 dense, spike like floral racemes are found on each panicle. The floral spikelets, each 4–15 cm long, have 3 to 4 florets (Hector and Jody, 2002). The blooms are light greenish brown or sometimes yellow in color and turn darker brown when they are mature. Plenty of very small seeds are produced in each plant. One thousand seed weight ranges from 0.3 to 0.6 g, and the number of seed per kg is between 7250000 and 9500000 (Trivedi, 2010: Tansı, 1988).

Figure 3. Rhodes grass a) Leaves of plant b) Flowering state (Bilgin et al., 2012-2020)

ENVIRONMENTAL REQUIREMENTS FOR RHODES GRASS CULTIVATION

Rhodes grass grows in different climatic conditions across the world and was reported growing in places where annual temperatures range from 16.5°C to above 26°C, with maximum yield at 30°C/25°C (day/night temperature). The Rhodes grass is usually cultivated in areas receiving an average annual rainfall of between 500 and 1500 mm. Whereas, Rhodes grass can be successfully grown at lower annual averages rainfall (<500 mm) and also temperature extremes (at 5°C or 50°C). Deep roots of Rhodes grass help to survive during dry seasons of up to six months and even up to 15 days of flooding (Cook et al., 2005, Harc, 2004; Ecocrop, 2014).

Figure 4. Flooding (Bilgin et al., 2012-2020)

Rhodes grass grows on mostly well drained soils with wide range of soil types. Drainage is an important constrain for seed production of Rhodes grass, and well drained fields are suitable for seed production. The aeration in clayey soils might be problematic; thus the plant does not grown well on very heavy clays, but grows well on light textured loamy and sandy soils. The Rhodes grass prefers soil pH between 5.0 and 8.3 (Hector and Jody, 2002); while some establishment problems have been reported on very acidic soils. The plant has high tolerance to salinity, which makes Rhodes grass particularly valuable in irrigated pastures. In addition, *chloris gayana* is tolerant to Li, but sensitive to Mn and Mg content in soils (Moore, 2006).

ESTABLISHMENT

The weed in a pasture that Rhodes grass will be planted should be removed from the field particularly at very early stage of Rhodes grass establishment. Weed control in the early establishment stage helps Rhodes grass plants to compete with weeds, facilitates establishment and increases further survival of plants. Another alternative weed control method is harvesting the Rhodes grass and weeds together.

Selective herbicide such as 2,4-Diklorofenoksiasetik acid may also be used to control young weeds with broad leaves (HARC, 2004).

The seeds of Rhodes grass is very small which requires a finer soil structure; thus seedbed should carefully be prepared. The weeds on soil surface should be cleared before ploughing, and the land should be ploughed at a suitable moisture content to obtain a fine and smooth seedbed for better contact between seed and soil particles (Fekede, 2000). Appropriate seedbed preparation increases the success in seed germination, seedling emergence and growth (CASCAPE, 2015).

Figure 5. Rhodes grass a) Seedling b) Seed (Bilgin et al., 2012-2020)

Planting should be carried out before the rainy season starts to enable sufficient available soil moisture needed to support germination of seeds and establishment of Rhodes grass. The germination of Rhodes grass seeds starts to germinate within 7 days after sowing (Moore, 2006). Seeds should be placed at 1.0-1.5 cm depth of soil surface. Deep burying of seeds may cause to failure or inadequate germination of seeds. The germination of Rhodes grass seeds will take place under slightly cooler conditions than needed for most of the summer growing grasses (Na Allah and Bello, 2019).

Rhodes grass establishment in a field can be carried out either vegetative using sprigs or using the seeds. Quality of seed (germination ability and purity), method of sowing, environmental conditions and field preparation significantly affect he rate of seed that will be used in planting. The seed rate, considering the aforementioned factors, is recommended to be between 3 and 15 kg ha^{-1} (Na Allah and Bello, 2019). Tansı (1988) indicated that 10 kg seed ha^{-1} applied with a seeder is sufficient to establish a good Rhodes grass cover. The highest yield under Çukurova ecological conditions was obtained with using 20 to 30 kg seed ha^{-1} in planting.

Cultivation of Rhodes grass using sprigs should be carried out at the beginning of the rainy season when the soil is sufficiently moist to encourage germination. Rhodes grass sprigs are obtained by separating the plant taken from the old vegetation into stolons. In addition, preparation of a good seedbed is an important factor affecting the success in establishment of Rhodes grass using sprigs. The sprigs planted rapidly grow and cover soil surface (Tansı, 1988).

Figure 6. Vegetatively (root splits) establishment of Rhodos grass (Bilgin et al., 2012-2020)

Figure 7. Vegetatively as established Rhodos grass (Bilgin et al., 2012-2020)

The seeds of Rhodes grass are very small and light; thus are difficult to handle. Rhodes grass can be row sown using a planting machine or broadcasted, which require 10–20% more seed compared to row sowing. Mixing seeds with soil or sand ma increase the success in broadcasting. A harrow or a roller should be used to cover the seeds following the broadcasting to increase the germination rate of by increasing seed-to-soil contact. Traditional drill planting provides proper seeding rate and depth and ensures that the Rhodes grass seeds are covered by soil and the intrarow spacing in traditional drill sowing should be 20 cm (HARC, 2004). Irrigation after sowing speeds up the establishment. Mixing soil after planting may reduce the germination rate, when seeds are buried below 1.5 cm deep.

Figure 8. The seed of Rhodes grass (Bilgin et al., 2012-2020)

FERTILIZER APPLICATION

Fertility level of soil is an important factor in Rhodes grass which is sufficiently productive in moderate to high fertile soils. Essential plant nutrients should be applied for a satisfactory Rhodes grass yield, when nutrients are deficient in soil. Therefore, application of nitrogen and phosphorus fertilizers is recommended. Fertilizer application rate at planting is 100 kg DAP (di ammonium phosphate) ha^{-1} at planting and 50 kg urea ha^{-1} after the establishment and every harvest (ESGPIP, 2008). In addition to increasing biomass, fertilizer application increases both the nutritional value of the product and the overall yield. If the pastures planted in Rhodes grass are maintained and fertilized regularly, the pasture will continue to provide high herbage yield for up to five years. The usual productive life of Rhodos grass is three years; however, this period can be extended with optimum fertilization (CASCAPE, 2015).

FORAGE YIELD AND QUALITY

The nutritional value of Rhodes grass decreases after flowering. Crude protein content varies with the age of material and available nitrogen content on a dry matter (DM) basis may range from 3% in old leaves to 17% in very young leaves. The in vitro dry matter digestibility (IVDMD), which is used to evaluate the nutritional value of ruminant feeds, varies from 40 to 80% (Cook et al., 2005).

Cultivation of grass and legume in mixture offers many potential superiority over cultivation of pure grasses or pure legumes. Mixtures are more commonly preferred over pure grass forage stands due to their higher total yield and protein content and balanced nutrition contents. Many researchers have reported that growing legumes and warm-season grasses together provides higher dry matter yields than pure standings (Aganoglu and Tansı, 1985; Gökkus et al. 1999; Tessema and Baars, 2006; Çınar et al. 2014). The average green forage yield for *Rhodes grass* in pure standings and alfalfa + *Rhodes grass* mixtures were reported as 53.40 t ha^{-1} and 68.44 t ha^{-1}, respectively (Çınar et al., 2012).

Figure 9. Rhodese grass-alfalfa (*Medicago Sativa* L.) mixtures (Bilgin et al., 2012-2020)

HARVESTING, THRESHING AND POST-HARVEST HANDLING

Plants grow and cover soil surface rapidly and reach the harvest or grazing maturity 4 to 6 weeks after planting (Tansı, 1988). The highest Rhodes grass yield is usually obtained in the second year. The nutritional value decreases rapidly after flowering; thus, the plants should be cut at the beginning of flowering for the hay. After the first year of planting, the plants can be harvested at any time of the year when reach the optimum harvest stage. The harvested grass can be fed fresh to live animals or can be dried for hay to be given later. Rhodos grass is not suitable for silage, but will make good hay when harvested at the beginning of flowering or a little earlier. Toxicity related to Rhodos grass has not been reported in anywhere in the world.

Figure 10. The harvest time of Rhodes grass (Bilgin et al., 2012-2020)

Rhodos grass is highly tolerant to intensive grazing and cutting, but extensive defoliation causes significant decrease in yield. The results of studies revealed that cutting every 28 days is better than cutting at 14-day intervals. The harvest of the pasture, which consists of Rhodos grass, in the first year takes a few months. In irrigated conditions, 30 to 70 tons ha-1 forage yield can be obtained with 4 to 5 cuts per year (Sağlamtimur and Tansı, 1989).

Rhodes grass is a palatable forage; thus gladly consumed by animals. Therefore, overgrazing may degrade the quality of pastures. For this reason, adaptation of cut-move system instead of grazing system in pastures composed of Rhodes grass would be more beneficial. Regular cut and fertilization of pastures may extend the benefits of pastures for a long period. Since the grass is fire resistant, burning can be applied on mature Rhodes grass.

 

Figure 11. The hay harvest of Rhodes grass (Bilgin et al., 2012-2020)

Rhodes grass is a cross-pollinating plant; therefore pure seed plots should be isolated by 30 to 60 m apart from each other. The row spacing for seed production of Rhodes grass is recommended between 80 and 100 cm. The harvest time of seeds when nearly 10% of the seeds shed (Tansı, 1988). Mature seed can be easily removed by gentle rubbing or shaking.

Grain combine harvester or sickles can be used to harvest seeds. The dried seed should be stored in a clean and dry room in a bag. The seed yield of Rhodes grass ranges from 70 to 650 kg ha^{-1}.The mature seed harvested should be dried in shade for 3 days. The threshing should be carried out when most of the seeds harvested turns to yellow and the seeds readily are separated from the head. Threshing should be carried out in a clean ground or material using sticks. The seed should be separated from chaffs and weed seeds and dried over a shade place. The viability of mature seeds may be up to two years, while rarely over a year for immature seeds (Yenesew et al., 2015).

Figure 12. The seed harvest in Rhodes grass (Bilgin et al., 2012-2020)

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CHAPTER 9

SILAGE CORN AND IMPORTANCE OF SILAGE CORN IN CATTLE FEEDING

INTRODUCTION

Livestock sector is the fastest growing branch of the agricultural economy in developing countries. However, issues related to animal feeding are considered to be the most important factor negatively affecting the production in livestock. Feed production in many regions where animal husbandry is present is usually carried out in a certain period of the year, while forage production can't be carried out in the rest of the year. One of the main purposes of silage is to meet the forage needs of animals in periods when fresh fodder plants and other forages are scarce or grazing is not possible. In addition, silage feeding practices are carried out not only in certain periods but also throughout the year in modern livestock farms in the world, and various plant silages are included in animal feeding throughout the year. The digestible dry matter yield per unit area produced by plants such as corn, wheat and vetch is higher than the silage of other plants; therefore, they are preferred by the livestock sector (Driehuis et al., 2000). Corn silage is most commonly used silage. Silage corn is the most common silage feed plant in the world and in our country. The method of controlled fermentation and preservation of forage plants with high moisture content by converting the water-soluble carbohydrates in the plant body into organic acids, primarily lactic acid, in an anaerobic environment is called silage production (Weinberg and Ashbell, 2003).

Corn silage is commonly consumed by ruminant animals. The corn silage is a nutritious feed source due to the taste and high energy value (Anonymous, 2018). Corn is one of the most commonly cultivated plants for silage both in the world and in our country due to the high energy, suitability for mechanized agriculture from planting to harvest, easiness in storage and usage, low loss ratio, high dry matter yield, high digestibility ratio, high quality and delicious silage feed, high yield per unit area, availability of seeds, ability to be ensiled without any additives (Acıkgoz et al., 2002). Corn is an ideal plant that can be stored without additional preservatives due to the sufficient sugar content, provides the highest digestible nutrients per unit area, has a delicious and high nutritional value, can be stored in silo for a long time and can be consumed as fresh-juicy feed in winter (Turan and Yılmaz, 2000).

Importance of Sowing And Harvest Time In Silage Corn

Corn, one of the oldest known field crops, is an increasingly important warm climate grain with high unit area yield (Anonymous, 2018). The cultivation area of corn, which has a versatile area of use in the world, continues to increase for green fodder and silage purposes. High yield per unit area, suitability for silage production and high feeding value of the obtained silage are the most important reasons for the preference of corn in livestock feeding. Silage corn varieties registered by international companies are mostly preferred by farmers. However, domestic companies and public research institutes recently started to breed silage corn varieties with high yield and quality. Especially, Ada-coded, AGA and Samada-07 varieties released by Sakarya Agricultural Research Institute are preferred by producers (Tas, 2020).

The production cost of silage corn from planting to harvest is not high; thus, silage corn is used extensively in animal feeding. One of the most important factors determining the potential of varieties in silage corn cultivation is the planting time. The planting time in regions where the temperature is high is postponed and carried out in the last week of June, while in the regions where the temperatures are not high, the planting takes place in April under main crop conditions. Corn varieties with high physiological FAO maturity group are the main crop and varieties with low FAO maturity group should be planted under the second crop conditions. Since high temperatures negatively affect vegetative growth and pollen viability, planting time is postponed. Genetic and environmental factors have a significant impact on the maturity period of corn. The studies revealed that late maturing varieties accumulate more dry matter than early varieties; thus, corn varieties should be chosen based on the planting time (Colwille, 1966; Lee and Estes, 1982).

Corn is the most preferred silage crop due to the high biomass per unit area, suitability for silage production and the high nutritional value of the obtained silage. Silage yield reported in different parts of the world varies, and an average yield was reported between 50 and 100 tons ha^{-1}.

A large number of corn varieties allowed to be commercially produced in our country are suitable for grain corn and are also used for silage production. The vegetation period of the corn to be grown for silage production is an important factor. The presence of ear at harvest time is important for the yield and quality of the variety cultivated.

Because, 50% of the green yield and 70% of the feed value in corn are obtained from the cobs. Vegetation period in transitional climate region where second crop agriculture is carried out is shorter than that of the coastal regions. Therefore, the preference of an unsuitable corn variety in the transitional climate region causes harvesting most of the silage corn plants without an ear. The carbohydrate and protein content of the cobs ensure the occurrence of fermentation at the desired level. Otherwise, silo feed with low quality is obtained and the expected benefit from silo feed could not be achieved (Sahin and Zaman, 2010).

Field Preparation, Sowing and Harvesting in Silage Corn

For silage maize planting, the field is plowed using a plough, large soil clods are broken up with a cultivator or a disc harrow and the roller is used to prepare the seed bed. The corn seeds can be directly planted on wheat stubble in irrigated fields for second crop due to the high germination ability of corn seeds. Plant density in silage corn planting should be between 100.000 and 140.000 plants ha^{-1}. The interrow distance in silage corn planting should be between 65 and 70 cm and the intrarow distance should be between 14 and 16 cm. Harvesting of silage corn should be carried out when the grain on the cob reaches the 2/3 milk-dough period.

Characteristics of Corn Varieties Planted for Silage

a) Plant height should be tall

b) The number of leaves and the ratio of leaves should be high

c) The weight of cob with grains in the plant should be high

d) Stem diameter should not be too thick (Anonymous, 2013).

e) Should be resistant to lying down.

f) ADF, NDF and ADL values, which are important quality characteristics of maize for silage, should be <40%, <50% and between 5 and 7%, respectively (Tas, 2020).

g) Dry matter ratio of a corn variety used as silage should be between 25 and 35% (Tas, 2020).

In silage corn breeding, soft kernel varieties with low neutral detergent fiber ratio (NDF, 40%) and high digestible acid detergent ratio (ADF, 30%), that gradually loss the moisture of whole plant should be preferred instead of multi-grained varieties with strong stem and rapidly lose grain moisture. In other words, varieties with high net energy value in animal feeding should be considered as the silage variety (Dwyer et al., 1998).

Ensiling Process of Corn Silage

Silage feed is an important source of forage used in economical, balanced and adequate nutrition of ruminant animals, especially beef and dairy cattle, in countries where animal husbandry developed (Tumer, 1996; Avcioglu et al., 1998). There are several basic criteria that are extremely important and indicators to make silage from a plant, and reveal the ability of ensiling. These criteria are the dry matter level of plants, sugar content and buffer capacity (resistance to acidification). Considering these criteria, corn is "close to perfect" and alfalfa is the "hardest" crop in terms of ensiling (Bolsen, 1999).

Silage, which is gladly consumed by animals, is an indispensable source of forage for cattle and sheep farms in seasons when fresh green grass is not available. Corn silage, considered good in terms of energy, is more delicious and nutritious than other forages. In addition, silage decreases feed costs in beef and dairy cattle since obtained at low cost. Corn silage is a very important source of feed because it does not require much knowledge and experience in ensiling, it can be easily made by every farm, it does not require high costs, it does not require too much labor, and low nutrient losses compared to hay and other storage methods (Filya, 2000). The studies indicated that when the silage is not well compressed and covered in an airtight manner, nearly 50% of nutrient content of corn silage may be lost due to molding and other problems which occur after ensiling (Kilic, 1986; Alcicek and Asyali, 1997). Corn is usually harvested at kernel milk and dough maturity stage, chopped at 9.5-12.5 mm diameter and ensiled. Then, the chopped biomass is compressed with the tractor weight in the ensiling area. The compression time, dry matter ratio, compacted layer thickness and product transport speed are important factors in ensiling process (Jones et al., 2004).

Harvest, which is one of the most important stages in corn silage, should be carried out at the right time and at the appropriate humidity level to store the material in a suitable structure. This is an important issue needs attention for a good silage fermentation. Chemical and microbiological structures of plants, the highest yield and digestibility vary with the maturity period of the plants. Therefore, the most appropriate harvest time for corn plants to be ensiled should be when the kernels reach 2/3 milk-dough level (Roth and Beegle, 2003).

Stages of silage and reactions occurring in corn silage

The main principle of silage making is to rapidly reduce the pH level of the ensiled material and maintain anaerobic conditions to ensure lactic acid fermentation under anaerobic conditions. The silage process can be examined in four basic stages. The first stage is a process that starts with harvest and continues until 24 to 48 hours after ensiling and is called "Aerobic respiration period". In this period, atmospheric oxygen can easily enter the harvested and chopped plant tissue. Dry matter losses occur due to the respiration of living plant cells and the activities of compulsory or facultative aerobic microorganisms. The second stage, called "anaerobic fermentation period", starts after the oxygen available in the ensiled material is exhausted. This period continues for a few days to a few months depending on the silo conditions and the conditions of the material. At this stage, different groups of microorganisms (*lactic acid bacteria*, (LAB), *acetic acid bacteria, enterobacteria, clostridia bacteria, molds* and *yeasts*) develop anaerobically and compete with each other for nutrients in the environment. The LAB use plant sugars (glucose, fructose, and sucrose) to produce high amounts of lactic acid and some acetic acid to lower the pH of the environment, and rapidly become dominant in fermentation of well-ensiled silages. The third stage is called "Anaerobic rest period" or "Stable period", which starts after ending the fermentation ends and opening the silage to feed the animals. This period may last from a few weeks to a year. Fermentation does not occur during this period; thus, organic acid composition of the silage does not change during the stable period. The silage material remains stable as long as the pH level is low enough and oxygen or water does not enter from outside. The number of almost all types of microorganisms significantly decreases. Some acid-tolerant microorganisms (some yeast species) become inactive, some microorganisms such as clostridia and bacilli survive by forming spore. Some specific microorganisms (*Lactobacillus* and *buchneri*) remain active in low numbers (Driehuis et al., 1999). During the second and third stage, the protein fractions of the feed are break down into smaller polypeptides, amino acids, amines and ammonia by plant and microbial origin enzymes. This protein degradation process, which lowers the feed value, is known as "proteolysis" and ammonia concentration in silage is generally used an indicator to determine the level of proteolysis (Driehuis and Odue Elferink, 2000). These microorganisms oxidize the protective acids in the silage, and consequently the pH level of silage increases and other undesired microorganisms start to grow (Woolford, 1990). The fourth stage is called the feeding period, which starts with silage removal from the silo for animal feeding. Silage surface starts to expose intense oxygen entrance following the opening of the silo. During the feeding period, aerobic microorganisms consume sugars, fermentation products such as lactic and acetic acid, and water-soluble carbohydrates in silage and cause a large loss of dry matter and nutrients. These soluble components break down by respiration. Consequently, carbon dioxide and water in the silo are released and the temperature increases. Yeast and molds are the microorganisms which had a leading role in aerobic decomposition of silage (Muck and Pitt, 1993; Woolford, 1999). In addition to causing a loss of highly digestible nutrients in silage, some mold types produce mycotoxins and some other toxic compounds, which may negatively affect the animal and human health (Wilkinson, 1999). The LAB species associated with silage are belonged to the genera *Lactobacillus*, *Pediococcus*, *Leuconostoc* and *Enterococcus* (McDonald et al., 1991). The most important feature that distinguishes LAB from others is hte tolerance to acidic environments. The LAB can lower the silage pH level below to 4 or less. The LAB is divided into three group according to sugar metabolism as mandatory homofermentative, selective heterofermentative or mandatory heterofermentative. Obligatory homofermentative LAB hexoses ferment over 85% lactic acid using the Embden Meyerhof glycolytic pathway (Limsowtin et al., 2003). The second group, selective heterofermentative LAB which have hexoses and aldolase, can ferment pentose's and phosphoketolase enzymes. Selective heterofermentative follow the same pathway in fermenting glucose as obligatory homofermentative bacteria, and they follow the phosphoketolase-dependent pathway in the fermentation of pentose's (Panesar et al., 2007). The obligatory heterofermentative species follow only the phosphoketolase-dependent pathway in sugar metabolism for both hexoses and pentose's, therefore, they also produce carbon dioxide with lactic acid, with a significant amount of acetic acid or ethanol (Axelson, 2004). A significant portion of the corn silage in our country is used in feeding of dairy cattle, while a very small portion is used in beef cattle feeding (Alcicek and Karaayvaz, 2003). Corn silage is gladly consumed by animals due to high energy content; thus it is considered the 'best' of forage crops for silage (DLG, 1997).

The Importance of Corn Silage in Dairy Cattle

Forages, especially silage, are of great importance in improving the dairy farming economically. Silage corn is of great importance in cattle feeding due to the short-term cultivation, high yield and high energy value (Ak and Dogan, 1997). The most important forage used in feeding of dairy cattle is corn silage. The most important reasons for common consumption of corn silage in dairy cattle are potential to produce high dry matter per unit area, reliability and continuity of this potential, high energy value compared to other forage sources, high consumption potential by dairy cattle, ease in mixing into total rations, easy to ensile, suitability for mechanization and being an important source of physically effective neutral detergent fiber (NDF) (Fernandez et al., 2004; Keles and Cibik, 2014).

The use of high amount of forage in dairy cattle rations with high milk fat yield limits the dry matter (DM) consumption due to the low rumen transition rate of forages and causes a decrease in milk yield. In this context, silage corn hybrids with low lignin content and high NDF degradability may have positive effects on the performance of dairy cows (Gencoglu et al., 2008).

The fertility of dairy cattle is closely related to the feeding. Therefore, the diets of a dairy cattle should have sufficient energy, protein, vitamins and mineral substances. The effects of vitamins on fertility usually comes up during the winter months. The β-carotene, which is the precursor of vitamin A, is important in the winter period and that fertility is negatively affected in insufficient β-carotene content. The β-carotene deficiency can be compensated by feeding with corn silage during this winter period (Hafez et al., 1993).

The two most important elements that make up the dry matter of milk are fat and protein content. Fat content and fatty acid composition are affected by the forage/concentrate ratio of ration, forage source (Castillo et al., 2006; Vlaeminck et al., 2006), and fat composition of ration (Warntjes et al., 2008). The fat level and composition of the milk changes depending on the feed type, nutrient content and processing technology used in feeding dairy cattle. Milk fat synthesis increases with the increase in the short-medium chain fatty acid content of the feed (Sun et al., 2013). The results of a study conducted to investigate the harvest time on milk fat composition revealed that the increase in corn harvest maturity does not affect milk yield, but reduces the presence of omega-3 fatty acids (Khan et al., 2012).

Issues to be considered in dairy cattle feeding with corn silage

a) All kinds of sudden feed changes should be avoided in silage feeding.

b) Silage should always be given to dairy cattle after milking. Otherwise, the smell of the silage passes into the milk and the milk quality will be negatively affected.

c) Silage should not be stored in the barn and silage odor should be removed from the barn with the ventilation. Otherwise, the silage smell will pass to the milk and the quality will decrease.

d) The positive effect of cellulose on milk yield and milk fat content should not be ignored. When the cellulose level of silage is insufficient, hay should be given to the animals along with the silage.

e) Silage can be given to dairy cattle as much as they can consume. However, care should be taken to use silages treated with different chemicals or of low quality.

f) Calves and young cattle should be fed with corn silage with abundant grains starting from 4-5th weeks (Kutlu, 2001).

The Importance of Corn Silage in Beef Cattle

Profitability in livestock breeding depends on many factors. Feed expenditures with a ratio of up to 70-80% in total expenses are the most important meat production expenses. Decreasing the cost of feed is the most important tool in increasing the profitability. Daily live weight increase is very easy in farms with high quality forages. Corn is the most suitable and most preferred crop for silage due to easy to ferment in water-rich forages, profitability and convenience for the second crop. In terms of feed value, 80-90 tons of corn silage obtained from a hectare is equivalent to approximately 25 tons of barley. Corn silage can provide a daily weight gain of 600-700 g in livestock without any additional feed. Livestock fed with concentrate rather than forage will be fattier, whereas the ratio of meat will be higher in corn silage based feeding compared to the fat ratio (Khan et al., 2012). Livestock breeding based on silage will provide benefits both economy of the breeder and the country (Yaylak and Alcicek, 2003).

The causes of spreading corn silage in livestock breeding are widespread of corn cultivation, adaptation of silage corn varieties to colder climates, effective weed control and development of efficient harvesting tools, produces more green biomass per unit area, growing as a second crop, maintains the quality for a long time following the harvest, consumed at a high level, contains high level of energy compared to other forages, needs less fertilizer than meadow, produces higher quality and cheaper silage, no additives for fermentation, suitability for the crop rotation, and the high moisture content of manure obtained from animals fed corn silage (Phipps and Wilkinson, 1985; Cete and Sarican, 1998).

Corn silage consumption varies between 1.5 and 2.5 kg per 100 kg live weight depending on the age of cattle, the dry matter content of silage and the concentrate feed level in the ration. The consumption of silage with a dry matter ratio of 30% and over gives better results. Two to three kg of crushed barley should be added to corn silage, when the dry matter ratio of corn silage falls below 20% (Phipps and Wilkinson, 1985). Daily weight gain in cattle obtained with corn silage is slightly lower than that of cereal feeding. In addition, many researchers reported that feeding with corn silage can replace the cereals, can be benefited more from the meat production ability of animals and may contribute more to the economy of the country. A cattle weighing 500 kg can consume up to 28 kg corn silage per day containing 30% dry matter (Alcicek et al., 1999).

Table 1. Daily silage corn consumption by live weight in beef cattle (Yaylak and Alcicek, 2003)

Live weight (kg)	Dry matter, (kg/day)	Corn silage (kg/day, 30 % DM)
100	1.5	5
200	4	13
300	6	20
400	7	23
500	8.5	28

Table 2. Feeding plan of corn silage (30% dry matter) in beef cattle (Alcicek and Karaayvaz, 2003)

Live weight (kg)	Feeding Time (week)	Increase in Live Weight (g/day)	Silage Needed, (kg/day)
175-250	1 – 10	1100	9
250-350	11 – 22	1150	13.5
350-450	23 – 33	1300	18
450-550	34 – 45	1200	19.5
550-600	46 – 55	1100	21
Total	55	1170	6230

Corn silage can give good results in the feedlot as well as in all dense feed systems. The feedlot, where cattle stays constantly and corn silage is supplied during the feeding period, is the best way to convert corn silage into money. This system can also be used in closed shelters. The most important thing is to provide good ventilation to reduce respiratory diseases. The manger length per animal in feedlot barns varies between 0.3 and 0.6 m depending on whether the feed is always in front of the animal or not. In order to support corn silage with mineral substances, 50 g mineral substance mixture per animal per day consisting of macro and micro elements at the beginning of the fattening and 120 g per day towards the end of the fattening should be added to the ration (Alcicek and Karaayvaz, 2003).

Corn silage has low protein, though high in energy value. Therefore, corn silage can be used as a basic feed in all production systems of dairy calves and in bull fattening. Calves can be fed with corn silage from 3 months to slaughter age, together with a small amount of protein, vitamin and mineral additions. There are researchers who emphasize that corn silage with high kernel content can be used from the 4th week on feeding calves. Corn silage can be given to dairy calves, which are under early weaning program, about three months old and the amount of corn silage can gradually be increased (Phipps and Wilkinson, 1985; Allen and Kilkeny, 1986).

CONCLUSION

The highest yields in developed countries where plant and animal production is carried out together, are obtained from both plant and animal production in the cycle. The model adopted by the modern world, started to be adopted and practiced in our country. Farmers have to produce their own feed to in the farm to lower the feed cost in livestock breeding. Silage corn is an important forage that is used extensively in integrated beef and dairy cattle farms. In addition to high yield in corn breeding programs, the quality characteristics (protein ratio, ADF, NDF, ADL, dry matter and energy value) of the silage corn varieties to be improved should also be at a desired level.

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CHAPTER 10

CONSERVATIONAL TILLAGE SYSTEMS FOR FORAGE CROPS

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INTRODUCTION

Agricultural production, which has been the main source of life since the beginning of civilizations, is faced with important threats with the increase in population and a decrease in natural sources. The demand for food is increasing day by day depending on the population. However, the fact that nature's potential to respond to these demands is limited makes humanity worried about the future. In the past, significant increases in agricultural production have been achieved with the opening of new agricultural areas and the use of modern agricultural techniques and fertilizers. However, today the increases in agricultural production have approached the limit values. Moreover, serious concerns have arisen that production may decrease in the future due to ecological, economic and many other reasons. In this process, sustainability and efficient use of resources in agriculture has been the focus of attention more than the increase in production.

Sustainable agriculture includes systems and practices that improve the production of sufficient and quality food which are needed by the rapidly growing world population, at affordable costs, and the protection of the environment and natural agricultural resources. Thus, conservation tillage, along with some complementary practices such as soil cover and crop diversity (FAO, 2016) has emerged as a viable option to ensure sustainable food production and maintain environmental integrity. In this respect, conservation tillage includes protection applications not only for the soil but also for all the natural resources.

The plow, which began to be used in the 6th century, is a revolution in agriculture and is the origin of modern tillage. Tillage is an indispensable element of conventional agriculture today and has become an important component of plant production. Tillage has many benefits such as soil preparation for seeding, reducing weeds, shuffling fertilizers and pesticides into the soil, smoothing the land surface, aerating and loosening the soil, and mixing plant residues into the soil. Tillage has a noticeable impact on the physical, chemical and biological properties of soil through different magnitudes. Continuous tillage can lead to a degradation of soil structure and low levels of soil organic matter, which could result in the formation of compressed surface or sub-surface layers that prevent root growth, restrict the movement of water and air and consequently decrease in yield. Additionally, conventional tillage may lead to high moisture loss and disrupt the lifecycle of beneficial soil organisms. Conventional tillage is also seen as one of the main causes of soil erosion, especially in uncontrolled conditions. So, there is increasing awareness all over the world of the negative effects of conventional agriculture and the need to change traditional agricultural practices. Over tillage loosens soil particles and making them susceptible to the erosive forces of wind and water that result in less-fertile farmlands. Through water and wind erosion, 15% of the world's agricultural lands have been exposed to high erosion and 40% are still under threat. Turkey’s arable land is mostly at risk of water (55%) and wind (5%) erosion. In addition, there is low organic matter content is 69% of the land as a result of applications such as continuous stubble burning or stubble collecting after harvest as well as continuous and non-rotational agricultural production throughout the country. Severe degradation of soil from wind and water erosion during the late 1800s and early 1900s led to the development of improved conservation tillage practices. These practices not only prevent erosion but also raise soil quality and soil fertility keeping the harvest residue in the soil and increasing soil organic carbon accumulation.

Conservation tillage (CT) has been defined as any tillage or no-tillage operation that maintains plant residues on at least 30% of the soil surface after tillage activities. The most common forms of CT are no-tillage, reduce-till, and mulch-till. No-till is defined as planting into unprepared soil and not disturbing more than 1/3 of the soil surface, ridge-till is defined as planting on ridges/rows formed during cultivation the previous year without disturbing the inter-row area, and mulch-till is defined as - full-width tillage that leaves more than 30 percent residues on the soil surface after seeding (CTIC, 2001).

CT is a concept that emerged in the United States after the dust bowl of the 1930s. So, there has been almost 90 years of the developmental history of CT involving research, machine development, herbicide development, innovations introduced by farmers, crop and fertilizer management, etc. CT is practiced on 45 million ha worldwide, predominantly in North and South America Some countries such as Brazil, Argentina, and Paraguay already produce 50% or more of their food by CT, it is estimated that worldwide CT currently accounts for only some 16% of food production. In Turkey, this ratio is 0.3% of the total field land. The most important reason for these low rates is that farmers consider mainly yield and short-term profit. Namely, instead of leaving a legacy of better land for future generations, farmers tend to prefer the short-term reality of feeding the present generation and making a living. Two basic reasons that transition to conservation tillage systems could be explained by ecological and economic factors. CT is the most expensive, complicated, organizationally slow system and need great energy and labor, on the other side it is also an ecologically unfavorable way of soil tillage (Zugec et al., 2000). CT systems have been planned with the aim of providing sustainable agriculture. The key element of sustainable agriculture is the soil-plant-nutrient cycle by improving the self-biotic recovery capacity of the soil In addition, the important of CT systems that enabling agricultural production to be less affected by changing climatic conditions will more increase in the future.

1. Conservation Tillage (CT)

CT, by most definitions, embraces crop production systems involving the management of surface residues (Unger et al., 1996). The main purpose of CT systems is provided to agronomic, economic, and environmental sustainability in agriculture. CT techniques maintain plant residues on at least 30% of the soil surface after tillage activities. In this way is minimizing the impact of water and wind erosion. When crop residues are properly managed they protect soil resources; enhance soil quality, restore degraded ecosystems, improve nutrient cycling, increase water conservation and availability, enhance pest suppression, reduce runoff and leaching of nutrients and sustain crop productivity and profitability (Lal, 1995). Actually, CT should be considered as combined with other practices to enhance environmental management, crop profitability, and agricultural sustainability. These complementary practices which are already used on agricultural lands include cover crops, crop rotation, sowing practices, integrated pest management, and crop nutrient management (USDA, 2001). CT system combined with these practices can be applied in 3 methods.

1.1. Conservation Tillage Methods

1.1.1. No-Tillage

No tillage system is a type of CT consisting of a one-pass planting and fertilizer operation in which the soil and the surface residues are minimally disturbed (Parr et al., 1990). According to Lal (1995), no tillage systems eliminate all pre planting mechanical seedbed preparation except for the opening of a narrow (2-3 cm wide) strip or small hole in the ground for seed placement to ensure adequate seed/soil contact. No tillage system is practiced and experimented almost all over the world. Especially, no tillage system (direct sowing, direct drilling) has been successfully applied in regions with an average annual precipitation between 200-500 mm. In addition, with direct sowing in arid regions with a good planning, better storage of water in the soil and consequently an increase in productivity lower energy costs per unit of production can been provided (Parr et al., 1990). In direct sowing system, weed control is generally achieved with herbicides or in some cases with crop rotation. In recently, this system applied on an area of approximately 160 million hectares from Finland to tropical areas (Kenya and Uganda) and to an altitude of 3,000 m above sea level (Bolivia and Colombia). It is successfully applied in different ecological conditions, from dry farming conditions (Morocco and

Western Australia with 250 mm / year rainfall) to very heavy rain Brazil (2.000 mm / year) or Chile with 3,000 mm of precipitation (FAO, 2016). In addition to these, non-cultivation agriculture, from half a hectare in China and Zambia to 1000 hectares of large farms in Argentina, Brazil and Kazakhstan, in areas with very different soil contents from 90% sand containing soils in Australia to 80% clay in Brazil, It can be applied easily by using additional machine parts (Tekin et al., 2017). The direct sowing system also contributed to the expansion of agricultural areas, as it made it possible to do agriculture even in areas that are marginal in terms of rainfall and productivity (Friedrich et al., 2012). Besides, almost all types of plants, including root and tuber crops, can be grown under no-till farming systems (Derpsch and Friedrich, 2009).

Many studies (Raper and Bergtold, 2007; FAO, 2008) have reported the success of no-tillage systems in many parts of the World. Parr et al. (1990) reported that no-till is practiced on less than 10% of the farmland in the USA. In recent years, this rate has exceeded 22%. Although no tillage is used extensively in many countries, the situation in Turkey is not at a wanted level. The success of direct planting depends on the use of timely and appropriate equipment. The non-tillage system, which is the most used among the conservation soil cultivation methods, has many advantages. Some of these advantages are up to 80% fuel savings, time saves compared to at least one tillage agriculture, up to 60% fewer person-hours per hectare, labour saving , soil organic matter improve, etc. (Baker et al., 2007).

Figure 1. Corn planting with no tillage system after wheat. (https://www.no-tillfarmer.com/articles/489-no-till-movement-in-us-continues-to-grow?v=preview)

1.1.2. Reduced Tillage

Reduced-minimum soil tillage is a system where the soil is treated once or twice without turning over, and at least 1/3 of the soil surface is covered with plant residues after sowing. This system includes different types depending on field ecological conditions or crops.

In-row subsoiling

The soil surface and residue are left undisturbed except for strips up to one-third of the row width. Within these strips, the soil below the surface is disturbed or loosened using shallow tillage implements. In-row subsoiling is non-inversion tillage. Other names for in-row subsoiling include ripping, row-till, and slot till.

Strip-till

Strip-till, retains a number of the benefits of no-till, but disturbs the row or zone using tillage practices only where the next crop will be planted. The space between the rows is covered with residue. Strip-till improves the seedbed environment, disturbing the soil only in a narrow zone up to 6–8 inches wide and 6–8 inches deep. This tillage practice is commonly done concurrently with planting and can be combined with in-row subsoiling to break up compacted soil layers (Licht and Al-Kaisi, 2005; Morrison, 2002).

Ridge-till

Ridge-till allows sowing in ridge created during maintenance or after harvest and to keep them in the same place every year. Specialized cultivators are used to forming and retain permanent ridges on which cash crops are grown. Crops are planted on the top of the ridge after removing residue, which is left between ridges.

Figure 2. Buffalo ridge-tillage seeder planting cotton into barley cover crop residue, Borba Farms, Riverdale, California. (https://www.researchgate.net/publication/237816063_Classification_of_Conservation_Tillage_Practices_in_California_Irrigated_Row_Crop_Systems).

1.1.3. Mulch-Tillage

Mulch-till uses chisel plows, field cultivators, disks, sweeps, or blades to till the soil before planting. The tillage does not invert the soil but leaves it rough and cloddy. Various chisel points or sweeps attached to the shanks affect the amount of residue cover left on the soil surface. Fall chiseling should be done to a depth of 8-10 inches, and spring chiseling should be no deeper than 6 inches. Disking or other shallow tillage operations can be used in seedbed preparation. A standard, or tandem, the disk does not till as deep and leaves more residues on the surface compared to heavy (offset) disks. Herbicides and/or cultivation control weeds in a mulch-till system. The effectiveness of mulch-till systems in reducing erosion depends on surface roughness, amount of residue, and tillage direction.

1.2. Benefits of Conversational Tillage Systems

For sustainability, CT systems should meet current and future societal needs for food and fiber, ecosystem services, and healthy lives, and that do so by maximizing the net benefit to society when all costs and benefits of the systems are considered (Tilman et al., 2002). The most important benefits of CT systems are the sustainability of the ecosystem and mineral recycling in the soil.

1.2.1. Effect on soil

While Lal et al. (2007) indicated that intensive tillage and burning the crop residues lead to severe erosion especially under high-intensity rainfall and high wind speed. CT especially no-tillage can enhance soil aggregation, promote biological activity, and increase water holding capacity and infiltration rates. This leads to greater available soil moisture and higher organic matter content. Remain crop residue on the soil surface throughout the year cover the soil and reduces erosion more than one-third (Claassen, 2012) and nutrient loss (Lal, Reicosky and Hanson, 2007). Moldenhauer et al. (1983) reported that soil losses declined about 86 percent when no-till equipment used in northern Mississippi. Similarly, some researchers identified sediment losses were reduced significantly using *CT* in the Southern Coastal and Mediterranean zone (Triplett et al., 2008; Yakupoglu et al., 2020). Reduction in runoff which is one of the major benefits of CT, also offers great opportunity to reduce surface and even ground water pollution (Kukal et al., 1991). Duiker and Myers (2005) reported that the threat of surface water contamination is very small under no-tillage because of dramatic reduction in erosion (runoff), and because the herbicides are very quickly broken down by soil organisms into harmless compounds. *CT* methods increased water in soil and available water for plants (McVay et al., 2006; Kargas et al., 2012), because they have the higher micro porosity in soils. Su et al. (2007) found that the soil water storage quantity using no-tillage was 25% higher than conventional tillage during a six-year study.

One of the most important benefits of CT methods to soil is that it improves soil organic matter (During et al., 2002). The highest values of soil N, P, K, Ca and Mg were recorded in CT (Rahman et al., 2008) and it could be due to not the inversion of top soil with less fertile subsoil to the surface, since there is no tillage (Ali et al., 2006). Busari et al. (2015) revealed that minimum tillage resulted in significantly higher pH and organic matter than conventional tillage suggesting that less soil disturbance is beneficial to soil chemical quality improvement. Furthermore, Kemper et al. (1987) found that CT increased the activity of surface-feeding earthworms, leaving the root channels undisturbed. Also, soil organisms decompose organic matter mechanically (fragmentation) and chemically (mineralization) as nutrients.

Soil organic matter which is an important indicator of soil quality is largely composed of organic carbon. Soils constitute the third largest carbon source after oceanic and geologic pools (Lal, 2004a). Soil organic carbon is a significant determinant of soil biology, aggregation and structural stability. This in turn affects soil fauna and microorganisms, infiltration rates, available water-holding capacity, susceptibility to erosion, biochemical stabilization and availability of plant nutrients (Chambers et al., 2016; Utuk and Daniel, 2015). Managing carbon through CT systems increases carbon sequestration, resulting in improved soil productivity and production profitability. Another advantage of CT is on global climate change by decreasing carbon emission. Carbon dioxide (CO_2) is one of the important "greenhouse gases," and soils store an abundance of carbon. The amount of carbon in soils, three times more than is stored in live vegetation and two times more than is stored in the atmosphere. With conventional tillage, the soil is mixed and aerated, and decomposition of organic matter is speeded, releasing CO_2 to the atmosphere. By contrast, under CT, soils store much more carbon than under conventional till. Therefore, CT has an important place among the measures that can be taken against climate change (Krauss et al., 2017).

1.2.2. Effect on productivity

CT systems are gaining increased production of crops by improving soil water infiltration, increasing soil moisture and fertility. Actually, the crop yield is related to root growth (Boone and Veen, 1994), water and nutrient use efficiencies (Davis, 1994) and ultimately to productivity (Lal, 1993). An increase in root density has been found only in the upper soil layers of no tillage (Martınez et al., 2008) and reduced tillage (Lal, 1989) systems. Because soil compaction of deeper soil layers under NT may impede proper development of roots. Also, Malhi and Lemke (2007) determined a 22% increase in root mass under no tillage compared with conventional tillage, in connection with the higher number of bio-pores and worm. However, Busari and Salako (2013) observed that the macornize root masses under minimum tillage and conventional tillage were significantly higher than under no tillage. This could be attributed to the soil compaction under no-till impeded root development and the growth of the main root axes (Martınez et al., 2008) and conventional tillage increased root penetration (Shirani et al., 2002). Also, Busari and Salako (2013) emphasized that corn yield under a minimum tillage system is likely to be more sustainable compared with conventional tillage. Another factor that has an impact on plant growth and yield is climate change. And CT systems play a role in the products being less affected by climate change, with crop-residue management (Wang et al., 2006). Improved infiltration and increased organic matter in CT are especially important on dry soils and CT may prevent losses in the crop yield through a persistent dry period. Tillage reduces available moisture by about 1/2 (Amini and Asoodar, 2015). Riley et al. (1994) indicated that better results were observed under CT in dry years than in wet years. FAO (2012) the report stated that during Kazakhstan′s 2012 drought and high temperatures, wheat grown under no-till practices were more resilient, leading to yield increases over conventionally cultivated crops.

Crop rotation is one of the basic conditions for successful and sustainable CT. A well-planned crop-rotation system can help reduce many of the risks associated with CT and by eliminating many of the stress factors. Forage crops that reduce pest pressures and leave a nutritious and soft soil for the next plant for maximum success and economy are undoubtedly the most important components of crop rotation around the world.

1.3. Crop Rotation in Conservation System

Crop rotations are planned to increase crop yields by improving soil conditions and fertility, and minimize pest weed and insect pressures. A well-planned crop-rotation system can help producers reduce many of the risks associated with CT, such as increased soil compaction, perennial weeds, plant diseases, and slow early season growth. Furthermore, a well-planned rotation enhances the effectiveness of forage crop establishment under CT systems, as required a good seed-soil contact of many small-seed forage crops. In this system where heavy residue may interfere with seed germination, rotation plan is a key to success forage crop. A diverse crop rotation can enhance CT systems, but diversification must be suitable for soil, territory and equipment used (Derpsch, 2008). Using cover crops or heavy-residue crops in crop rotation increases soil-surface coverage, and provides significant soil conservation and economic benefits (Morton et al., 2006; Snapp et al., 2005). Forage-based rotations may include cover crop which allows integration of livestock into cropping systems and provide another innovative way to enhance crop rotations (Katsvairo et al., 2006).

Corn can be grown successfully following corn in no-tillage system, but these fields can develop several challenging situations such as hard to control perennial weeds, leaf diseases and N deficiency. Continuous alfalfa sowing also result in lower forage yields by causing more potential damage some insects and weed (dodder) that prefer to hayfields, such as wireworm, mosaic virus, leaf grub, mildew, root borer. Long-term corn rotation after four years of alfalfa harvest may be an alternative, but due to their common hosts a quadruple rotation system with wheat-corn-barley can be applied directly to the fields without tillage and be better. This crop rotation is beneficial for both alfalfa as poaceae tend to reduce the growth of weeds. After two-year's corn, soybean can be included in rotation. In this way, many of the negative effects of third- and fourth-year corn are avoided; the soybean crop provides opportunities for weed control. Soybean leaves excellent soil structure and no heavy residue, therefore these fields makes them excellent candidates for CT systems, especially no-tillage (directly sowing). In four- years rotation, corn and soybean can be used with cereals both grain and forage purposes. This rotation increases forage production and helps reducing insecticide and nitrogen inputs. However, some researchers found that when a corn/soybean or corn/oat/forage rotation was used, no-till corn yields were similar or lover to tillage corn yields. Although many studies have investigated the effect of conservation soil tillage on crop yields, a lot of uncertainties still exist (Amini and Asoodar, 2015). These uncertainties can be solved by trying different rotations in CT systems in different soils and regions. No-till alfalfa establishment works well following corn silage for spring sowing and following a small grain for fall seeds. Consequently, planning to harvest corn silage in the third year of three-year corn/ alfalfa rotation could help improve the potential success of no-till alfalfa. Alfalfa also can be effectively sown no-tilled in the late summer following a spring-sown sorghum-sudangrass which is well competitive with existing weeds. Another choose that can be rotated with silage corn may be rye to maintain productivity. The rye helps loosen soil during the winter and evaluate excess nutrients left from the corn crop (Morton et al., 2006). Consequently, crop rotation should be an essential part of successful conservation tillage systems for economic, agronomic aspects and also sustainability.

1.4. Profitability in Conservation System

The main benefits of CT practices improve soil productivity and crop yields, thereby and this must inevitably result with increasing net returns (Bergtold et al., 2005). However, farmers take into account cash gains rather than long–term real gains such as water conservation, soil fertility, and sustainability. Profitability in CT depends on a number of factors, including effective management, soil suitability, suitable rotation, equipment selection, pest pressures, and climate. Low cost in CT systems over conventional systems primarily results from reductions in the use of labor and machinery. Another factor that will lower production costs is the inclusion of high-residue winter cover crops. Winter cover crops reduce weed pressure and improve water conservation, resulting in reduced pesticide and irrigation costs (Saini, 2005). Also, CT systems may provide additional income from grazing animals with winter cover (Anand, 2006). The decline in crop yield in the first years of CT and the fragmentation of agricultural land is other factors the obstructing profitability of conservation tillage. CT actually appears to be profitable as a system that reduces or completely eliminates the cost of tillage. CT systems with cover crops, especially legume forage, can reduce production risks (Derpsch, 2004). Also, a systematic crop rotation can improve the economy of CT by controlling weeds and diseases and by eliminating many of the stress factors. Butorac (1994) has been reported that well-drained soils light to medium in texture with low humus content, more profitable and respond best to CT especially to no-tillage. Conservation systems can significantly reduce crop losses during drought (Barnett, 1986).

Actually, the economy of CT is uncertain for farmers. On the one hand, it can be more expensive than conventional tillage for farmers because of higher chemical use. On the other hand, it can be less expensive because of decreased fuel and heavy equipment costs. The result depends on the balance between these opposing cost trends. Also, taking into account the benefits of these systems to the soil and environment, the conditions of regional and environment-based cultivation should be examined.

1.5. The Disadvantage of Conservation Tillage systems

In CT, the harvest residues remain in the field as a result of little and no-tillage of the soil and the sowing process is done on these residues. The most important problem in these systems; it may be necessary to use more chemicals due to hard to control of weeds and harmful pathogens, since the fields are not tillage. There is particular concern about perennial weeds becoming a problem after a few years of CT. With some CT systems, farmers often find that they have to use 14 - 37% more herbicides than they did use conventional tillage. Since harvest residues do not mix with the soil, the severity of pathogens may increase and new diseases and pests may appear that required the use of more chemicals. In addition, this system requires special sowing machines that provide a good seed-soil contact and can place the seed in moist soil and do this without clogging with residues on the surface. This may requires changes in existing seeder or purchase of new equipment and machines. Since the soil warms later in the CT system, the sowing time should be better adjusted compared to conventional tillage. Long-term CT may require the use of different techniques against different problems in weed control, fertilization and spraying. In addition, preventive farming systems require a high degree of management skills, so farmers require training and technical knowledge.

2. Integration of Forage Crops to Conservation Tillage Systems

Forage crops which are grown to obtain high-quality and high-yielding animal products, also play an important role in maintaining ground cover, preventing erosion, accumulating nitrogen in the soil and improving land condition. In other words, forage crops are seen as a group of plants that can best for soil and water conservation, which are the targets of CT systems. Also, forage crops contain a wide variety of plant species that can grow in different soil and climatic conditions. Forage crops, especially the legumes, which have the characteristics of increasing the yield of the plants that come after them, are also very important in the crop rotation. Also, forage legumes are indispensable plants of crop rotations because they improve soil organic matter due to dense root residues and rhizobium bacteria in their roots. On the other hand, fodder crops are important in rotation since their root structures such as rhizomes and stolon are good for erosion prevention and they leave softer harvest residues for sowing. Additionally, forage crops grown as second crops (silage corn, soybean and sorghum) and grains (wheat, barley and oat ect.) are successfully used in this system.

Forage production in CT can to consider as an opportunity to directly improve and diversify the animal productions, improvement the quality and biomass production in forage crops, and gradually engage the farmlands in the preservation. This integration reinforces the relevance and sustainability of agriculture. Forage crops are generally similar to arable crops for their establishment requirements by no tillage. Many brassica species are used for forage cropping, along with grasses, legumes and herbs, all of which require shallow seeding. But a wide range of cereal species are also used, often for whole-crop silage, which have a greater tolerance of the depth of seeding. Proper equipment selection is important for small seed forage crops, especially in direct sowing system. Otherwise, insufficient germination and emergence will result in significant yield loss.

According to FAO (2018), the most grown crops in CT systems are soybean, fodder crops and corn in the world, respectively. Forage crops as alfalfa which have traits such as deep rooting, good quality forage, and rapid grown allowing several cuts in the year and improve soil properties, are used under CT systems. To benefit of perennial forage includes the increase soil organic carbon and nitrogen, but also the facility of producing equivalent or greater yields compared with the conventional management (Posner et al., 2008). For example, organic forage-grain crop rotations showed comparable crop yield and higher profit than conventional crop rotations in three long-term forage production strategy in Canada (Drinkwater et al., 1998). Chen et al. (2019) reported that Reduced-tillage management enhances soil properties (carbon, nitrogen and organic matter) and crop yields in alfalfa-corn rotation in the Songnen Plain, China. In another study (Karunatilake et al., 2000), alfalfa and meadow brome grass mixture were established following three different annual crops under no-tillage and compared conventional tillage. Plant development, growth, and dry matter production in forages was examined, and zero tillage was better than conventional tillage. Results of these studies indicate that no-tillage is a feasible alternative for establishing forage crops, even where levels of previous crop residue are very high. In another study, it was conducted to evaluate the effect of summer crop rotation (sorghum or soybean), tillage system (no-tillage and conventional), and intercropping (corn and palisade grass) on crop yield (soybean and corn grain, sorghum silage and palisade grass dry matter) and soil nitrogen stocks (Gomes et al., 2020). This study has been concluded that no-tillage system resulted higher yields; 6% for soybean, 100 % for sorghum and 17 % for corn, when compared to conventional tillage. Effects of no-till and conventional till were studied in a corn-soybean rotation on a clay loam over a 4-year period, and in a sorghum-groundnut tillage trial on a sandy clay loam for one season (Thiagalingam et al., 1991). In study further report that applications of

30, 60 and 120 kg N ha^{-1} significantly increased flag leaf area of sorghum by 24, 41 and 47% for no tillage and 11, 24 and 44% for conventional till. The response to nitrogen of no tillage was much higher than conventional cultivations. Ngwira et al. (2012) examined the effects of CT practices on crop productivity, profitability and soil quality under the conditions encountered by smallholder farmers in two farming communities from 2005 to 2011. As a result, CT showed positive benefits on corn yield, with highest increases of 2.7 t ha^{-1} and 2.3 t ha^{-1} in mono-crop corn and corn–legume intercrop, respectively, than the conventional tillage.

Some studies on no-tillage forage establishment in annual crop rotations indicate that forage crop establishment can often be higher than under conventional tillage (Hart and Dean, 1986). However, CT systems can have neutral or negative consequences on yield of forage crops for reasons such as rotation, environmental and grown conditions. For example, high levels of previous crop residue can interfere with growth of no tillage crops (Cochran et al., 1977), and can limit the amount of light reaching the soil surface (Wolf and White, 1992). Allelopathic effects from phytotoxic substances produced from decaying residues have been shown to inhibit germination and establishment of subsequent crops (Hicks et al., 1989). Wolf and White (1992) concluded that previous crop residue had to be removed for successful establishment of alfalfa under no tillage, while Bahler et al. (1987) suggested that successful no tillage alfalfa establishment in oat stubble was achieved only if weeds and invertebrate pests (slugs) were controlled. Hernanz et al. (2002) investigated the effects of conventional tillage, reduced tillage and zero tillage farming methods on crop yields in the wheat-vetch and wheat-wheat rotations. As a result, they found that there is no statistical difference between the yields of the two alternations of tillage systems. In another study, corn (18%) and soybean (10%) yields under conventional tillage were increased compared with no-tillage, in a three-year study in United States. Despite the negative consequences in yields of zero tillage still, no tillage as it reduce machine and labor was more advantageous (Mourtzinis et al., 2017).

In Turkey, CT still has not reached the desired level despite it start long years ago. But it has been studied by many researchers to reveal positive and negative aspects of the CT systems in Turkey. Gozubuyuk et al. (2017) were determined the effects of different tillage systems with vetch, wheat and sunflower (in irrigated) and vetch, wheat and fallow (rainfed conditions) rotations on some physical characteristics of soil. For the 9-year in study, conventional tillage, reduced tillage and no-tillage practices were used. The results indicated that the highest bulk density and penetration resistance values and the lowest porosity were in the no tillage. Also, soil moisture content was the highest in no tillage. Yalcın (1998) tried six different systems in order to determine the most suitable seed bed preparation systems in silage corn cultivation as the second crop. It was determined that silage corn yield is the highest in conventional plowing method, but CT is important in terms of soil characteristics (soil water retention capacity, soil sinking resistance, volume of soil and porosity ratio). Korucu (2002) investigated fuel consumption, working time, soil organic matter and grain yield of the second corn under no tillage in two-year. As a result of two years, the highest fuel consumption and working hours were obtained in the classical tillage system, while the lowest fuel consumption and working hours were found in no tillage. While the highest grain yield was obtained by classical sowing method with 6831 kg ha^{-1}, it was followed by twin flat disc + 8 wavy disc with low mulch at 6758 kg ha^{-1}. Karabulut (2017) was determined the yield and some quality features of Hungarian vetch (*Vicia pannonica* Crantz) under no-tillage, reduced tillage and conventional tillage systems and different seed ratios during 2015 and 2016 seasons. At the end of two years, the processes did not differ from each other in terms of forage and grain yields, but grain protein content was found higher in no tillage. When efficiency and economy are considered together, it has been determined that zero tillage is more suitable for both hay and grain yield. Altıkat and Celik (2012) were determined the effects of different no-till seeders and tractor forward speeds on some of soil physical properties and seed emergence of summer vetch and winter wheat. According to obtained results, the no-till seeders with hoe type furrow opener provided better soil physical properties and the highest percentage of emergence than the other two no-till seeders. No-till seeders had a significant effect on the mean emergence time and percentage of emergence. Gozubuyuk et al. (2015) examined the effect of four different tillage practices in a Hungarian vetch–winter wheat crop rotation compared to fallow–winter wheat crop rotation for water use efficiency was investigated in a semi-arid region for three years. Tillage practices consisted of; Conventional tillage (moldboard plough + cultivator + combined harrows + precision seeder); reduced tillage-1 (cultivator + combined harrows + precision seeder); reduced tillage-2 (rotary power harrow + precision seeder) and no-tillage (no-till seeder). Experiment was conducted applying randomized complete block design based on split-plot trial plan. Water contents of soil were the highest in the no tillage. Although the amount of weeds in winter wheat plots was the highest in the no tillage practice (67.4 kg ha^{-1}) when considering three-year average values, grain yield in no tillage was also high (2652 kg ha^{-1}). Same authors indicated that the no-till vetch–winter wheat rotation could be more suitable than the conventional tilled fallow–winter wheat rotation due to the opportunity of high crop production in semi-arid regions.

Conservation tillage is a system by allowing continuous cropping to take place almost indefinitely without significant damage to soil structure. Animal holdings tend to produce continuous short-rotation silage and hay crops in response to forage requirement, and the use of these short-term rotations in *CT* increases their profitability. This is limited by the choice of forage species to those that can be converted into hay or silage. Legume forage crops in rotations are critical in *CT* for both soil fertility and balanced feeding of animals. *CT* provides the sustainability in agriculture and also flexibility that allows integrated animal and cropping systems to develop to new targets.

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CHAPTER 11

DETERMINATION OF MORPHOLOGICAL CHARACTERIZATION AND QUALITY VALUES OF EINKORN WHEAT (*Triticum monoccocum*) GENETIC RESOURCES IN NATURAL FLORA

INTRODUCTION

It has been determined that collecting, storing and using genetic resources is very important in order to increase agricultural production and keep it at a high level in the conditions of your day. It has been understood that it is necessary to protect genetic resources in the future (Anonymous, 2003).

Turkey, topography, climate and geomorphological aspects of a wide variety of shows, so it is also rich habitat types and in this case, the number of plant species endemism rate and also caused the increase. Davis (1965-85) and Davis et al. (1988) indicates that the total number of our plants with seeds is 8.745 and 2763 plant species corresponding to one third of this number are endemic species. Rock (1998), the number of plant taxa in Turkey has reached 10 754 in 3708 and their units (34.8%) reported to be endemic. Vural (2003), while Turkey has reported that a number of important crops and other plant species of origin or diversity center.

Collection of plant genetic resources in Turkey and has begun work on evaluating the first quarter of XX century. Turkish scholar Mirza Gökgöl, characterized by thousands of different types of over 18.000 wheat samples gathered from all over Turkey and also they have identified 256 new wheat varieties. Thus, Gökgöl, "the farmer varieties in Turkey, an endless treasure trove for plant breeders," he has set (Gökgöl, 1935; 1939).

Wheat farming in Turkey, dating back 10 000 years. Archeological studies on wheat which first appeared and where spread around the world, including the southeastern Turkey shows that the

Fertile Crescent Area (Harlan, 1995; Van Zeitz and Deer Roller, 1995; Karagoz et al., 2010). In Turkey, wheat (*Triticum* spp.) Many wild relatives, there are local varieties and botanical varieties. There is widespread particularly in the southeast Anatolia region, including in Turkey. Diploid wheat (einkorn wheat) first emerged in the Karacadağ region of southeastern Anatolia and spread to all over the world from here (Özberk et al., 2016).

In recent studies, it has been reported that the cultivation areas of local wheat varieties are gradually decreasing (Karagöz 2014; Kan et al., 2015; Morgounov et al., 2016). It've estimated, but not a statistical official information about the area where the cultivation of local varieties of local wheat and barley with the total cultivation area in Turkey could be up to 565 312 hectares (Karagoz, 2014). Among the local wheat varieties, it has been determined that the 11 varieties that are grown and find the largest cultivation area are Zerun, Ak Wheat, Red Wheat, Yellow Wheat, Karakılçık, Kırik, Einkorn Wheat, Koca Wheat, Topbaş, Şahman and Üveyik Wheat varieties (Kan et al., 2015). In our country, not every product grows in every region due to climatic factors, natural resources and economic factors. Some products specific to the region and some city are grown. Products that have increased in popularity, specific to the region or the city, are faced with the dangers of not meeting the needs in line with the increasing demand. The agricultural product that grows only in a certain region / city or is only demanded from that region / city is damaged by any disease, harmful and different climatic conditions, and it harms the regional and national economy. In this study, it was aimed to investigate the possibilities of growing einkorn in Bilecik, which is an event whose production and market is widespread especially in Kastamonu province.

In addition to all these, although einkorn plant can be found in the natural flora of Bilecik province, there is no einkorn wheat production in Bilecik province. The reason why our farmers who do breeding activities in Bilecik province do not prefer blackberry can be interpreted as not knowing the plant and not knowing its market share. With this study, benefits, morphological features and agriculture of einkorn plant in the literature; It was built for the purpose of being raised and recognized in the province of Bilecik, which is known for its proximity to big cities and richness of natural resources.

Einkorn wheat accepted as ancestor wheat; Different from durum and bread wheat, having a shelled structure, resistant to diseases and pests due to its single spike and tight husk structure, high competitive power in arid conditions and poor soils, having higher oil content and a higher yellow lutein ratio compared to bread wheat, It is also rich in protein, phenolics, tocopherols and carotenoids as a functional food compared to other wheat types, in addition to its health benefits associated with whole grain consumption and its medicinal properties such as its importance in human nutrition and blood sugar regulation. It is a very important breeding material (Karagöz et al., 1998). Seeds collected from Bilecik flora: location, date and time information sharing Turkey Seed Gene Bank donated in order to provide convenience to the breeder is an important step for the protection of genetic resources and bio smuggling fight.

METHODS

Diagnosis and Collection

Einkorn wheat Bilecik province, Gölpazarı district, Kurşunlu village location at 40 ° 14'32.8 ”N 30 ° 13'56.4” E coordinates, was identified according to Davis (1985) and the collection process was carried out. Morphological characters of plant populations were observed, IBPGR (International Plant Genetic Resources Fodder Crops Description List) and UPOV promotion lists of plant species were used in characterization. Quality values; It was conducted at the Field Crops Central Research Institute - Food and Quality Assessment Unit.

Germination

The seeds that were ready to be planted were germinated in the Bilecik Şeyh Edebali University Faculty of Agriculture and Natural Sciences Research and Application area by using sterile peat and perlite at a ratio of 3:1 and sown in voils (Figure 1, 2).

Figure 1. Preparation of viols for germination of seeds

Figure 2. Seeds germinated in viols

It has been ensured that a single plant is formed from seedlings grown in the plastic greenhouse.

Dislocation

The seedlings obtained were transplanted into the previously prepared field plot. Each row was 11.2 m long and 3 rows were planted and maintained, with 15 plants in a row (Figures 3, 4, 5).

Figure 3. Open pits for planting seedlings in the field

Figure 4. Seedlings planted in the pits opened in the field-1

Figure 5. Seedlings planted in the pits opened in the field-2

Maintenance / Cultural Operations

Soil Analysis

Before the fertilization process, soil analysis was made on the planted land. The results of this analysis are given in Table 1.

Table 1. Physical and chemical properties of the soil in the trial area

Research Area	Values
pH	8.11
Saturation	54
EC (dS m^{-1})	0.73
Salt (%)	0.026
$CaCO_3$ (%)	8.3
O.M. (%)	1.5
K (kg da^{-1})	1.1
P_2O_5 (kg da^{-1})	3.5
Cu (cmol kg^{-1})	3.837
Fe (cmol kg^{-1})	7.944
Mn (cmol kg^{-1})	6.735
Zn (cmol kg^{-1})	1.790

In the study, soil samples were taken from 10 different locations with a depth of 0-30 cm from the trial area in order to determine the soil properties and analyzed in the soil analysis laboratory of Eskişehir Geçit Zone Agricultural Research Institute. As a result of the analysis, the physical and chemical properties of the soil are given in Table 1. According to these results; The soil of the research area is sandy loam, medium alkaline and medium salty. In addition, it was determined that the amount of lime and organic matter in the soil of the trial area is medium and the amount of phosphorus and potassium is low.

When the soil preparation failed, organic mineral soil regulator mixture was applied to the soil. With the sowing, 6 kg / da DAP (diammonium phosphate) fertilizer containing 18% nitrogen (N) and 46% phosphorus (P) was applied. Unlike other wheat varieties, zinc sulfate was not applied due to the high zinc content of einkorn. Due to the rapid growth of the weeds during the tillering period of the einkorn wheat, 25 g / da + 100 ml herbicide application was made (Figure 6).

Figure 6. General view of plants

Climate Data

Table 2. The average temperature, relative humidity and total precipitation values for the year 2019 and long years average (LYA) in the province of Bilecik

Climate Data	Years	Months					
		January	February	March	April	May	June
Average Temperature (^{0}C)	2019	3.5	4.7	7.6	10.8	17.9	21.3
	LYA	2.6	3.6	6.7	11.6	16.2	19.7
Relative Humidity (%)	2019	77.1	75.2	57.9	65.3	59.9	66.6
	LYA	76.6	73.5	69.2	65.2	65.2	64.3
Total Precipitation (mm)	2019	51.6	70.6	16.5	40.6	32.4	163.4
	LYA	49.3	40.7	46.1	45.3	43.8	37.3

* **Source:** Bilecik Meteorology General Directorate.

The 2019 growing period and climate data for long years of Bilecik province are given in Table 2. When Table 2 is examined, it is seen that the average temperatures for January, February, March, April, May and June are above the long-term average with the values of 3.5, 4.7, 7.6, 10.8, 17.9, 21.3 0 C, respectively. In line with the climatic data, the einkorns were irrigated 3 times during the germination, stalk and yellow melting periods (Figure 7).

Figure 7. General view of plants

Harvest / Threshing

The einkorns, which reached the harvest maturity, were harvested with a sickle, then they were blended with a single spike threshing machine in Bilecik Şeyh Edebali University Faculty of Agriculture and Natural Sciences Research and Application area.

Figure 8. Single Ear Thresher

Figure 9. Single Virgo

RESULTS AND DISCUSSION

Morphological Characterization

Morphological characteristics of einkorn population obtained at the end of the research; Coleoptile in anthocyanin formation: Absent or very weak plant growth methods: vertical, flag leaf, appendages in anthocyanin formation: Weak Flag leaf deflection rate: medium, Ploidi time (when first seen spikelets on 50% of spike): Moderate, flag leaf sheath waxen: medium, greasiness in Miscellaneous Weak, Waxen portion which the handle is connected to the spike: Average plant height (stem, spike, including bone and ribs): medium, the thickness condition of the handle in the middle of the cross section: Thin essence, the shape of spike profile parallel edges, Spike density: dense, spike length: medium, fishbones or the presence of projections: var Tagging the length of the burr or protrusion on Spike end portion very short, Basak color: White to pale yellow, concave hairiness of the top node of Spike scale: Absent or very weak, Old shoulder width of outer husk shoulder width: Medium, Lower outer husk beak shape: Inclined, Lower outer husk beak length: Medium, Lower gull beak shape: Curved, Lower gull concave hairiness degree: Weak, Inner glume beak shape: Less curved, grain color: white, staining demonstrated against the grain of phenol: Intermediate, plant growth nature: Winter, glutenin composition: Locus Allele Glu A1 also arise, glutenin composition: Locus Glu allele B1 at emergence, glutenin composition: Locus Alleles of Glu -D1 was also found to occur.

Our Findings; Conducted by Demirel, 2013; In the study in which he examined the morphological and molecular characteristics of gernik (*T. dicoccum*) and einkorn wheat (*T. monococcum*), one of the important gene centers of our country; As a result of field observation of the materials from Kastamonu, 9 of them were tetraploid (*T. dicoccum*), 14 of them were diploid (T. Grain number 22.1 pieces, spike yield 0.52 g, plant yield 0.64 g, biological yield 1.85 g, harvest index 34.24%, earing time 73.18 days, ripening period 107.2 days, thousand grain weight 38.4 g, protein ratio was determined as 17.54%. The hairiness ratio is 100% in *T. dicoccum*, 22.2% in *T. monococcum*, 88.8% in *T. dicoccum* and 44.4% in *T. monococcum*.

Quality Values

Technological and some nutritional properties of einkorn wheat obtained at the end of the research; hectolitre weight: 76 kg/hl, thousand grain weight: 26 g, hardness: 62 PSI, grain protein: 10.96%, flour yield: 39.42%, ash: 1.67%, SDS solution holding capacity: 93%, faringograph water absorption: %53.34, farinograph softening degree: 170 BU, energy: 340 kcal/100 g, protein: 13.8%, fat: 1.18%, farinograph development time: 1.2 min, farinograph stability: 1.2 min.

Our findings Sanal 2013, by evaluating 1960s until the local varieties used by our farmers, quality and usage in Turkey, which is made to determine the kinship with each other and of Einkorn wheat result of this study; hectolitre weight: 78 kg/hl, thousand grain weight: 27 g, hardness: 62 PSI, grain protein: 11.83%, flour yield: 40.48%, ash: 1.75%, SDS solution holding capacity: 95%, faringograph water absorption:% 54.65, farinograph softening degree: 170 BU, energy: 340 kcal / 100 g, fat: 1.8%, farinograph development time: 1.3 min, farinograph stability: 1.3 min, partially similar to the results he found.

SUGGESTIONS

In this study, Bilecik flora collected from Einkorn of wheat seeds: location, date and time information sharing has been given to Turkey Seed Gene Bank. This will be an important step in the conservation of genetic resources and in the fight against bio-trafficking. Conducting similar studies will serve this purpose. In addition, studies similar to this will provide convenience to the breeder as it will constitute a resource for the development of new varieties.

Acknowledgments

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CHAPTER 12

PHOSPHATE DEFICIENCY STRESS IN *Pisum sativum* var. *arvense* L. GENOTYPES: A TWO-YEAR FIELD EXPERIMENT

INTRODUCTION

Phosphate is an required nutrient for crops in growth and development (Demirkol, 2020). It is involved in nucleotides synthesis and cell structural components (Li et al., 2018). It also plays an important role in many reactions such as photosynthesis and respiration in plants (Puga et al., 2017; Li et al., 2018).

Agricultural areas have generally insufficient availability of soluble phosphate for plants (Pei et al., 2013). Under phosphate deficient conditions, death or significant yield and quality losses are reported in plants (Qamar et al., 2005; Demirkol, 2020). Long-term stress of phosphate deficiency irreversibly damages plant cells (Li et al., 2018). Plants have evolved several biochemical and physiological strategies against phosphate deficiency stress, which enable to enhance phosphate utilization (Li et al., 2018; Demirkol, 2020).

Forage pea is an annual legume diploid plant. It is also a rich source of protein as an important forage crop (Demirkol and Yılmaz, 2019). It has higher phosphorus consumption compared to other crops to form root nodules for nitrogen as a legume (Powers et al., 2020). Therefore, forage pea is known as a sensitive crop against phosphate deficiency stress. Such problems could be overcome by increasing the studies on natural genotypes because they have high impotance in breeding programs for stress conditions due to their high diversity (Demirkol and Yılmaz, 2019).

The purpose of this study was to determine the responses of forage pea genotypes under phosphate deficient condition in two-year field conditions.

MATERIALS and METHODS

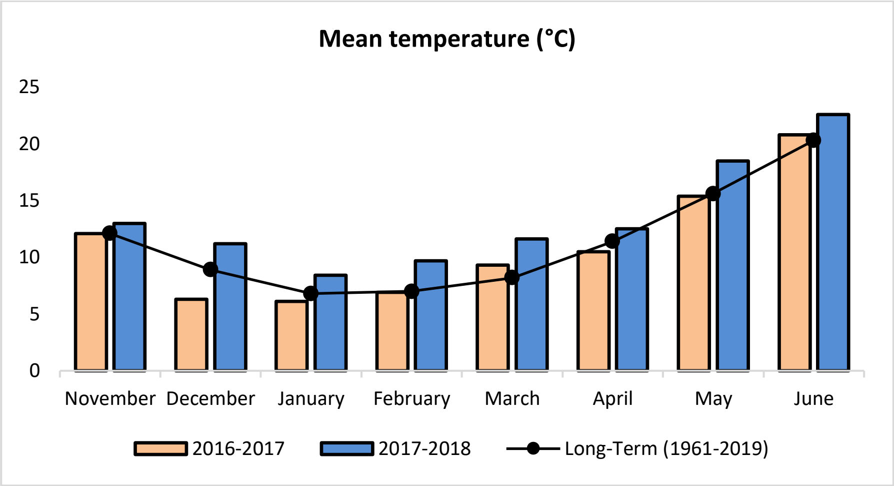
Plant materials

The seeds of the four genotypes were obtained from local farmers in the East Black Sea Region in Turkey.

Experimental setup growth conditions

A field study was conducted in randomized complete block design with four replications in Ordu province in Turkey (40° 58' N, 37º 56' E, 10 m above sea level) during 2016-2017 and 2017-2018. The experiment was designed under normal or phosphate-deficient conditions.

While the mean temperature values of the first year of the study were generally similar to the long-term averages, the lower values were observed in December and January (first year) (Figure 1). The mean temperature values of the second year of the study were higher than the average of the first year and long years average (Figure 1). The difference between years did not cause any negative effects on plant growth. The total precipitation data for both years of the study were generally suitable for pea cultivation.



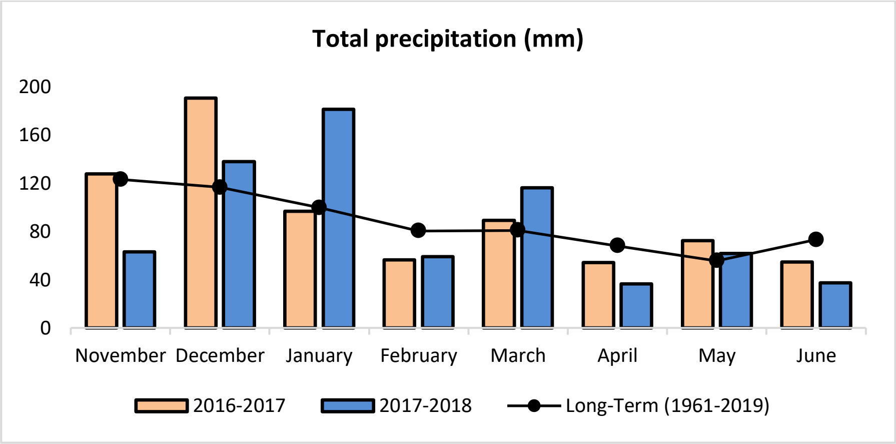


Figure 1. Climatic values of the experiment area. The data were taken from Ordu Meteorology Directorate

The soil of experimental area was a clay-loam, neutral (pH: 6.88), salt-free (EC: 464 µS cm^{-1}), moderate in organic matter (2.84%), adequate in terms of nitrogen (0.086-0.141 %) inadequate in phosphorus (7.22 mg/kg) and adequate potassium (49 kg/da) (average of two years).

The treatments consisted of control (0 kg/ha P_2O_5), and fertilized (60 kg/ha P_2O_5 before seeding and in each following year). All treatments had the same N fertilizer level of 30 kg N/ha applied. The seeds were planted with 100 seeds m^{-2} seeding rate in November 18, 2016 and November 13, 2017. The plot size was 6 m × 1.4 m with eight rows spaced 17.5 cm. During the trial no irrigation was done. Harvesting was started at the time when the pods had started to form on the bottom. The samples from each plot was oven dried at 60 °C to enable determination of hay yield.

Determination of ADF, NDF and crude protein contents

The crude protein rate, acid detergent fiber (ADF), and neutral detergent fiber (NDF) values are the main forage quality parameters. In the present study, their contents were measured with near-infrared reflectance spectroscopy (NIRS). ADF, NDF and crude protein analysis were performed with three replicates per analysis.

Free proline content

The method of Bates et al. (1973) was performed for the assesment of free proline content.

Determination of chlorophyll content

The chlorophyll contents of forage pea genotypes were determined on five randomly selected plants from each plot. In the study, in order to determine chlorophyll a and b content, fully expanded younger fresh leaves (1.0 g) were extracted with 90% acetone and filtered. Then absorbancies were measured with a UV/visible spectrophotometer (Shimadzu, Japan) at 645 and 663 nm.

Total phenolic content

The total phenolic contents of forage pea genotypes were determined on five randomly selected plants from each plot. The total phenolic content was determined by absorbance at 765 nm with UV-visible spectrophotometer (Shimadzu, Japan) by minor modifications of Lin and Tang (2007).

Determination of antioxidative enzymes

The antioxidative enzymes of the forage pea genotypes were determined on ten randomly selected plants from each plot.

In the study, in order to determine antioxidative enzyme activities, the samples were homogenized and suspended in enzyme-specific buffers. Than, the suspensions were centrifuged and the supernatants were used to measure protein amounts in shoots using bovine serum albumin as a standard by the method of Bradford (1976). The ascorbate peroxidase (APX), catalase (CAT), glutathione reductase (GR) and superoxide dismutase (SOD) activities were performed by using the methods of Wang et al. (1991), Chance and Maehly (1955), Sgherri et al. (1994) and Beauchamp and Fridovich (1971), respectively.

Statistical analysis

All analyzes in the study were performed three times. SPSS version 22 (SPSS, Inc., Chicago, IL, USA) was used for statistical analyzes. Tukey's test was performed at the $\alpha=0.05$ level to determine whether mean changes were significant.

RESULTS and DISCUSSION

Yield and quality parameters

The two-year field study results showed that the phosphate deficiency stress condition caused yield and forage quality losses in G1, G2, and G4, compared to their counterparts grown under non-stress condition in both years of the study (Figure 2-5). Surprisingly, no change was observed in hay yield (second year), crude protein rate, ADF and NDF values in G3 under the phosphate deficiency stress condition (Figure 2-5). G2 was identified as the most sensitive genotype against phosphate deficiency stress in two-year field conditions. Nearly, 50% yield losses were observed in both years in this genotype under the stress condition (Figure 2). Phosphate deficiency stress affects photosynthesis mechanism of plants negatively and causes reduced plant growth (Li et al., 2018). Similar results were also showed that phosphate deficiency stress causes serious yield losses in plants (Gupta et al., 2017; Parra-Almuna et al., 2018). The results of this study indicate that G3 has a potential to tolerate phosphate deficiency stress. This means that this genotype scavenges phosphate and then uses it more effectively in phosphate-limited soil compared to the other genotypes (Powers et al., 2020).

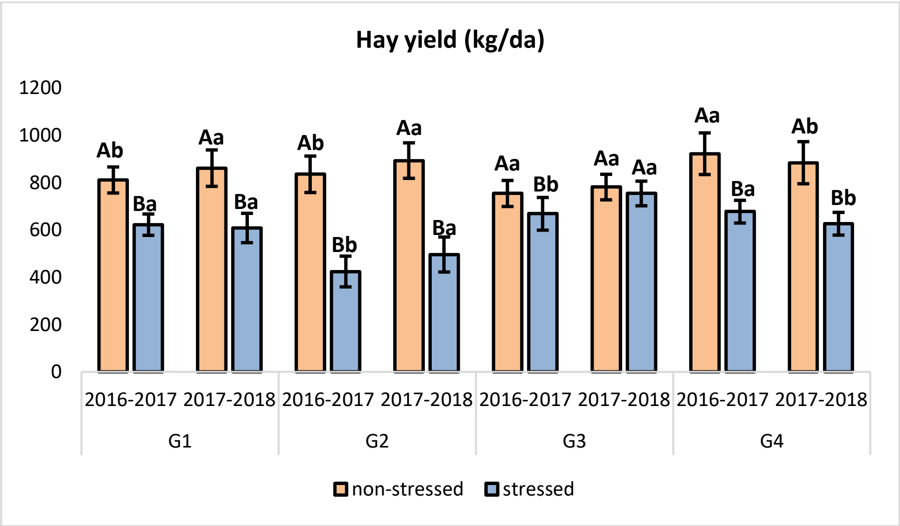


Figure 2. Hay yield (kg/da) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

The crude protein ratios were decreased and ADF values were increased in G1 and G2 under the phosphate deficiency stress condition compared to their counterparts grown under non-stress condition in both years of the study, while no changes were observed in G3 and G4 (Figure 3, 4).

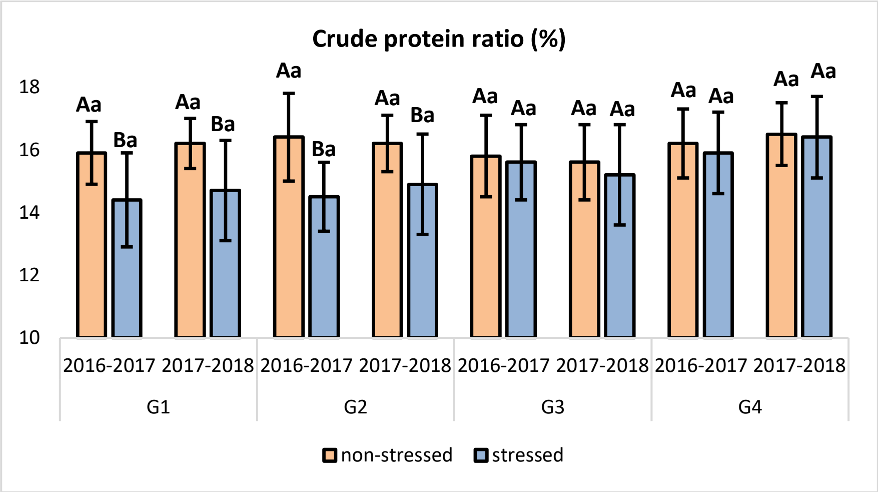


Figure 3. Crude protein ratio (%) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

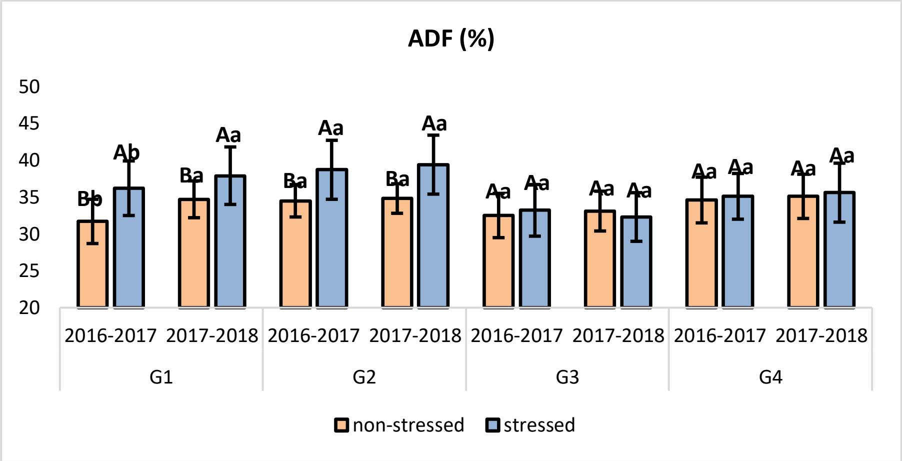


Figure 4. ADF (%) value of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

The NDF values were increased in G1, G2, and G4 genotypes under the phosphate deficiency stress condition compared to their counterparts grown under non-stress condition in both years of the study, while no change was observed in G3 under the stress condition (Figure 5).

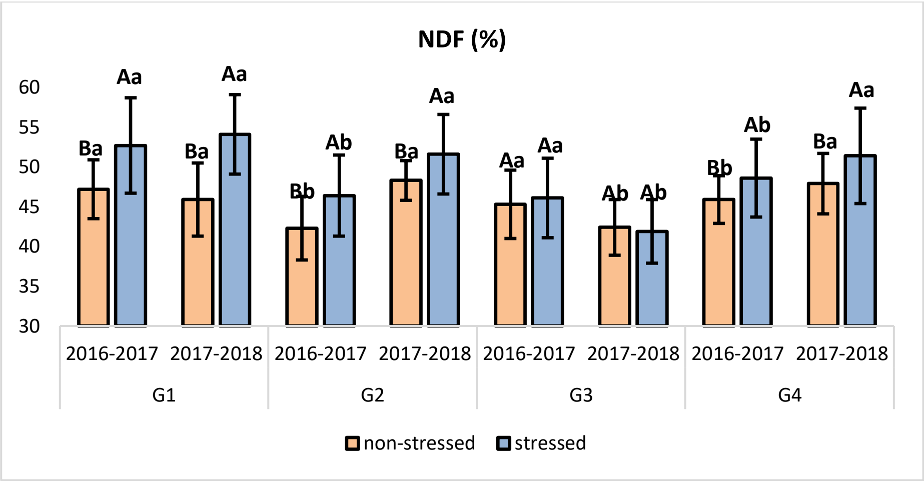


Figure 5. NDF (%) value of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

Increasing ADF, NDF and decreasing crude protein ratios negatively affect the digestion and nutritional value of forages (Demirkol and Yılmaz, 2019). Previous studies have reported the reductions in forage quality under stress conditions (Demirkol, 2020; Hedayati-Firoozabadi et al., 2020)

Physiological and biochemical parameters

Free proline contents were increased under the phosphate stress condition in G3 (4.8 and 3.6 times in the first and second year, respectively) and G4 (1.5 and 1.8 times in the first and second year, respectively) genotypes, while no changes were observed in G1 and G2 (Figure 6).

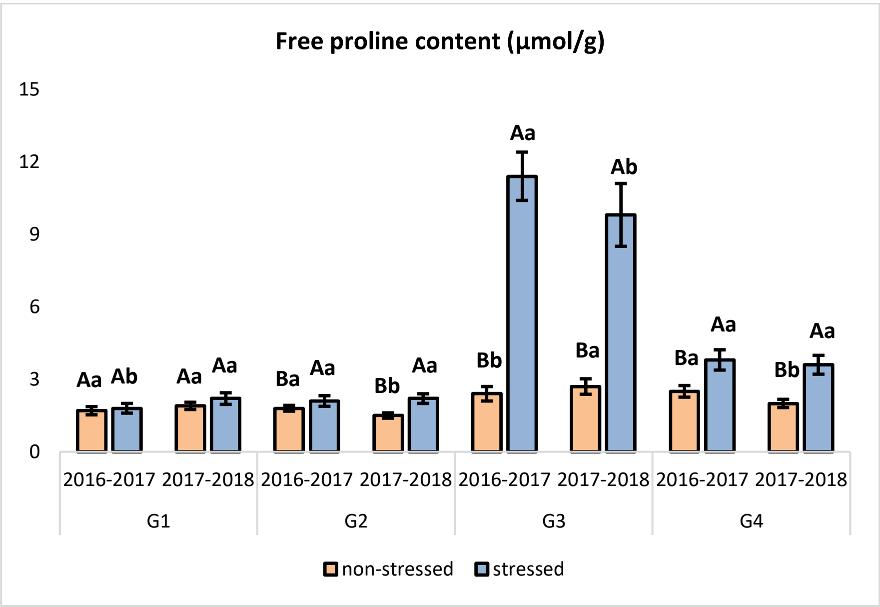


Figure 6. Free proline content (µmol/g) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

Free proline is known as an osmoprotectant accumulated by plants under various stress conditions (Rahneshan et al., 2018).

Therefore, the increased free proline is thought to be a responsible for phosphate stress tolerance especially in the G3 genotype.

G1, G2, and G4 had significant reductions in chlorophyll a and b under the phosphate deficiency stress condition compared to their counterparts grown under non-stress condition in both years of the study, while no change was observed in G3 genotype (Figure 7, 8), suggesting that G3 as the less sensitive genotype against the phosphate deficiency, is able to preserve chlorophyll contents under the stress condition. Previous studies indicate that chlorophyll content is a one of the main biochemical marker of phosphate deficiency stress (Park et al., 2012; Li et al., 2017).

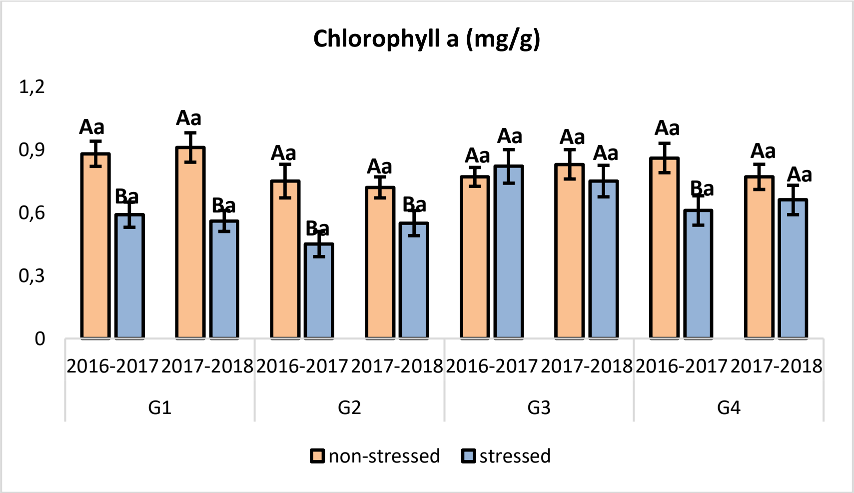


Figure 7. Chlorophyll a (mg/g) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at p<0.05. Values with the different small letter in a population in a treatment indicate a significant difference between years at p < 0.05

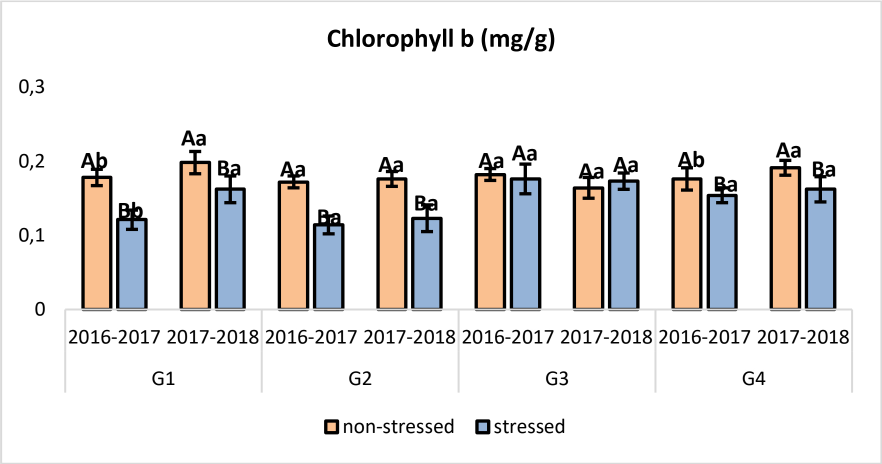


Figure 8. Chlorophyll b (mg/g) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

Total phenolic content were increased in G3 and G4 under the phosphate deficiency stress condition compared to their counterparts grown under non-stress condition in both years of the study, while no changes were observed in G1 and G2 (Figure 9). In previous studies, it was reported that the increase of total phenolic content is a defensive response by plants against various abiotic stress conditions (Kim et al., 2006).

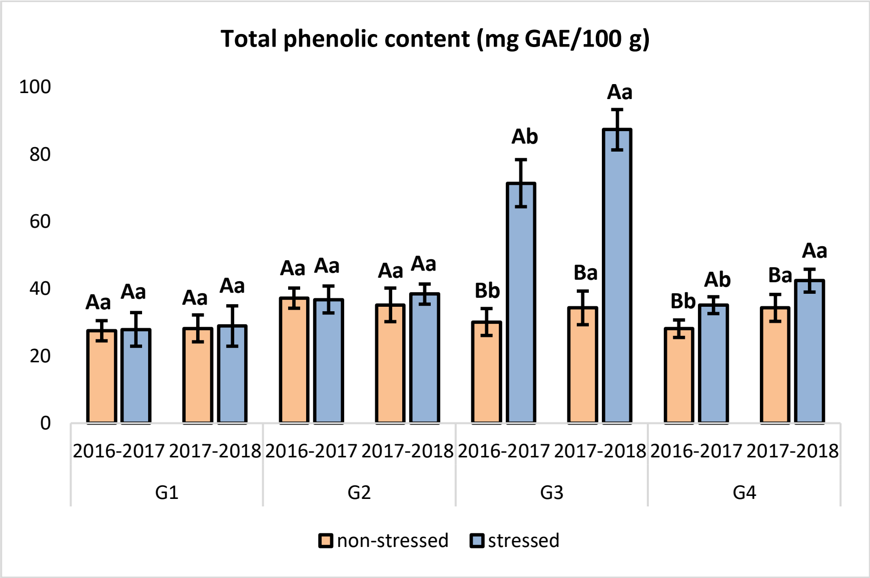


Figure 9. Total phenolic content (mg GAE/100 g) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

APX and GR activities were not statistically significant in all genotypes under phosphate deficiency stress condition compared to their counterparts grown under non-stress condition in both years of the study (Figure 7, 8). This means that APX and GR are not effective under phosphate deficiency stress in forage pea. However, CAT and SOD activities were increased in G3 in both years under phosphate deficiency stress condition compared to its counterpart grown under non-stress condition (Figure 11, 13).

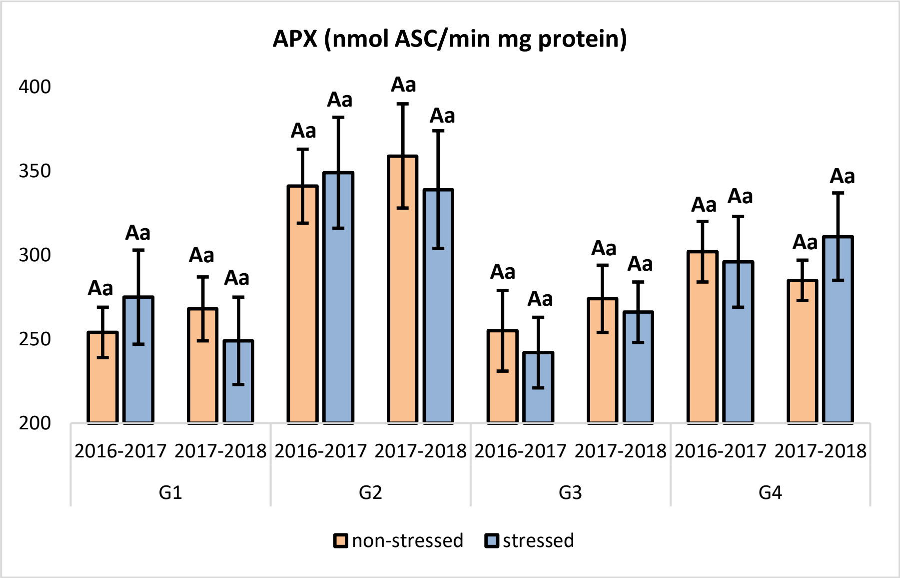


Figure 10. APX activity (nmol ASC/min mg protein) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

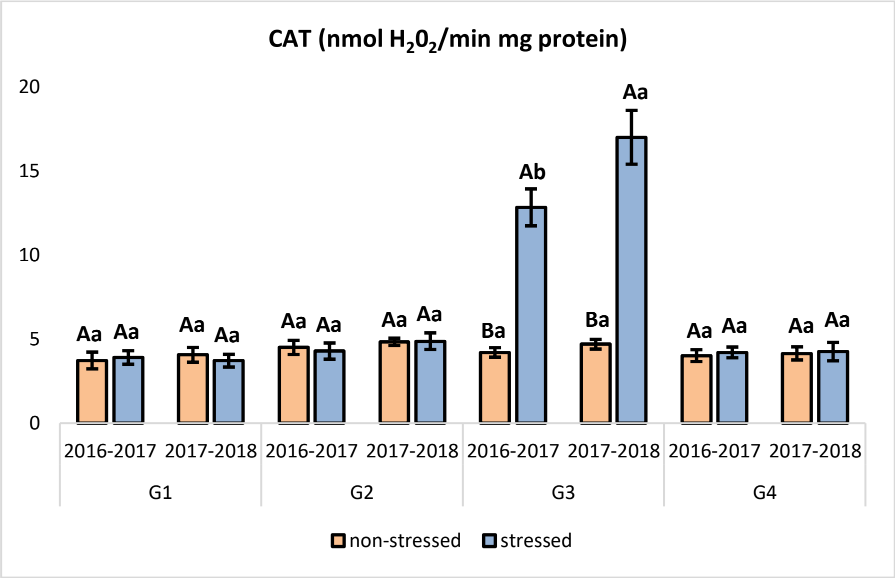


Figure 11. CAT activity (nmol H_20_2/min mg protein) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$.

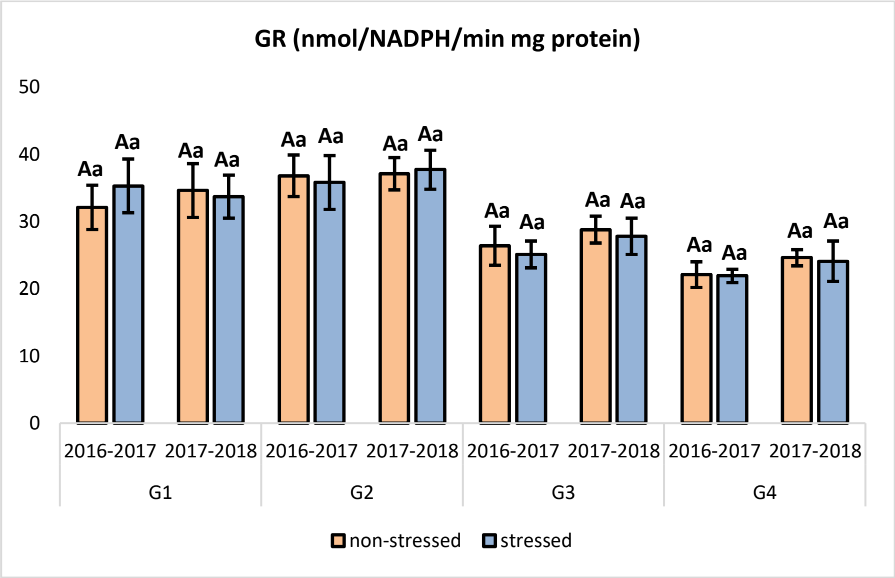


Figure 12. GR activity (nmol/NADPH/min mg protein) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

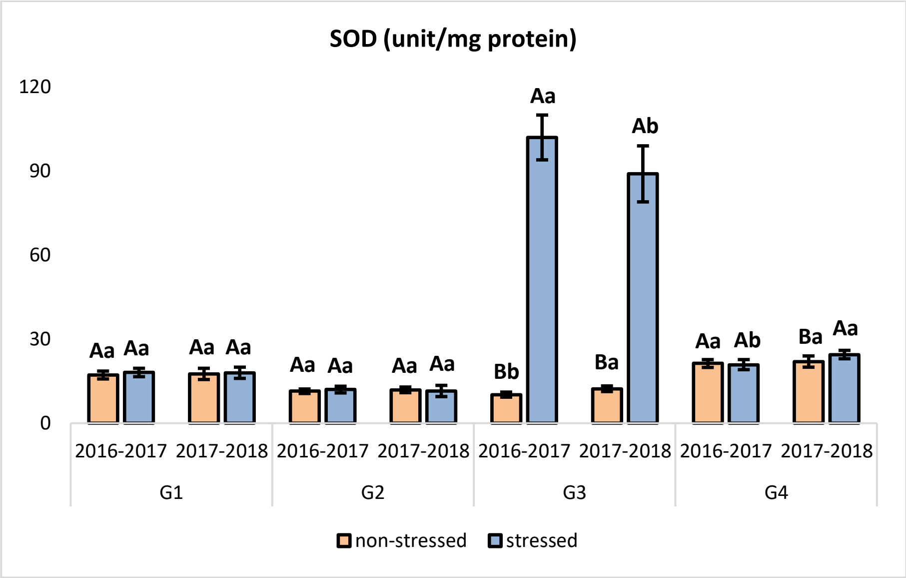


Figure 13. SOD activity (unit/mg protein) of the genotypes under non-stressed and stressed conditions in two-year field study. Data represent mean±SD of triplicates. Values with the different capital letter in a population in a year indicate a significant difference between non-stressed and stressed populations at $p<0.05$. Values with the different small letter in a population in a treatment indicate a significant difference between years at $p < 0.05$

The CAT and SOD activities of the other genotypes were not changed under phosphate deficiency stress condition except the second year in G4 for SOD activity (Figure 11, 13). It has been suggested in different studies that there is a relationship between tolerance against stress conditions with SOD and CAT activities in plants (Acar et al., 2001; Gondim et al., 2012; Kıran et al., 2019).

CONCLUSION

Developing crop varieties that require less phosphate fertilization is highly essential for forage crop cultivation. As a result of the two-year experiment, phosphate deficiency stress caused significant yield and quality losses in G1, G2, and G4, while G3 was less affected. Therefore, G3 has a potential against phosphate deficiency stress in field conditions. SOD and CAT as antioxidative enzymes are thought to be effective in being more tolerant against phosphate deficiency stress in forage pea. The results obtained in the study could be used in forage pea breeding purposed to develop tolerant varieties under phosphate-deficient soils.

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CHAPTER 13

THE CURRENT STATUS OF THE MEADOW-RANGELANDS, CULTIVATION OF FORAGE CROPS, AND LIVESTOCK IN BURSA, TURKEY

INTRODUCTION

The population growth in Turkey has led the country to face the problem of inadequate and unbalanced nutrition. Animal proteins have a special role in meeting the daily protein requirement of humans and at least 33 g of our daily protein requirement of 70 g should be of animal origin. However, only 13-17 g of the daily protein requirement is met by animal proteins in Turkey (Cevheri and Polat, 2009). This points to the fact that the main nutritional source of the population is carbohydrates and the consumption of animal proteins such as meat and milk per person is at an incomparable level to that in developed countries. The problems in Turkey regarding inadequate and unbalanced nutrition mainly stem from the problems in livestock breeding and animal product production (Demiroğlu-Topçu and Özkan, 2017). Animal nutrition in Turkey is largely based on natural meadows-rangelands, plant wastes, stubble, and low-quality feeds such as straw. However, forage crop cultivation is the most effective and economical way of supplying feed. In addition to providing feed, which is one of the most important inputs of animal production, forage crops have positive effects both on the physical and chemical properties of soils and yield and quality of the crop plants that follow them (Kuşvuran et al., 2011). However, forage crops are of particular importance in animal nutrition, as they are cheap sources containing the nutrients necessary for the stomach microflora, rich in minerals and vitamins, increase the reproductive power of animals, and provide high-quality animal products (Serin and Tan, 2001). Today, feed input constitutes 70% of the costs of animal production. Reducing feed costs is an important issue for profitable livestock breeding. Thus, it is necessary to improve pasture areas and increase forage crop cultivation areas. Animal breeding that is based on inefficient pastures, mainly feeding the animals with hay and stubble, and high-input concentrate feed is surely not profitable. On the other hand, a substantial increase has been recently observed in the number of cultural and hybrid animals in Turkey compared to native breeds. Therefore, it has become even more necessary to increase the forage crop plantation areas and their productivity to meet the need for roughage, which is necessary for the adequate and balanced nutrition of the livestock of Turkey whose quality level has increased. Animal production is affected by various factors including breeding, maintenance, management, nutrition, health, research, education, distribution, marketing, and ultimately feed production and all these factors must be fulfilled to increase animal production (Kuşvuran et al., 2011). Although there has been an increase in forage cultivation areas due to the supports in recent years, the current roughage production in Turkey can only meet about 26% of the current need (Okçu, 2020).

There are 14.6 million hectares of meadow and rangelands in Turkey. The Marmara Region, with 569,632 ha, has 3.90% of the meadows and rangelands of Turkey. The total animal stock is 66.6 million in Turkey and the Marmara Region alone contains 7.6 million of this stock. In Bursa, there are 230.468 da of meadow and rangelands and a total of 502.138-da forage crop cultivation area. According to the 2019 data, there are 239,355 cattle, 494,594 sheep, 84,931 goats, 2710 buffaloes, and 4,489 horses, donkeys, and mules in Bursa, a city in

Turkey with 17 districts. The present study examined the current state of the meadow-rangelands, forages, and animal livestock in Turkey, the Marmara Region, and Bursa Province and examined the general state of Bursa using the data from Turkey Statistical Institute (TURKSTAT) and the Bursa Provincial Agriculture and Forestry Office (BDPAF).

Total Land Size of Turkey and the Marmara Region

According to the TURKSTAT data for 2019, in a total area of 230 million da in Turkey, there are the total cultivation area of cereals and other herbal products is 153 million (66.55%) da, the total area of fallowing lands is 34 million da (14.6%), the total area of vegetable gardens is 7.9 million da (3.43%) of, the total area of fruit gardens and the total cultivation area of beverage and spice plants is 35 million da (15.29%), and the total cultivation area of ornamental plants is 52 thousand da (0.02%). The Marmara Region also has 23 million-da cultivable land, corresponding to 10.12% of Turkey's total land area (Table 1).

Table 1. The land size and distribution in Turkey (da) (TURKSTAT, 2019)

Region	Total area	Cereals and Other Herbal Product Area	Fallowing Land	Vegetable Garden Area	Fruit Garden, Beverage, and Spice Plants Area	Ornamental Plants Area
Mediterranean	22,040,315	13,446,567	1,525,663	1,709,112	5,349,834	9,139
Eastern Anatolia	24,303,322	16,890,766	5,459,473	336,237	1,616,515	231
Aegean	27,500,514	16,043,758	1,873,016	1,334,668	8,230,861	18,211
Southeastern Anatolia	29,015,815	20,308,211	2,047,994	680,416	5,979,169	25
Central Anatolia	77,362,428	54,705,998	18,539,900	1,829,695	2,245,327	1,508
Black Sea	26,438,965	14,285,855	3,530,204	805,837	7,817,069	1,542
Marmara	23,259,266	17,340,050	785,923	1,200,453	3,911,065	21,775
Total	**229,920,625**	**153,021,205**	**33,762,173**	**7,896,418**	**35,149,840**	**52,431**
%	**100.00**	**66.55**	**14.68**	**3.43**	**15.29**	**0.02**
Marmara %	10.12	11.33	2.33	15.20	11.13	41.53

In the Marmara Region, the cultivation area of cereals and other herbal products is 17.3 million da (74.55%), the total area of fallowing lands is 786 thousand da (3.38%), the total area of vegetable gardens is 1.2 million da (5.16%), the total area of fruit gardens and total cultivation area of beverage and spice plants is 3.9 million da (16.82%), and cultivation area of ornamental plants is 22 thousand da (0.09%) (Table 2).

Table 2. The land size and distribution in the Marmara Region, Turkey (da) (TURKSTAT, 2019)

Provinces	Total area	Cereals and Other Herbal Product Area	Fallowing Land	Vegetable Garden Area	Fruit Garden, Beverage and Spice Plants Area	Ornamental Plants Area
İstanbul	718 504	659 472	1 563	29 471	27 467	531
Tekirdağ	3 911 723	3 758 691	-	31 472	121 460	100
Edirne	3 112 974	3 006 012	5 886	55 760	42 816	2 500
Kırklareli	2 302 124	2 243 275	12 895	17 204	28 750	-
Balıkesir	3 880 249	2 468 355	191 945	265 662	953 852	435
Çanakkale	2 925 159	1 985 703	146 582	213 454	579 420	-
Bursa	2 999 490	1 439 600	214 194	411 487	931 221	2 988
Bilecik	821 335	504 934	116 644	60 189	139 568	-
Kocaeli	792 879	551 128	81 050	32 557	127 472	672
Sakarya	1 676 887	682 705	888	77 557	904 983	10 754
Yalova	117 942	40 175	14 276	5 640	54 056	3 795
Total	**23,259,266**	**17,340,050**	**785,923**	**1,200,453**	**3,911,065**	**21,775**
%	**100**	**74.55**	**3.38**	**5.16**	**16.82**	**0.09**

The Current Status of the Meadow and Rangelands

Rangelands are natural resources of high-quality and low-cost roughage. Ensuring and maintaining the biological diversity and ecological balance in rangelands can be made possible by protecting them and grazing by following the management principles. However, the long-lasting applications of early and intensive grazing on the pastures have caused the deterioration of the vegetation cover and decreasing grass yield and quality. Therefore, only about 10% of the rangelands of Turkey are in good or extremely good condition (Özinan et al., 2017).

Also, there are 14.6 million hectares of meadow-rangelands in Turkey, comprising about 18.7% of the country's area (TURKSTAT, 2019). In the Marmara Region, the total meadow-rangeland area is 569,632 da (Okçu, 2020). In Bursa, 23,046.60 hectares of the total of

1,088,638 ha is used as meadow-rangeland. This constitutes 2% of the total area of the city (BDPAF, 2019). Karacabey District ranks first in terms of total meadow-rangeland areas, followed by Mustafakemalpaşa, Yenişehir, İnegöl, and Nilüfer districts (Table 3).

Table 3. The meadow and rangelands of the districts of Bursa, Turkey (ha)

District	Meadow-Rangeland Area (ha)	District	Meadow-Rangeland Area (ha)	District	Meadow-Rangeland Area (ha)
BüyükOrhan	258.1	Karacabey	8083.1	Orhaneli	109.4
Gemlik	362.8	Keles	837.5	Orhangazi	89.6
Gürsu	32.5	Kestel	544.1	Osmangazi	260.0
Harmancık	153.4	Mudanya	592.2	Yenişehir	2074.9
İnegöl	2039.5	Mustafakemalpaşa	6110.2	Yıldırım	0.3
İznik	503.4	Nilüfer	995.8	**Total**	**23046.8**

The determination, restriction, and allocation studies that were carried out within the scope of the rangeland law in Bursa between 1999 and 2019 led to a determination of an area of 22638.8 m^2 in 489 villages, restriction of an area of 20107.5 m^2 in 385 villages, and allocation of an area of 17512.6 m^2 in 307 villages (Table 4). Of the determination studies across the city 99.9% were completed, while 88.7% of the limitation studies and 77.3% of the allocation studies were completed (Briefing, 2019).

Table 4. The distribution of the determination, limitation, and allocation studies on the rangelands of Bursa, Turkey, by years (Briefing, 2019)

Years	Determination Studies		Limitation Studies		Allocation studies	
	Number of villages	Area (m^2)	Number of villages	Area (m^2)	Number of villages	Area (m^2)
1999-2012	467	21593.7	363	19505.6	249	15872.7
2013	0	0.0	6	134.7	19	358.9
2014	1	11.5	-	-	14	328.4
2015	1	17.5	-	-	-	
2016	1	8.5	-	-	3	27.1
2017	1	81.9	-	-	3	60.7
2018	4	168.0	1	36.2	-	
2019	14	757.6	15	431.0	4	205.1
Total	489	22638.8	385	20107.5	307	17512.6

The improvement studies were carried out between 2003 and 2020 in 34 villages of 7 districts in Bursa including Kulaca Village in İnegöl District, Ovaesemen, İsmetpaşa, Akhisar, Hamidiye, Uluabat, Sultaniye, Hotanlı, Bakırköy, Yenikaraağaç, and Beylik villages in Karacabey District, Soğuksu Village in Kestel District, Yalıntaş, Üçbeyli, Ovaazatlı, Derecik, Yeşilova, Kayabaşı, Demirdere, Ormankadı and Paşalar villages in Mustafakemalpaşa District, Akharem village in Orhangazi District, Menteşe, Karacali, Karaköy, Yolören, Karasıl, Söylemiş, Barçın, Çayırlı, İncirli, Köprühisar, and Çeltikçi villages in Yenişehir District, and Samanlı Village in Yıldırım District (BDPAF, 2019). Although some rangelands in Karacabey and Mustafakemalpaşa districts were in good condition, we have determined various problems in the rangeland areas. In general, rangelands are grazed early and intensively and sheep-goats continue grazing on the pasture throughout the year until snowfall. Especially some rangelands areas were heavily invaded by thorny plants, due to the lack of any combat against the plants (Figure 1). The invasion of milk thistle (*Silybum marianum*) was quite high, especially in areas with manure heaps. The plant hinders the efficient use of the areas where it is widespread and prevents grazing of the animals due to its thorny structures.

Figure 1. The growth of thorny plants in Yeşilova Village and Yavelli Village in Mustafakemalpaşa District

Moreover, rush (*Juncus effusus*) invasion was observed in a portion of the base rangelands (Figure 2). Goat breeding is not carried out in villages with rush invasion, leading to an increase in plant population. In their study carried out in Turkey, Merchant (1993) reported that the rush plant could be controlled by goats, which have similar mouth anatomy to that of sheep, and the plant was sensitive to grazing in early spring. Although the number of studies on the base rangelands in Turkey is limited, the available studies have pointed out heavy and early grazing in public base rangelands as an important issue and rush (*Juncus effusus*) invasion ranked first among its troubling consequences (Koç et al., 2005; Sürmen and Koç, 2010). Koç (2010) determined that the rush plant could only colonize the base rangelands in rare locations where sheep did not go to in the rangelands of sheep-breeding villages in Erzincan. However, in the base rangelands of

Bursa, the villagers have stated that the rush plants were consumed by sheep during their early growth, which is insufficient for the control of the plant.

Figure 2. Rush (*Juncus effusus*) invasion in the rangelands of Menteşe Village in Yenişehir District

In certain villages where heavy rainfall is common in winter and spring, the rangelands are submerged in water and rush growth in these rangelands increases. Some rangeland parcels in Kulakpınar Village of Karacabey District are exemplary of this type of rangelands (Figure 3).

Figure 3. The overall appearance of the rangelands in Kulakpınar Village in Karacabey District

In recent years, the growth of wild horehound (*Marrubium peregrinum*) and blackberry (*Rubus fruticosus*) in some rangelands of Bursa has become widespread (Figure 3).

Figure 3. The invasion of blackberry and wild horehound in the rangelands of Yavelli Village in Mustafakemalpaşa District

The soil heaps caused by moles are of concern in some rangelands of Yenişehir District (Figure 4). Especially in the rangelands in Karacabey and Mustafakemalpaşa districts, piles of animal manure and wastes such as glass bottles are present (Figure 5).

Figure 4. The soil heaps caused by moles in the rangelands of Menteşe Village in Yenişehir District

Figure 5. A section of the rangelands of Ormankadı Village in Mustafakemalpaşa District

Another problem of the rangelands is the uncontrolled burning of thorny plants and bushes by the villagers to eliminate them (Figure 6). The dry plant wastes are not removed from the environment especially after their burning and no procedure follows uncontrolled burning.

Figure 6. The uncontrolled burning of the rangelands in Durumtay Village in Mustafakemalpaşa District

The Current Status of Forage Crop Cultivation

According to the data of TURKSTAT for 2019, the total forage crop cultivation area was 21 million da and total forage crop production was 52 million tons (Table 5).

Table 5. Turkey's Cultivation Areas (da) and Production Amounts (ton) of Forage Crops in 2019

Regions	Cultivation Area	Production	Cultivation Area	Production	Cultivation Area	Production	Cultivation Area	Production
	Alfalfa		**Vetch**		**Silage Maize**		**Sainfoin**	
Mediterranean	188,682	423,107	343,944	392,706	427,883	1,937,208	63,139	61,699
Eastern Anatolia	3,245,605	6,522,150	1,153,507	807,267	175,998	829,326	1,153,025	1,184,423
Aegean	560,851	2,879,118	681,037	925,489	1,385,698	8,173,626	26,579	42,173
Southeastern Anatolia	116,303	172,706	73,640	69,531	387,543	1,781,280	12,808	10,905
Central Anatolia	948,512	5,152,962	653,118	786,306	1,343,345	5,116,452	296,648	227,990
Black Sea	513,205	1,177,673	704,224	792,653	575,267	2,541,755	96,198	91,208
Marmara	345,815	1,260,044	283,564	459,168	1,175,543	5,942,157	11,548	14,882
Total	5,918,973	17,587,760	3,893,034	4,233,120	5,471,277	26,321,804	1,659,945	1,633,280
Marmara (%)	5.84	7.16	7.28	10.85	21.49	22.58	0.70	0.91
	Oat		**Grass pea**		**Wheat (Fresh grass)**		**Green Corn**	
Mediterranean	68,071	69,215	11,094	3,667	28,184	33,814	9,534	28,701
Eastern Anatolia	621,963	426,788	46,908	31,660	750	1,275	1,510	6,045
Aegean	308,496	495,462	37,586	41,931	37,241	75,555	27,831	199,061
Southeastern Anatolia	-	-	2,057	1,086	-	-	50	31
Central Anatolia	295,616	167,256	750	408	3,828	5,246	40	160
Black Sea	402,166	347,162	-	-	-	-	7,077	13,193
Marmara	711,860	1,343,940	454	160	142,372	283,797	14,411	33,343
Total	2,408,172	2,850,623	98,849	78,912	212,375	399,687	60,453	280,543
Marmara (%)	29.56	47.15	0.46	0.20	67.04	71.00	23.84	11.89
	Triticale		**Turnip**		**Forage pea**		**Italian grass**	
Mediterranean	28,201	22,481	143	699	340	1,115	5,352	17,397
Eastern Anatolia	11,445	20,302	55	292	796	685	-	-

Aegean	74,397	146,223	36,029	202,236	14,264	32,141	57,237	133,672
Southeastern Anatolia	100	120	-	-	-	-	-	-
Central Anatolia	15,138	13,749	3,961	22,437	22,355	33,810	13,513	27,643
Black Sea	5,484	4,097	1,362	3,055	17,945	21,473	1,775	6,593
Marmara	38,691	70,164	15,342	69,349	78,243	175,581	86,575	366,013
Total	173,456	277,136	56,892	298,068	133,943	264,805	164,452	616,709
Marmara (%)	22.31	25.32	26.97	23.27	58.42	66.31	52.64	59.35
	Barley		**Bitter vetch**		**Fodder beet**		**Sorghum**	
Mediterranean	78,340	101,420	1,334	967	2,747	12,922	5,626	13,320
Eastern Anatolia			350	123	-	-	95	318
Aegean	161,560	270,515	6,852	5,627	10,072	54,680	8,954	23,295
Southeastern Anatolia			9,698	3,125	-	-	270	220
Central Anatolia	1,118	1,208	5,245	3,440	715	3,882	998	3,092
Black Sea	50	30	130	59	2,583	7,116	1,185	5,003
Marmara	44,901	93,806	1,157	1,014	1,635	8,452	9,376	35,690
Total	285,969	466,279	24,766	14,355	17,752	87,052	26,504	80,938
Marmara (%)	15.70	20.12	4.67	7.06	9.21	9.71	35.38	44.10
	Rye		**Clover**		**Broad Bean (Forage)**		**Total**	
Mediterranean	12,243	8,013	-	-	100	15	1,274,957	3,131,285
Eastern Anatolia	112	30	-	-	-	-	6,405,119	7,797,981
Aegean	5,544	8,836	-	-	8,799	3,802	3,448,178	12,930,233
Southeastern Anatolia	1,876	4,690	-	-	7,071	7,110	611,416	2,050,534
Central Anatolia	3,367	2,082	-	-	-	-	3,456,287	11,568,123
Black Sea	-	-	-	-	-	-	2,335,088	4,786,594
Marmara	28,683	50,947	45	67	11,306	3,045	3,001,521	10,211,619
Total	51,825	74,598	45	67	27,276	13,972	20,532,566	52,476,369
Marmara (%)	55.35	68.30	100.00	100.00	41.45	21.79		

Considering the cultivation areas of forage crops with respect to the regions, the Eastern Anatolia Region, where animal breeding activities are intensively carried out, ranks first with 6.4 million da, followed by the Central Anatolia and Aegean regions, respectively.

Considering the green forage production amounts with respect to the regions, the Aegean Region ranks first with a total production of 12.9 million tons, followed by the Central Anatolia Region with a production amount of about 11.6 million tons and the Marmara Region with a production amount of 10.2 million tons, respectively (Table 5). Considering the forage crop cultivation areas in Turkey in a more general sense, the cultivation area of alfalfa ranks first with 5.91 million da, followed by the silage maize cultivation area of 5.47 million da, the vetch cultivation area of 3.9 million da, and oat cultivation area of 2.41 million da, respectively. Considering the production amounts of forage crops, silage maize ranks first with a total production of 26.3 million tons, followed by oat with a total production of 17.6 million tons and vetch with a total production of 4.2 million tons, respectively (Table 5). With its high adaptation, longevity, high yield and nutritional value, and suitability of some of its species for grazing, oat is a valued forage crop that is most commonly cultivated in field agriculture. With its extremely high yield per area and digestibility, maize is widely cultivated especially as a silage feed in Turkey (Demiroğlu-Topçu and Sezgin, 2017).

The total forage crop cultivation area and production in the Marmara Region is 3 million da and 10.2 million tons, respectively. According to the data of TURKSAT for 2019, the most cultivated crops in Bursa are alfalfa, vetch species (common vetch, Hungarian vetch, and other vetch species), silage maize, and oat. In the entire city of Bursa, the cultivation areas of silage maize, alfalfa, oat, and vetch species were 213.52 da, 94,205 da, 77,705 da, and 4,570 da, respectively. Considering the cultivation areas and production amounts, Mustafakemalpaşa District ranks first in the cultivation areas and production of silage maize, vetch species, alfalfa, and Italian grass, followed by Karacabey District.

Table 6. Bursa's cultivation areas (da) and production amounts (ton) of forage crops in 2019 (BDPAF, 2019)

District	Cultivation area	Production	Cultivation area	Production	Cultivation area	Production	Cultivation area	Production	Cultivation area	Production
	Alfalfa		Vetch species		Silage maize		Oat		Italian grass	
B.Orhan	950	1900	701	1052	3831	17240	11732	15252	-	-
Gemlik	110	220	10	13	28	106	45	63	-	-
Gürsu	50	75	300	390	200	900	900	1215	-	-
Harmancık	500	700	500	450	100	350	2666	2133	-	-
İnegöl	9900	14850	3250	2925	7850	40675	5600	5600	20	70
İznik	400	720	1000	1500	300	1200	235	400	-	-
Karacabey	21000	33600	6000	12000	48000	262500	14000	21000	7000	21000
Keles	3338	12017	4000	4000	1580	6950	1800	3240	-	-
Kestel	1700	2040	1065	1354	900	4440	1785	175	42	210
Mudanya	3200	25600	2600	5250	5000	26500	6000	12000	500	2000
MKP	35500	170400	14400	2390	93500	561000	10500	23625	8500	55250
Nilüfer	4565	25564	3218	6436	13443	67215	9286	18572	353	706
Orhaneli	1780	3916	2720	2687	1700	8500	4150	4150	-	-
Orhangazi	1282	3488	1276	1595	1390	5560	286	343	-	-
Osmangazi	1400	5600	3000	7500	1680	6720	870	2175	28	84
Yenişehir	8500	17000	4530	5208	33900	168600	7850	20803	150	900
Yıldırım	30	105	-	-	10	1035	-	-	44	396
Total	**94205**	**317795**	**48570**	**54750**	**213412**	**1179491**	**77705**	**130746**	**16637**	**80616**

Karacabey District has the largest cultivation area and the highest production of oat (14 thousand da and 21 thousand tons), followed by Büyükorhan and Mustafakemalpaşa district, respectively. Italian grass is grown only in nine districts of Bursa, with Mustafakemalpaşa District having the largest cultivation area (8,500 da) and production amount (55,250 tons) (Table 6).

Animal Potential

According to the data of TURKSTAT for 2019, Turkey has 66.6 million livestock comprising a total of 17.9 million cattle (26.83%), 48.5 million sheep and goats (72.78%), and 260 thousand equids. The Marmara Region has 11.42% of the livestock of Turkey and has about 2.3 million cattle, 5.2 million sheep and goats, and 27.7 thousand equids (Table 7).

Table 7. The distribution of the number of animals by the regions across Turkey in 2019 (TURKSTAT, 2019)

Regions	**Cattle**	**Sheep goat**	**Equids**	**Total**
Mediterranean	1,397,966	6,318,397	17,216	7,733,579
Eastern Anatolia	3,750,706	11,604,953	63,495	15,419,154
Aegean	2,802,015	5,259,694	39,193	8,100,902
Southeastern Anatolia	1,745,633	9,408,118	47,653	11,201,404
Central Anatolia	3,436,543	8,465,594	30,478	11,932,615
Black Sea	2,460,613	2,121,045	33,054	4,614,712
Marmara	2,278,855	5,303,678	27,742	7,610,275
Total	**17,872,331**	**48,481,479**	**258,831**	**66,612,641**
%	26.83	72.78	0.39	100
Marmara (%)	**12.75**	**10.94**	**10.72**	**11.42**

In Bursa, Karacabey District has the greatest animal potential with 164,082 animals and 52,770.1 HB, followed by

Mustafakemalpaşa District with 131,299 animals and 43,577.5 HB. In Bursa, Yıldırım District has the lowest animal potential with 3,348 animals and 1,601.02 HB. Karacabey District ranks first in cattle potential with a total of 49,978 animals, while Mustafakemalpaşa District ranks second with a total of 48,996 animals. Again, Karacabey District ranks first in sheep and goat potential with a total of 112,919 animals, followed by Mustafakemalpaşa District with a total of 81,690 animals (Table 8).

Table 8. The number of Animals and HB values of Bursa in 2019 (BDPAF, 2019)

District	Cattle *		Sheep-goat **		Equids***		Total	
	Number of Animals	**HB value**	**Number of Animals**	**HB value**	**Number of Animals**	**HB value**	**Number of Animals**	**HB value**
B.Orhan	9731	7937.45	32178	2721.82	507	188.5	42416	10847.77
Gemlik	2134	1503	8454	793.68	94	43.2	10682	2339.88
Gürsu	2086	1785.5	9637	842.32	2	0.6	11725	2628.42
Harmancık	2525	2107.5	10948	987.66	28	11	13501	3106.16
İnegöl	18553	13717.65	63800	6131.44	279	111.1	82632	19960.19
İznik	3075	2143.05	22136	2002.96	35	16.5	25246	4162.51
Karacabey	**49978**	**41221.1**	**112919**	**10958.6**	**1184**	**590.4**	**164081**	**52770.1**
Keles	3989	3193.55	23446	2204	178	65.9	27613	5463.45
Kestel	5012	3476	16713	1590.94	71	34.3	21796	5101.24
Mudanya	5914	4818.5	14185	1220.5	26	11.4	20125	6050.4
MKP	**48996**	**36861.6**	**81690**	**6452**	**613**	**263.9**	**131299**	**43577.5**
Nilüfer	11878	9444.35	31703	3074.74	149	73.1	43730	12592.19
Orhaneli	12299	9371.65	33955	3154.4	477	191.4	46731	12717.45
Orhangazi	10192	7392.2	13192	1169.78	318	144.2	23702	8706.18
Osmangazi	5210	4330.15	25118	2405.42	309	135.1	30637	6870.67
Yenişehir	**48607**	**41406.85**	**78091**	**7452.18**	**117**	**47.8**	**126815**	**48906.83**
Yıldırım	1886	1425.2	1360	129.02	102	46.8	3348	1601.02
Total	242065	157072.9	579525	53291.46	4489	1975.2	826079	212339.6

B.Orhan: Büyük Orhan. MKP: Mustafakemalpaşa * Buffaloes are included. Buffaloes are only found in İnegöl. İznik. Karacabey. MKP. Nilüfer. Orhaneli. Orhangazi. Osmangazi, and districts.
** The group includes sheep, goats, and lambs-kids.
** The group includes horses, mules, and donkeys.

CONCLUSION and RECOMMENDATIONS

The yield capacities of the rangeland-rangelands of Turkey are considerably low. Furthermore, in addition to being low-yield, the rangeland-rangelands of Turkey are destroyed and yield extremely inadequate and low-quality grasses due to early grazing and overgrazing. On the other hand, the amount of roughage that is obtained from meadow-rangelands and forage crops can only meet 26% of the current requirement (Okçu, 2020). This also applies to Bursa and the requirement of animals for roughage is mostly met by the excess and intensive grazing in the rangelands. Across the city, rangeland improvement and management projects are carried out to strengthen the yield potential of the rangelands, leading to improved grass yield and quality in the rangelands of villages within a period of 3-5 years. Thus, the main concern here is the lack of protection of the rangelands by the villagers after the completion of these projects. In addition to the rapidly increasing grazing pressure, the wild weed problem emerges and rangelands return to their pre-improvement state. Thus, only implementing the improvement and management projects is not a solution in itself. Encouraging forage crop cultivation and providing training programs both about the use of rangelands and improvement methods to the producers will greatly contribute to the solutions of these issues.

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CHAPTER 14

THE IMPORTANCE OF BEES IN RANGELANDS

INTRODUCTION

Apiculture, which is one of the oldest agricultural activities in the world, is a traditional activity in Europe, a tool to increase producer incomes in countries like Spain, Poland, Hungary, Greece and Turkey, an important source of foreign income in the Far East, Central and South America, and in African countries, and in countries like USA, Canada and Japan, it is mostly considered as an activity contributing to pollinations (Vural, 2008).

Turkey, which has four seasons, is one of the most important countries in the world in terms of different climate characteristics and ecological zones and agricultural production diversity. It is also the gene center of many plants and animals with its characteristics (Onde and Vurdu, 1988). In our country, which is one of the countries that have the richest plant flora in the world, it is estimated that around 10.000 plant species can grow naturally. It is known that approximately 450 plant species growing naturally are cultured, and are important for apiculture (Sorkun, 2008). Turkey, which is located in Anatolian geographical area where apiculture is old and widespread, is one of the countries that has a say in apiculture because 75% of honey plant species that have been identified in the world can grow here (Firatli et al., 2000; Genc and Dodologlu, 2011). According to 2015 data, it ranks 2nd in the entire world with 107.665 tons of honey and 4.750 tons of wax production (Demiroglu Topcu and Ozkan, 2016).

Apiculture, which is an agricultural activity in every aspect, can be performed in the boundaries of any business place or on slopes, forest edges, or meadow-pastures where flowers and nectar are found abundantly outside the business area (Sonmez, 1984). As a result of apiculture activities, many by-products, such as pollen, royal jelly, bee venom, and propolis are also obtained besides honey and wax. These products are used both as foods and in the treatment of many diseases (Kaftanoglu, 2003). Honey, which is one of the most valuable nutrients offered by the nature for people, is not only a satiating substance, but is also sweet and magical food providing person with health and fitness. Bees that produce honey, have the ability to be the most diligent, creative, and enigmatic creature among living beings when compared to their structure (Sonmez, 1984).

There are more than 20.000 species of bees of different families on earth, and the species in the *Apis* genus in the *Apidae* family are called honey bee (Ozbek, 1979). Honey bees have to collect some substances from the nature, and transport them to the beehive to survive. These substances are nectar, pollen, water and propolis. Sugars that exist within the nectar are an important source of carbohydrates for the flight power, and vital activities of bees. Pollen is the main source of protein, fat, vitamin and mineral (Lauffer, 1987). It is of great importance for tissue growth in bees that feed their offspring and complete incubation, especially in the glands. The part of pollen that is collected from the nature exceeding daily use is stored in honey cells, and is then used for protein needs during periods when there is no pollen arrival to the colony (Genc and Dodologlu, 2011).

The existence of living things depends directly or indirectly on plants; and therefore, strong common organic bonds were established between these in time. This partnership is usually mutual. One of the best examples of this is the relations between the honeybee and the flowers of the plants. They need bees for pollination, and bees need flowers for feeding (Gemici et al., 1995). Based on this notion, bees play active roles in transforming nectar and pollen sources into valuable apiculture products, as well as ensuring the diversity and continuity of plant generations by helping in pollination (Kumova et al., 2001). In flowery plants, pollination is the first step of the creation of the seeds that can live, develop, and become a new organism. The product obtained as a result of pollination created by insects, especially by bees, account for about 35% of human food (Buchmann and Nabhan, 1996). Additionally, 70% of the plants in the world are pollinated by bees, and more than 80% of the pollination is carried out by honeybees (Ozbilgin, 1999). Honeybees are considered as the first-degree pollinators, because they have large colonies, and can be easily transported and managed (Kuvanci, 2009).

The unique geography of Turkey, year-long diverse climate, and rich flora make our country a suitable ecological area in terms of apiculture. Different honeys are produced depending on the flora of the different regions in our country. Pine honey is produced in Mugla and its surrounding areas, citrus honey is produced in and around the Mediterranean region, and other provinces produce very high quality flower honey (Kayral and Kayral, 1984). Every year, a large nectar wealth dries up and is lost in our country. Apiculture can turn this wealth into very valuable products. Our country, which is covered with highlands and mountains not suitable for agriculture, is very suitable for apiculture (Firatli and Gencer, 1995).

BEES

Bees are insects that make up the *Apiformes* group of the *Apoidea* upper family in the *Hymenoptera* order (Michener, 2007). There are approximately 25.000 bee species identified in worldwide (O'Toole and Raw, 1991). Species other than the honeybee (*Apis mellifera*) are known as bumblebee. However, there are approximately 10 other species of honeybees apart from *Apis mellifera* on earth, and they are found in Far Eastern countries. Climatic conditions, topographical structure, and location of our country on earth have made the vegetation and, accordingly, other creatures diverse and abundant, as well as the bee fauna to be very rich. For example, it was determined in the past that there were approximately 500 species of the *Megachilidae family* only (Ozbek and van der Zanden, 1992a; 1992b; 1993; 1994). It is estimated that there is a total of approximately 2.000 bee species in our country.

Since bees are vital to sustaining all living things in worldwide they are considered key species in the nature. However, it should be sadly emphasized that although the density of bees declined rapidly in our country for the past three decades, some species are probably extinct, and some are about to become extinct (Ozbek, 2002). For example, the population of *Melitta dimidiata*, which is the important pollinator of alfalfa (*Medicago sativa* L.), which was found to be quite dense in 1970s, *Melitta leporina*, *Rhophitoides canus* and *Melitturga clavicornis*, which are very important pollinators of clover, have fallen a lot in recent years. In some of our regions, *Rhophitoides canus* has almost completely disappeared, and is among the rare species in many areas.

Humblebees, which constitute a very important group of bumblebees, have become almost extinct in recent years (Ozbek, 1997; 1998; 2000; 2002), even though they were very abundant until 1970s (Ozbek, 1979), and even in 1980s (Ozbek, 1983). Species like *Bombus incertus*, *B. niveatus*, *B. sylvarum daghestanicus*, *B. argillaceus*, and *B. armeniacus*, which have very high populations in Eastern Anatolian Region, and which are the pollinators of many wild and cultural plants, have now decreased, and become rare in some regions. Among these, *B. argillaceus* is partially in a good condition, but others are moving towards become extinct. *Bombus fragrans*, *B. sulfureus*, *B. velox*, and *B. brodmanni* are considered as the endangered species (Ozbek, 1998; 2000; 2002).

Honey bees are very good pollinators, but they cannot be effective in many plant species. Bumblebees continue this task very successfully in these plants. Considering this situation, studies were conducted to ensure more use of different bumblebees and culture of different bumblebee species; and *Nomia melanderi* was used in alfalfa, *Megachile rotundata* in clover and in some other culture plants in the USA since 1960s (Free, 1993). *M. rotundata* was originally from Europe and West Asia, and accidentally passed to the United States.

As well as direct benefits of bees, including the honey bee, the fact that they carry out pollination in culture plants, perhaps their most important function is that they continue the lineage of many plant species by pollinating various wild plants in the nature, allowing them to spread to the world, and helping to sustain other plants that make up a community with these plants, and finally, allowing thousands of animals of different groups, which use these plants as food and shelter or nests to live. Although they ensure the continuation of the biodiversity, they also perform a function that is vital for our country, like the prevention of erosion, without human beings even knowing this many times. The presence of plant species that are pollinated by oligolectic bee species depends entirely on the activity of these bee species if there is no possibility of vegetative reproduction. Plant species, which are visited by oligolectic bees heavily, are in important families such as Asteraceae, Fabaceae, Malvaceae, Onagraceae and Cactaceae.

Plant Species And Characteristics In Rangelands

Forage crops which contain the nutrients which livestock farm animals must take to survive and to give desired products, are not harmful to animal health and animal products when fed in certain limits, can be defined as plants growing spontaneously in agriculture or nature in various areas. Forage crops grown in agriculture system and natural meadow-pastures are important sources of feed in providing quality, inexpensive, and abundant feed for animals. Also, these plants provide feed, which is the most important input in animal production, affecting positively the physical and chemical features of the soils where they grow, and the yield and quality of the culture plants that follow it (Demiroglu Topcu and Ozkan, 2017).

In our country, rangelands are an indicator of our socio-economic conditions and development. Especially, animal breeding is performed mostly with natural pastures and natural meadows; and rangelands are the main source of feed of our livestock (Alcicek and Karaayvaz, 2002; Anonymous, 2004). In addition to being an indispensable source of economic animal breeding, pastures also perform the function of turning CO_2 into oxygen with photosynthesis for a longer period of time, preventing erosion. It also has features like storing the soil and water, being the source of spring waters, cleaning the air, and of course, providing an important recreation area as a fauna, beautifying the environment with green cover (Anonymous, 2004; Dede, 2016). They also have very important tasks like creating biodiversity, being a gene source for culture plants, providing shelter for wild animals, and protecting the soil against erosion. Among the meadows and pastures constituting approximately 1/4 of the area of our country, 30% of the rough feed that animals need is covered (Gokkus, 1994).

Natural pasture areas have a very important place in the terrestrial areas of the world, and pasture vegetation of many plant species is also important in terms of sustaining natural balance and meeting the social and economic needs of people. Pastures are suitable for using mainly for grazing of the large and small cattle in terms of their natural structure; and apiculture activities are an area of agricultural activity that cannot be ignored in these areas. Pasture vegetation was created entirely as a result of natural plant species in the environment as a result of natural succession processes; and using chemical inputs that may adversely affect the natural structure of vegetation is not mentioned in this respect.

The importance of apiculture activities should not be ignored for sustaining plant generations in vegetation and which need the pollination of bees for seed production; and therefore, the preservation of natural balance. Honeybees have very important roles in the continuation of the vegetation in the nature. In our country, it is mandatory to see the honeybee as an indispensable element of agriculture and to use it effectively in pollination. In this way, natural pasture areas with proper ecology and genetic variety will be made use of for apiculture, and quality and quantity will also be increased in plant production.

Pasture vegetation is made up of a large number of plant species, and the plant species that make up the botanical composition consist of three main groups as grasses, legumes and plants from other families (Gokkus and Koc, 2001). Forage crops of the legume family, which are among the indispensable elements of pastures, are an important feed material for animals as well as being a precious source of pollen and nectar for bees (Howes, 1979; Sorkun, 1987; Balci, 1992; Otles, 1995).

Plants like astragalus, ivy, henbit, thyme, lavender, mint, sage, mustard, alfalfa, white clover, red clover, crimson clover, sainfoin and bird's foot trefoil, which are abundant in meadows and pastures in Turkey, are very important and rich nectar and pollen sources for bees (Genc ve Dodologlu, 2011; Demiroglu and Topcu, 2016). Pasture areas, which consist of rich plant species, allow multifaceted use; and therefore, made use of by grazing farm animals for apiculture and honey production, which is an important agricultural activity (Gokce, 2002; Gul et al., 2005).

Alfalfa (*Medicago sativa* L.), which is one of the most valuable forage crops grown in the world and in our country, is one of the valuable legume forage crops that have highest protein yield to the unit area (Acikgoz, 2001; Soya et al., 2004). Hay and green herbages are delicious and nutritious for all kinds of animals. The flowers are violet or purple, and rarely white. Sainfoin (*Onobrychis viciifolia* Scop.), which is the native plant in our country, is an important forage crop with its features like adapting to ecological conditions very well, and being able to grow in aqueous and rural areas. Its flowers are pink or rosebud in color and the plant stem is in the form of a bundle. It is a very important forage crop, and also a good honey plant (Madoc, 1934; Pellet, 1940; Rozov, 1952).

As it is already known, erosion is one of the most important problems in our country, and human and animal deaths increase to very advanced dimensions from time to time because tons of soils are transported to the seas every year. It is very difficult to even estimate the losses in plants and wildlife in the nature. The ploughing of slope areas, which began in 1950s in our country, over-grazing and gradual reduction of forest cover accelerated the erosion very much. In the examinations and observations in Eastern and Northeastern Anatolia, which have rough terrain structure, it was noted that the common vegetation in slope areas that were previously ploughed and then abandoned consisted mostly of plants in the Asteraceae, Boraginaceae, Brassicaceae, Campanulaceae, Compositae and Fabaceae families that needed bee pollination.

The Relation Of Bees And Rangelands

There are thousands of plant species in pastures with importance as nectar and pollen source. They may be grouped as legume forage crops, trees and shrubs (Dogaroglu and Dogaroglu, 2012). Honeybees, which are the most important pollinator of plants, prefer the flowers of some plant species more, which is affected by factors like the structure of the flower, the color of the petals, the volume of nectar, the composition of sugar and amino acids in the nectar (Corbet et al., 1984). There is also a close relation between the visits of the bees to pasture vegetation, nectar and pollen production (Genc and Dodologlu, 2011).

It is very important in apiculture to know the variety of the flora, and the flowering period of honey plants on pastures. Plants can be used effectively by keeping beehives in this region during the flowering period of plants. Researchers emphasize that more efficient apiculture can be carried out by determining the flowering periods of plants in pastures in different regions (Deveci et al., 2012). Instead of plenty of flowers and plenty of nectar for a short period of time, there should be nectar present for longer periods. The condition for this is that there should be various honey plants in the area, and when one or more are finished, they should pass on to the others and collect honey extract for longer periods. The flower condition during spring and summer is the main source of a more productive and successful apiculture. Natural pastures and meadows, which are very important for livestock, are also valuable sources of nectar for bees (Sonmez, 1984).

Obtaining quality and highly efficient products is the most important target of the modern agriculture; and therefore, as well as technical procedures, problems about pollination and fertilization should also be known; and solutions should be found for these problems. In almost all pollinated plants, and in many of the self-pollinating plants, the pollination of bees causes both increased yield and increased quality in products (McGregor, 1976; Free, 1993). In addition to proper cultivation techniques regarding potential yield, bees that are effective in pollination must be adequately be made use of. Rincker et al. (1988) emphasized the importance of favorable climate conditions and pollinator bees for the cultivation of successful alfalfa seeds, and the yield of clover seeds increased up to 211 kg da^{-1} in favorable conditions. Also, some researchers emphasized that the clover plant was self-infertile, and binding seeds in its flowers was provided by outside pollination, which also depended on bee activity, and that multiple bee visits in a flower were important (Ozbek, 1979; Fearn, 1987; Richards and Edwards, 1988).

Numerous scientific studies were conducted on flowery plants that honeybees visit mostly. According to the results obtained in these studies, it was determined that the legumes family, which is valuable for valuable pasture areas, hosts significant sources of nectar and pollen for bees in their flowers, and that bees visited these plants frequently (Baydar and Gurel, 1998; Ozbek, 2002; Karaca et al., 2006). The study of pollination has a long and rich history, but in many ways we have still only begun to understand the various facets of this important ecological interaction. This is particularly true for rangelands, wild lands, and native habitats (Harmon et al., 2011).

CONCLUSION

From past to our present time, the most important factories where honey, which has treating features and nutritious value for humans, have been produced by bees, are natural pasture areas. Bees, which can easily travel to the flower they want in the nature and collect the necessary raw materials, are the most important group among the pollinator insects. Pasture areas, should be made use of in addition to the increase in the quality and yield in plant production and in honey production. It should not be forgotten that our country has geography with suitable locations for apiculture in all seasons of the year with rich variety of plants and climate types.

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CHAPTER 15

GREEN MANURING AND USE OF FORAGE CROPS IN GREEN MANURING

INTRODUCTION

According to results of many analyses conducted on various regions of Turkey, the organic matter and nitrogen content of over 75% of Turkey's soils are classified as low or very low. Only around 6% of soils in Turkey has sufficient or more organic matter content. The adequate phosphor content is classified as low or very low in over 75% of Turkey's soils. The ratio of soils containing adequate phosphor in ample quantities is around 14%. This situation is reversed for potassium: 80% of the soils in Turkey is rich or very rich in adequate potassium. Only around 1.3% of the Turkish soils contain insufficient potassium (Ergene, 1987; Yetgin, 2010).

Organic substances improve the physical properties of the soil, help aeration of the soil, regulate the water holding capacity of as well as behavior of water within the soil, and allow more suitable soil temperatures. The fact that organic matters are scarce and nutrients lack in soils of Turkey, shows the importance of application of organic manures on these soils (Karakurt, 2009).

The yield increase caused by the use of fertilizers in agricultural products is around 50% on average. This value can increase up to 80% in some products. Nutrients effective in crop development are nitrogen, phosphorus and potassium, respectively. Their effects depend to the type of product as well as the soils, which is the growth medium. In case where the lacking nutrients are not replaced by use of commercial and organic manures, losses will occur in soil fertility, and consecutively in product yield. (Anaç and Okur, 1998). In Turkey, 6 million tons of chemical fertilizers, 39 thousand tons of agricultural chemicals and hormones are used annually for agricultural production. The uncontrolled use of synthetic chemical inputs in agricultural praxis creates a life-threatening danger that can reach all the living through the food chain, as such praxis causes pollution and disrupts the natural balance (Yücel and Altındişli, 1999; Yetgin, 2010). In addition to preventing such damages and obtaining healthy food without polluting the natural resources and disrupting natural balance, the organic manures are needed to enhance the yield per unit area and to improve quality.

Organic manures are needed for organic agriculture, which is important in the world and in our country for a healthy nutrition and a healthy environment. This is the underlying reason for the importance of organic manures. Organic manures consist barnyard manures, compost and green manures. However, difficulties in both usage as well as provision of the first two and ease of application of the green manuring make the green manuring the most effective source in practice.

GREEN MANURE AND GREEN MANURE PLANTS

The substances given to the soil in order to increase the vegetative production are called fertilizers, and the process of giving these substances to the soil is called fertilization.

Green manuring, on the other hand, is the process where the plants that create vegetative parts in short time, ploughed under and incorporated into the soil to improve the physical structure and to increase the organic matter and nitrogen content of the soil. Plants grown for this purpose are called green manure plants (Florentín et al., 2010; Rosenfeld and Rayns, 2011).

History of green manuring is old. There are Chinese records writing that green manure plants, especially forage crops were buried in soil in pre-blooming period 3000 years ago. Similarly, there are records of Roman and Greek farmers applying green manure on infertile soils (Parson,1984; Açıkgöz, 2001). Increasing the organic substance content of the soil, remedying the soil structure, enriching the soil in nitrogen, ensuring proper functioning the nutrients and preventing erosion and soil lose on unsown fields are among the purposes of green manuring. However, the main purpose of green manuring is the improve the physical structure of the soil.

For green manuring, annual or perennial species of legume forage crops are commonly used. Among the annual species, common vetch, hairy vetch, broad bean, pea, lupine species, soybean, crimson clover, berseem clover and persian clover are most commonly used. In some regions, perennial species such as red clover, alsike clover, white clover, sometimes alfalfa are sown for green manuring purposes. Also, mustard, grass species, rye, oat and buckwheat are cultivated for green manuring (Açıkgöz 2001; Karakurt, 2009). Plant species most frequently used as green manures are in Table 1 below.

Table 1. Green Manure Plants (Kaçar and Katkat, 1999)

Forage Crops	Non-Forage Plants
Alfalfa	Rye
Red clover	Oat
Melilot	Barley
Soybean	Buckwheat
Field pea	Wheat
Cowpea	Grass
Crimson clover	Mustard
Hairy vetch	Rapeseed

For green manuring, it is most suitable to choose the plants that accumulate nitrogen at its roots, thus enriching the soil with nitrogen. The green manure plants are ploughed and incorporated into the soil around 10% blooming (Figure 1).

Figure 1. Ploughing of green manure plants

SELECTION OF GREEN MANURE PLANTS

Since the green manure plants are very diverse, it is necessary to select the species best corresponding to the current climate, soil and farming conditions in the locality. For example, some of the forage crops like warm climates, while others can thrive better in cool climates. Likewise, some forage crops are suitable for autumn planting and some for spring planting.

The following aspects must be considered for selection of the green manuring crops;

- Its value as a forage crop,
- Amount of organic matter, or nitrogen if forage crop, to be accumulated in the soil,
- Seed price,
- Rooting status,
- Ease at ploughing and disintegration,
- Development status and soil requirements (Taban and Turan, 2012).

The green manure plant to be selected should grow fast, grow excessive above the soil level and develop well even in poor soils. For example, rye crops are sown in autumn after harvesting of silage maize and buried under ground for maize next spring. Under suitable climatic conditions, soybeans are planted after harvesting oats or wheat and buried under the ground in autumn. If the green manure plant is grown in orchards, the season of development of trees should be considered.

BENEFITS OF GREEN MANURING

The green manure increases the yield of the soils and helps obtaining more and higher quality products but its most significant benefit is that it enriches the soil in terms of organic matters. Especially in places where barnyard manure is scarce, the organic matter content of the soil is significantly increased by use of green manure. Organic matter is one of the most important factors affecting the physical, chemical and biological properties of soils. It directly increases the fertility of soils by positively affecting the physical properties such as improving the structure of the soil, aggregate strength, water holding capacity and aeration. Organic matter constitutes the form of all nutrients, especially nitrogen, which is permanently present in the soil and is not easily washed away.

Ploughing the green manure plants into the soil adds high quantities of easily degradable organic matter. If the green manure plant used is a legume forage crop, the degradation occurs at a higher rate due to high N content in the plant tissues. However, contrary to general thought, green manure does not increase the organic matter ratio of the soil at high rate. It only stops or minimizes the organic matter reduction of the agricultural soils. A 15 cm topsoil layer of a soil containing 2% organic matter contains 5 ton/da organic matter. If a forage crop as green manure, generating 250 kg/da organic matter, is ploughed and incorporated into this soil, 2/3 of this organic matter decomposes and evaporates. With the remainder, the amount of organic matter available in the soil increases by only 1.6%. In other words, in order to increase the organic matter ratio of this soil from 2% to 3%, it is necessary to apply green manure for 63 years (Açıkgöz,2001). For this reason, the main purpose of green manuring should not be to increase the organic matter ratio of the soil, but to preserve and to balance the organic matter ratio of the soil. In line with this fact, it was understood that 25 years of green manure application in Louisiana and 9 years in Arkansas did not significantly increase the organic matter of the soil (Waddle, 1984). Similarly, it was found that green manuring with vetch, broad bean, clover and ryegrass for one year in Samsun did not affect the organic matter content of the soil but increased the enzyme activity of the soil (Kara and Penezoğlu, 2000).

The green manure encourages formation of roots and aggregates of the plants during vegetation period. Physical structure of the soil improves as a result of accelerated microorganism activities and disintegration after plowing (Çepel, 1988; Karakurt, 2009; Talgre, 2013; Gezgin, 2018; Acar et al., 2019).

With green manuring, significant nitrogen is introduced into the soil, depending on the nitrogen content of the plant selected. Excessive ratios can be achieved with green manuring, especially when legume forage crops are used. Studies proven that legume forage crops sown for green manuring provides approximately 10-30 kg N per decare (Anonymous, 1975; Karakurt, 2009). Table 2 shows the amounts of nitrogen, phosphor and potassium provided per decare by the crops.

Table 2. The amount of nutrients provided by legumes ($kg.da^{-1}$) (Atilla, 1999)

Plant	Product (kg)	Nitrogen		Phosphor		Potassium	
		Stem	Root	Stem	Root	Stem	Root
Cowpea	182.6	10.6	2.5	2.2	0.7	7.6	1.5
Soybean	253.7	18.5	1.0	4.7	0.2	12.2	0.7
Broad Bean	194.3	19.2	3.6	3.4	0.7	17.1	2.2
Vetch	243.5	17.1	3.0	4.1	0.8	18.3	2.5
Red clover	253.7	15.5	4.9	3.6	1.5	17.0	3.6

Biological nitrogen fixation is the process of converting atmospheric N2 into ammonia (NH3) or other molecules in the soil which can be easily accessed by plants (Rosenfeld and Rayns, 2011; Meena et al., 2018), and is carried out by symbiotic relationships with *Rhizobium* bacteria living in the root nodules of plants of leguminous family (Karaöz, 1992; Florentín et al., 2010) as shown in Table 3.

Table 3. Approximate soil nitrogen yield of several legume green manure crops (Acar et al., 2019)

Green Manure Crop	Scientific Name	Nitrogen Yield (kg ha^{-1} $year^{-1}$)
Alfalfa	*Medicago satvia*L.	125-600
Red clover	*Trifolium pratense*	73-460
Crimson clover	*Trifolium incarnatum*	100-150
White lupine	*Lupinus albus*L.	75-300
Common vetch	*Vicia sativa*	90-250
White clover	*Trifolium repens*	50-450
Pea	*Pisum sativum* L.	80-160
Yellow sweet clover	*Melilotus officianalis*	15
Soybean	*Glycine max* L. Merr.	65-200
Persian clover	*Trifolium resupinatum*	100
Hairy vetch	*Vicia villosa*	40-208
Fanugreek	*Trigonella foenum-graecum*	30
Lentil	*Lens culinaris*	13
Forage bean	*Vicia faba* L.	97-152
Subterranean clover	*Trifolium subterraneum*	4-320

As it can be seen, legumes provide more nitrogen to the soil with their roots and aboveground organs. In addition, since legumes contain high levels of N, microorganism activity and degradation are faster after plowing.

Snapp et al. (2002) reported that the yield obtained in corn production in areas that could not be fertilized due to limited opportunities in South Africa is very low, but if a legume green manure plant is included in the system, up to 50 kg of organic nitrogen can be added per 1 decare soil. They also reported that significant increases could be achieved in the amount of product obtained.

Green manuring provides soil with organic matter and nitrogen, affects the physical and chemical structures of soils, enhances humus accumulation and increases microbial activity in soils thus helping to improve the biological properties of the soil (Çolak, 1988; Kara and Penezoğlu, 2000).

The roots of the forage crops go deep in the soil thus regulating the air and water content of the soil, transporting the nutrients to upper layers, preparing soil for sowing and helping to maintain that status for longer periods of time. Due to these properties, they facilitate the cultivating of heavy soils that are difficult to process. They help the root systems of the plants to develop more easily (Sezen, 1991).

Green manure plants protect the soil from water and wind erosion, especially in inclined areas. They prevent the rains falling on the soil from damaging the soil structure. Green manure plants also keep the soil warm and reduce the root losses that occur in perennial plants by keeping the snow on the surface of the soil in winter.

Green manure makes it possible to control most pests, nematodes and fungi, especially by using plants which secrete substances that kill pests and diseases and reduce their harmful activities. In green fertilization, it is possible to control most pests, nematodes and fungi, especially by using plants that secrete substances that kill diseases and pests and reduce their harmful activities. Disease or pest density is reduced by choosing a green manure plant without a host. Soil diseases are eliminated or reduced thanks to high biological activity.

Green manuring, which increases soil fertility by positively affecting the physical, chemical and biological properties of the soil, can also be used in weed control. Plants to be used in green manuring are incorporated into the soil, mixed with weeds. With the next ploughing, these are completely destroyed. Germination of weeds can also be prevented by leaving the green manure on the soil surface as a thick layer of mulch (Karakurt, 2009).

GREEN MANURE PLANTS GROWING SYSTEMS

In terms of green manuring, Turkey is divided into two as Coastal Areas, Passage and Central Anatolia Region. In green manure plants; It is desired to be compatible with climate and soil conditions, deep rooted, resistant to diseases, rapidly growing, high biological yield, easy to obtain seeds and small seeds. Also, the green manure should have a full return rate over its costs.

For green manuring, the plants are grown in four different types: 1- Principal (Main) plant, 2- Intermediary plant, 3- Sub-plant and 4- plant for sowing on stubbles (Soyergin, 2003; Karakurt, 2009; Taban and Turan, 2012).

Principal (Main) Plant: If the green manure plant is grown as the main plant, the field is reserved only for this plant for one year and no other crop is obtained from there during the process. However, two different species of green manure plant can be sown on the same field in the same year. The plant planted in autumn is mixed with the soil at the beginning of spring. Immediately after, the plant planted in its place is mixed under the soil in autumn, and two different green manure plants are grown as the main plant in the same year. This method is mostly used to enhance the yield of light sandy soils which are very poor in humus. Economically, this system is not suitable for soils with high fertility. Although it is possible to sow the green manure plant as the main plant in all regions in Turkey, it is mostly sown in Central Anatolia and Eastern Anatolia regions and especially in the form of sole or mixture cultivar for soil improvement.

Intermediary Plant: Unlike other systems, this method is not very dependent on soil and climatic conditions. In this system, sowing is done in August-September, it is used in April-May. It is necessary to be careful in choosing the plants to be grown. Because the plants remain in the field for longer periods. Although it is very beneficial as it forms large amounts of stem and root parts, it uses a significant part of the soil moisture in spring. Thus, it poses a water problem for the next plant after itself. In Turkey, especially in the coastal regions, green manure plants are grown as intermediary plants, to increase soil fertility and organic matter.

Sub-Plant: Use of green manure plants as lower plants is especially beneficial in soils which receive high volumes of precipitation (more than 600 mm) and which offer good characteristics. In the application of this system, the development time of the upper plant should be taken into account. The upper plant to be selected should complete its development quickly and leave the field as soon as possible.

In this regard, the most suitable plants are winter cereal crops and especially the winter rye. The winter rye is the crop which leaves the field earliest, compared to other cereals. Under suitable conditions, summer cereals are also good upper plants. Especially clovers from legume forage crops are suitable plants for growing as sub-plants. The sowing time of the sub-plant depends largely on the soil and climatic conditions. For example, sowing is done as early as possible in light soils (beginning of March). Thus, the plant develops rapidly by taking advantage of the water accumulated in the soil in winter. Otherwise, it will be damaged by the drought that occurs in the spring.

Plant for Sowing on Stubbles: In this system, the plant is sown on the stubble after harvesting of the main crop in summer or by sprinkling the seeds before fallow breakdown (manually or by use of fertilizer distributor), like it is applied in the Central Anatolia Region, by burying them with a plow afterwards. But in this system, the green manure plants require much water. They are suitable for regions with early summer and autumn rains or places with irrigation possibilities. As plants for sowing on stubble, fast growing and especially annual plants should be preferred.

In some regions, green manure plants can be used by grazing. Excessive vegetative parts are buried as green manure. In areas with high herbage demand, the green manure plant is harvested for grazing, and the remaining stubble is mixed into the soil. In both methods, the amount of organic matter and nitrogen added to the soil is significantly reduced compared to normal green manuring. But, since the plant is used twice, these applications are preferred in some regions.

MATTERS TO BE CONSIDERED FOR GREEN MANURING

The issues to be considered in the cultivation of green manure plants are fertilization, the amount of seed to be used, the time and depth of incorporation of the plants into the soil.

Fertilization; Naturally, the fertility of the soils where green manure plants are used is commonly very low. In such soils, the missing nutrients must be added before sowing the green manure plant. For non-leguminous plants, it is necessary to apply phosphorus and potassium fertilizers, especially nitrogen. For legumes, especially phosphorus, potassium and calcium fertilizers should be used. Legumes need large amounts of calcium for best development. Calcium to be given to legumes not only strengthens the soil and root development of these plants but it also significantly increases the nitrogen binding capabilities of these plants.

Amount of seeds; For plants used as green fertilizer, the amount of seed per decare to be sown with the seed drill should be as follows. 14-16 kg da^{-1} for vetch, 20-25 kg da^{-1} for broad beans, 18-20 kg da^{-1} for cereals, 5-8 kg da^{-1} for mustard, 8-10 kg da^{-1} for sunflower, 10-12 kg da^{-1} for field pea, 12-14 kg da^{-1} for cowpea and 10-12 kg da^{-1} for soybeans (Karakurt, 2009). If the seeds will be spread manually, the amount of seeds should be increased by 20% compared to sowing with a seed drill. The amount of seeds should be further increased if it is desired to have a good vegetation cover on the soil surface during winter period and thus protecting the soil from erosion.

Time and depth of incorporating green manure plants into the soil; The incorporation time of the plants used for this purpose varies according to the region and the sowing time of the main crop. In regions with mild winters, it is recommended to plough and incorporate the green manure plants sown in autumn 2-3 weeks before sowing the main crop, during blooming period of the plant in early spring (Henson et al., 1955). Plowing the plants becomes more difficult and disintegration takes longer in later periods. But incorporation of green manure plant in early periods provides less organic matter and nitrogen to the soil. Yet the plant disintegrates more easily and making it easier to sow the main crop (Auld et al., 1982). The most important factor is the C:N ratio of the plant. Plants with higher C:N ratios require longer times for disintegration in the soil.

Better results are obtained when precipitation is received, or the soil is irrigated right after incorporation of the green manure plant into the soil. The soil dries up and the plant cannot germinate if the precipitation is delayed. Despite these positive effects seen in regions with regular precipitation, green manuring does not yield good results in arid regions. Especially in arid regions where the grain-fallow system is practiced, the green manure plants sown on fallows cause a decrease in the yield of the main crop since they consume the water, which is already limited in the area. Studies conducted in the USA and Canada found that annual or perennial legumes grown on fallow land consume water in the layers of the soil, therefore decreasing the grain yield (Army and Hide, 1959; Biederbeck and Bouman, 1994). For this reason, green manure applications are recommended in regions with minimum 500-600 mm annual precipitation rates and regular rainfalls or in areas that can be irrigated.

Another important consideration for green manuring is the depth of incorporation into the soil. Incorporation of green plant at deeper level also prevent loss of nutrients due to washing out.

CONCLUSION

In different regions of our country, it is possible to ensure continuity in soil fertility and to obtain high quality and yield with appropriate plants and green manuring at the appropriate time. Green manuring is crucial for nitrogen input saving and also for environment in cultivated plants. By reducing the nitrogen input, the microorganisms that play a role in nitrogen fixation, minimize the environmental problems that nitrogen may cause yet provide the soil with nitrogen in a cheap manner. Although the use of excess nitrogen fertilizer provides a high increase in yield, it causes environmental pollution by mixing with groundwater and potable water by washing due to its high nitrate content.

Fertilizer, one of the agricultural inputs, is necessary for the production of foods needed for a balanced and regular nutrition of the ever-increasing world population. In addition to its negative effects on the soil flora, the use of excess nitrogen fertilizer causes significant problems on human health and the general economy by reducing the resistance of plants to diseases and pests, mixing with groundwaters and potable waters, accumulating in various plants which are eaten by the humans. In recent years, as a way of increasing the yields, the green manuring has come into prominence as an alternative to mainstream commercial fertilizers. Given the advantages of green manure, its use should be encouraged.

A sustainable agricultural production practice, which is also sensitive to the environmental and human health, should be promoted and favored and awareness of both the producers as well as the masses should be increased.

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CHAPTER 16

IDENTIFICATION OF MORPHOLOGICAL AND AGRONOMIC PROPERTIES OF ALFALFA POPULATIONS (*Medicago sativa* L.) IN SEMI-ARID CONDITION IN TURKEY

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INTRODUCTION

Alfalfa (*Medicago sativa* L.) is one of the most widely grown forage legumes throughout the world. It is cultivated in more than 80 countries on more than 35 million hectares (Rashmı et al., 1997; Radović et al., 2009).

There are more than sixty annual and perennial species belonging to the genus Alfalfa (*Medicago*). The main gene centers of this genus with the species of alfalfa are Caucasus, Northwest and Northeast Anatolia, Iran and Turkey. There are various ecotypes of alfalfa that adapt to changing climatic conditions in different geographical regions and can be distinguished from each other. These ecotypes tend to form subpopulations for subspecies. It is therefore useful to evaluate wild subspecies populations (Hanson et al., 1988; Michaud et al., 1988; Putnam et al., 2001; Şakiroğlu et al., 2010).

Alfalfa is a perennial flowering plant that can be sown both in spring and autumn. In the year of stand establisment, alfalfa seedlings can be damaged by the heavy frosts of autumn in the early development period when autumn planting is done and plant deaths can be seen. For this reason, spring planting is recommended in regions with hard winter conditions. In the early spring plantings, the moisture remaining from the winter and the spring rains are benefited. The plant, which is one of the cool season forage species, begins to grow in spring, and flowering time takes place between May and October depending on the grown location. In addition, it can be mowed several times a year from the plant harvested at the 10% flowering period (Heath et al., 1973;

Wasser, 1982; Bosworth and Stringer, 1992; Ruan et al., 2012; Christian et al., 2020).

Alfalfa plant can be easily grown in a wide range of soils. However, it likes rich, crumbly, well-drained loamy soils. It is a plant that is resistant to high temperature and drought and can survive under 40-45 ° C high temperature and 45-50 cm annual rainfall, even under 35 cm low rainfall conditions. Alfalfa, which is a perennial plant, can grow 60-90 cm in length.

Depending on the genotype and environmental conditions, it was determined that the plant height could reach over 1 meter. It can have taproots that can go 7-9 m deep and a root crown of 3-5 m deep in sandy soil conditions. It has been determined that old plant roots can go down to 19 m and even alfalfa root having 39 m are found in Nevada (Heath et al., 1973; Smoliak et al., 1981; Rashmı et al., 1997).

Alfalfa is a plant with good drought tolerance with its deep root structure. Annual rainfall requirement is around 300-360 mm, and irrigation implement in arid conditions greatly increases productivity (Heath et al.,1973; Stanton, 1974; Schweitzer, 1988).

This plant is the most important feed crop in the global feed market. This importance sources from its high feed quality. In addition to the quality of the feed, its adaptability, high herbage yield, ability to bind the free nitrogen in the air to the soil via Rhizobium bacteria in its roots add value to its value. Due to nitrogen fixation, the leaves of the plant contain a high amount of protein. The root structure that can go deep ensures that the plant has an improved efficiency in water use and nutrient intake. With these qualities, it has excellent properties for sustainable agriculture (Ball et al., 2001; Putnam et al., 2001; Radović et al., 2009; Lei et al., 2017; Singer et al., 2018; Kulkarni et al., 2018).

It is of great importance that alfalfa can be grown under dry conditions as well as cultivation under irrigated conditions, high nutritional quality and yield, and its use in rangeland improvement and artificial pasture establishments. The fact that it remains dormant during dry periods and does not need nitrogen fertilization increases its importance as a rangeland plant due to its re-development with rainfall (Açıkgöz, 2001; Herrmann et al., 2010; Bouton, 2012; Sabancı et al., 2013).

The plant, which is deliciously consumed by all animal classes, is invaluable for the rehabilitation of overgrazed rangeland areas due to its early growth and preserving its green parts longer than grasses (Evanko, 1953; Heath et al., 1973; Stanton, 1974; Smoliak et al., 1981; Dittberner and Olson, 1983).

Today in Turkey, especially in rangeland improvement in the over-seeding, alfalfa varieties are needed that can be used in mixtures of artificial pasture plants. There is no registered alfalfa variety improved for dry conditions (Anonymous, 2019a).

Alfalfa varieties imported from abroad or developed for irrigated conditions are used in rangeland improvement studies and artificial pasture mixtures. For this reason, problems of adaptation and shortening of the pasture establishment's life are encountered. It is necessary to develop new varieties for the arid conditions of the region by taking advantage of the existing genetic diversity for a more economical and more sustainable production. Thus, the loss of national resource that may occur due to import is prevented.

In this study, the characteristics of alfalfa materials collected from semi-arid areas of the Central Anatolia Region in Turkey were determined and materials could be used in future breeding programs were identified.

MATERIALS and METHODS

Materyal ve Metot

This research was carried out at İkizce Research and Application Farm of the Field Crops Central Research Institute in 2017, 2018 and 2019. In this study, 10 alfalfa materials collected from Ankara and Kırıkkale provinces, which have semi-arid climatic conditions, and 2 control varieties (Drylander and Apollo) were used.

In the spring of 2017, alfalfa populations and control varieties were planted in small pots. Then, trial materials were transplanted into the nursery plot in a size of 70 x 70 cm. The 24 plants from population and control varieties were established in each plot.

The main stem length (cm), main stem thickness (mm), main stem number (pieces), green herbage (g / parcel) and dry herbage (g / parcel) yields of the materials in the nursery plots established in 2018 and 2019 were determined.

The study was conducted in the İkizce location where was 439.4 mm in the total amount of precipitation in 2018. In the same year, April precipitation, which is the development period of the plants, was 2.6 mm.

In 2019, the amount of precipitation in May was 3.8 mm. These precipitation amounts in April and May were too below the long-term average of the region (April 41.9 mm, May 51.8 mm).

While the highest average temperature in April was 17.4ºC for many years, it was 19.9ºC in 2018. For many years, the highest average temperature in May was 22.4ºC, while it was 21.9ºC in 2019 (Anonymous, 2019b).

The soil structure of the research area is determined such as clayey-loam, low amount of organic matter (1.31%), the sufficient amount of phosphorus available to the plant (9.47 kg/ha), the high amount of potassium useful for the plant (149.86 kg/ha), salt-free (0.565 dS m^{-1}), very high lime ratio (31.31%) and the slightly alkaline (pH=7.70) (Anonymous, 2017).

The research results were examined in detail under the headlines of morphological and agricultural characteristics. The data obtained were evaluated with basic statistical analysis (average, lowest and highest value, standard deviation and coefficient of variation) using the excel program.

RESULTS and DISCUSSION

Morphological features

The average, the lowest, highest, standard deviation and coefficient of variation values in main stem length, main stem thickness and main stem number of alfalfa populations and control varieties in years of 2018 and 2019 are given in Table 1.

Table 1. The average, the lowest, highest, standard deviation and coefficient of variation values in main stem length, main stem thickness and main stem number of alfalfa materials

Materials	Main Stem Length (cm)			Main Stem Thickness (mm)			Main Stem number		
	2018	2019	Ortalama	2018	2019	Ortalama	2018	2019	Ortalama
Drylander	50.9	54.2	52.6	2.2	2.9	2.6	6.7	35.3	21.0
Apollo	80.0	109.2	94.6	3.5	3.4	3.5	60.0	73.5	66.8
ANK-302	63.2	67.4	65.3	2.3	1.9	2.1	29.9	35.7	32.8
ANK-307	70.9	87.9	79.4	3.2	2.8	3.0	97.2	92.9	95.1
ANK-308	69.8	91.6	80.7	3.0	3.2	3.1	45.9	68.7	57.3
ANK-310	45.8	72.2	59.0	2.4	2.4	2.4	22.8	39.6	31.2
ANK-311	55.0	71.2	63.1	2.4	2.7	2.6	34.4	52.1	43.3
ANK-313	85.2	110.9	98.1	3.7	4.0	3.8	50.3	72.0	61.2
ANK-316	76.6	105.1	90.8	3.2	3.9	3.5	33.4	45.7	39.6
ANK-317	83.0	95.7	89.3	3.8	3.5	3.7	43.5	80.7	62.1
ANK-318	90.7	109.8	100.2	3.9	3.9	3.9	43.3	67.1	55.2
ANK-319	73.1	104.0	88.5	3.5	3.9	3.7	27.3	44.9	36.1
Averages	70.3	89.9	80.1	3.1	3.2	3.2	41.2	59.0	50.1
The lowest values	45.8	54.2	52.6	2.2	1.9	2.1	6.7	35.3	21.0
The highest values	90.7	110.9	100.2	3.9	4.0	3.9	97.2	92.9	95.1
Standard deviations	14.1	19.4	16.3	0.6	0.7	0.6	22.5	19.2	20.2
Coefficients of variation (%)	20.1	21.5	20.3	20.0	20.6	19.4	54.5	32.6	40.4

In the field, the environment is constantly changing, and the alfalfa (*Medicago sativa* L.) crop shows a corresponding, genetically programmed responce to environment (Fick et al., 1988).

The same authors added that seed germination, elongation of basal buds, flowering, and cold hardening are specific examples of plants responces to enviromnent. The same authors explaned that yield components are a function of vegetative growth rate and plant morphology. Moreover, the yield components of a forage crop are (i) number of plants per unit area, (ii) number of shoots (or tillers) per plant, and (iii) mass per individual shoot.

Main stem length is a plant character that is affected by environmental stress factors. It is one of the most important indicators of plant growth and development. With the increase in stem length, herbage yield also increases. Many researchers examined the stem length of the different alfalfa genetic materials. They stated that the variations seen in this subject are caused by both genetic structure and environmental conditions (Sağlamtimur et al., 1986; Smith et al., 1989; Juan et al., 1993; Aka and Avcıoğlu, 2003; Basafa and Taherian, 2009; Yılmaz, 2011; Tucak et al., 2014).

The values of lowest, highest and average plant height in the populations and control varieties in 2018 and 2019 were determined as 45.8, 54.2 cm; 90.7, 110.9 cm and 70.3, 89.9 cm, respectively (Table 1). According to the two-year average data, plant height varied between 52.6-100.2 cm and average plant height was found to be 80.1 cm.

In terms of plant height, it was observed that there was a change of 20.1% in 2018, 21.5% in 2019 and 20.3% on two year average in alfalfa materials. The highest and the lowest plant heights were obtained from the population numbered ANK-318 and the Drylander control variety, respectively.

The plant heights of this study are in agreement with some other research results. For example, Öten and Albayrak (2014) found the main stem length of alfalfa genotypes between 67.45-101.28 cm (Yeşil and Şengül, 2009; Ünal et al., 2012; Öten and Albayrak, 2014; Bıçakçı and Balabanlı, 2016; Öten et al., 2016).

The values of lowest, highest and average main stem number in the populations and control varieties in 2018 and 2019 were determined as 6.7, 35.3; 97.2, 92.9 and 41.2, 59.0, respectively (Table 1). According to the two-year average data, the numbers of stem varied between 21.0-95.1 and the average number of stem was found to be 50.1. In terms of the number of stem of the materials, they showed a change of 54.5%, 32.6%, and 40.4% in 2018 and 2019 and two-year average, respectively. The highest and the lowest stem numbers were obtained from ANK-307 numbered population and Drylander control variety, respectively. The genetic structure and environmental conditions of the plant have also a significant effect on this feature.

In previous studies, it was found that the numbers of alfalfa stem varied between 4-50. The findings of this study are exactly similar to the results of other researchers (Volenec and Charney, 1990; Soramatine and Maksimova, 1990; Smith et al., 1991; Tan and Şengül, 1999).

Environmental conditions and agronomic practices affect alfalfa genotypes differently in terms of main stem number. Many researchers have obtained different results on this subject. When alfalfa is planted sparsely, the plants generate more stem numbers via receiving more water, nutrients and light. As the number of stem in the plant increases, the yield changes and increases positively (Perry and Larson, 1974; Razden and Cocking, 1981; Akbari and Avcıoglu, 1994; Şengül, 2002; Demiroğlu and, 2008; Yılmaz, 2011).

In plants, stem thickness is not a desired feature as it reduces the amount of digestible material. However, the thin stem is not preferred because it will increase the risk of lodging. The main stem thickness in alfalfa changes depending on the morphological structure of the plant and environmental conditions. It is stated that alfalfa stem thickness is affected by temperature and varies from year to year (Alınoğlu et al., 1972; Manga, 1979; Şengül, 1995; Koç and Tan, 1997; Aka and Avcıoğlu, 2003; Şengül and Sağsöz, 2004; Dumlu et al., 2017).

The lowest, highest and two-year average of the main stem thickness of alfalfa materials in 2018 and 2019 were determined as 2.2, 1.9 mm; 3.9, 4.0 mm and 3.1, 3.2 mm, respectively (Table 1). According to the two-year average data, main stem thickness varied between 2.1-3.9 mm and average stem thickness was found 3.2 mm.

In terms of main stem thickness, it was observed that there was a change of 20.0% in 2018, 20.6% in 2019 and 19.4% on two year average in alfalfa materials. The highest and lowest stem thickness were obtained from the population number ANK-318 and the material numbered ANK-302, respectively.

Alfalfa stem thickness has changed according to the genetic structure and environmental conditions like other morphological features. At the same time, the results of this study were consistent with many other research results. Among these researchers, Şengül and Sağöz (2004) and Dumlu et al. (2017) reported that the stem thicknesses in the alfalfa plant are 1.40-5.80 mm and 2.81-3.04 mm, respectively (Alınoğlu et al., 1972; Gülcan, 1974; Aka and Avcıoğlu, 2003; Şeker et al., 2003b; Şengül and Sağsöz, 2004; Dumlu et al., 2017).

Agricultural characteristics

The lowest, the highest value, two-year average, standard deviation and coefficient of variation values of green and dry herbage yields of study materials are given in Table 2.

Table 2. The lowest, the highest value, two-year average, standard deviation and coefficient of variation values of green and dry herbage yields of alfalfa materials

Materials	Green Herbage Yields (g/parsel)			Dry Herbage Yields (g/parsel)		
	2018	2019	Average	2018	2019	Average
Drylander	1392.9	1810.0	1601.4	393.8	452.5	423.1
Apollo	3875.0	6935.0	5405.0	1124.7	1733.8	1429.2
ANK-302	1670.0	2200.0	1935.0	456.8	550.0	503.4
ANK-307	2950.0	5655.0	4302.5	753.1	1413.8	1083.4
ANK-308	2365.0	7265.0	4815.0	619.6	1816.3	1217.9
ANK-310	850.0	2105.0	1477.5	231.6	526.3	378.9
ANK-311	1160.0	3320.0	2240.0	323.7	830.0	576.8
ANK-313	2955.0	7580.0	5267.5	748.2	1895.0	1321.6
ANK-316	2180.0	4695.0	3437.5	536.3	1173.8	855.0
ANK-317	3015.0	5230.0	4122.5	774.3	1307.5	1040.9
ANK-318	3210.0	5480.0	4345.0	877.9	1370.0	1124.0
ANK-319	1560.0	5640.0	3600.0	390.0	1410.0	900.0
Averages	2265.2	4826.3	3545.7	602.5	1206.6	904.5
The lowest values	850.0	1810.0	1477.5	231.6	452.5	378.9
The highest values	3875.0	7580.0	5405.0	1124.7	1895.0	1429.2
Standard deviations	946.0	2036.1	1412.6	261.4	509.0	359.9
Coefficients of variation (%)	41.8	42.2	39.8	43.4	42.2	39.8

There are a number of reason for the slower rate of progress in increasing yields with alfalfa but there is abundant genetic variability within and among alfalfa cultivars, and there is no indication that we are close to the limits that can be achieved in breeding for increased yield (Hill et al., 1988). The same researhers pointed out that breeders have increased the proportion of plant assimilates going into the desired plant organs (seed in many crops) without increasing total plant growth. In addition to they said that yield increases must be achieved by altering assimilatory processes.

Alfalfa with a strong root system can be grown without irrigation in dry regions with an annual rainfall of 200 mm and in humid regions with 2500 mm of rainfall. A satisfactory yield is obtained from the plant also in arid conditions.

Yield and quality of alfalfa are affected by genetic and non-genetic factors. These effects can be listed as planting and cutting frequency, soil fertility, harvesting method, presence of diseases and pests and other environmental factors. Today, it is possible to come across many different scientific articles on alfalfa yield (Yılmaz, 1975; Manga, 1981; Hill and Baylor, 1983; Gülcan and Anlarsal, 1988; Elçi et al., 1994; Hatipoglu et al., 1999; Tucak et al., 2014; Gökalp et al., 2017; Turan et al., 2017; Karaköy and Saraç, 2018).

The lowest, the highest and the two-year average of green herbage yields of alfalfa materials in 2018 and 2019 were determined as 850.0, 1810.0 g / parcel; 3875.0, 7580.0 g / parcel and 2265.2, 4826.3 g / parcel, respectively (Table 2). According to the two-year average data, green herbage yields varied between 1477.5-5405.0 g / parcel and the average green herbage yields was found to be 3545.7 g / parcel.

In terms of green herbage yields, it was observed that there was a change of 41.8% in 2018, 42.2% in 2019 and 39.8% on two year average in alfalfa materials. The highest green herbage yields was given by the Apollo control variety, followed by the population ANK-313. The lowest yield was obtained from ANK-310 numbered material.

The results of this study showed that good yields can be obtained in dry conditions. It is also compatible with the views that the yield trait is affected by genetic and environmental factors (Manga, 1981; Gökalp et al., 2017). It is also similar to Kır and Soya (2008), who reported that the average green herbage yield varied between 931-1359 g / plant.

In the alfalfa trials conducted before, different results were obtained in dry harbage yield as well as green herbage yield. Genotypic structure, climate and soil conditions are effective on this change in yield. In addition to these, agronomic methods such as planting time, sowing method, irrigation, fertilization and weed control are practices that affect yield (Hoff and Dotzenko, 1968; Pupkov and Romenskaya, 1975; Hatipoglu et al., 1999; Altınok and Karakaya, 2002; Töngel and Ayan, 2010; Açıkbaş et al., 2017; Engin and Mut, 2017; Dumlu et al., 2017; Türk et al., 2018).

The lowest, the highest and the two-year average of dry herbage yields of alfalfa materials in 2018 and 2019 were determined as 231.6, 452.5 g / parcel; 1124.7, 1895.0 g / parcel and 602.5, 1206.6 g / parcel, respectively (Table 2). According to the two-year average data, dry herbage yields varied between 378.9-1429.2 g / parcel and the average dry herbage yields was found to be 904.5 g / parcel.

In terms of dry herbage yields, it was observed that there was a change of 43.4% in 2018, 42.2% in 2019 and 39.8% on two year average in alfalfa materials. The highest dry herbage yields was given by the Apollo control variety, followed by the population ANK-313. The lowest yield was obtained from ANK-310 numbered material. Genetic and environmental factors have been effective on dry herbage yield of genotypes. The results of this study were similar to the findings of some other researchers (Pupkov and Romenskaya, 1975; Şengül, 1995). Tahtacıoğlu et al. (1996) and Hatipoğlu et al. (1989) were found dry herbage yields in alfalfa such as 1291-1781 kg / da and 246.3-324.7 kg / da, respectively.

RESULTS

There are no alfalfa varieties developed for dry conditions in our country. For this reason, there is an urgent need for alfalfa varieties that can be used in over-seeding of rangelands, artificial pasture establishment and dry farming areas. This study was planned to meet this need. Two of the 10 populations included in this study passed the control drylander in the characteristics examined. However, these two populations gave values close to the other control Apollo. These two populations ANK-308 and ANK-313 for main stem length, main stem thickness and the number of main stem took the values of 80.7 and 98.1 cm; 3.1 and 3.8 mm; 57.3 and 61.2, respectively. Drylander had the values 52.6 cm, 2.6 mm and 21.0 in main stem length, main stem thickness and the number of main stems, respectively. In this study, green herbage and dry harbage yield values of ANK-308 and ANK-313 populations were 4815.0 and 5267.5 kg / da; 1217.9 and 1321.6 kg / da, respectively. Green herbage and dry herbage yield values for Drylander were 1601.4 and 423.1 kg / da, respectively. ANK-308 and ANK-313 populations gave higher green and dry herbage yield than the control variety Drylander. It will be appropriate for these two native materials, which adapt to the regional conditions, to take part in future breeding studies.

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CHAPTER 17

INVESTIGATION OF THE POSSIBILITIES OF USING SOME CORN VARIETIES AS SILAGE

INTRODUCTION

Maize plant ranks third in the world in terms of cultivation area, after wheat and paddy, and first in terms of production amount. In the USA, which is the world's largest maize producer, 56% of the production is used as animal feed (Tansı et al., 2009).

Maize has become the most important silage plant due to reasons such as the high rate of green yields per unit area, its suitability for silage production, and the high nutritional value and taste of the obtained silage (Açıkgöz, 2001).

According to the statistics of 2018, it has been reported that silage maize is grown in 1 170 832 hectares in the world and the yield per ha is 9 836 kg (FAO, 2018). According to data of 2018 in Turkey 4,610,436 acres of silage maize is grown. It has been recorded that the yield per decare is 5 032 kg (TUIK, 2018).

In a study conducted in Van ecological conditions regarding the silage yield and yield characteristics of the maize plant, the average plant height was 350 cm, the green leaf rate 17.8%, the stem rate 45.1%, the cob rate 37.1%, forage yield 6586 kg da^{-1} and dry matter yield 1796 kg da^{-1} has been determined (Yıldız and Erdoğan, 2018). In the ecological conditions of Antalya province, the average plant height for silage maize was determined as 234 cm, leaf and stem ratio 46.8%, cob rate 35%, forage yield 6345 kg da^{-1} and dry matter yield 2333 kg da^{-1} (Erdal et al., 2009). In a study conducted in the ecological conditions of Erzurum province, the plant height of silage maize was determined as 246.9 cm, the rate of cob was 28.6%, and the silage yield was 6233 kg da^{-1} (Güney et al., 2010). In the ecological conditions of İzmir province, the yield of maize varieties for silage was determined as 8423 kg da^{-1} and dry matter yield 2010 kg da^{-1} (Geren et al., 2003).

It is possible to successfully grow maize for silage in every region of our country. However, it is possible to determine which variety gives better yield for which region by local trials. In this direction, this study was carried out in the growing period of 2020 in order to determine the silage yield and yield characteristics of 6 maize in Bingöl.

MATERIAL and METHODS

In this study, 6 maize varieties (Es armandi, DKC 5741, Sygenta atomic, LG 30.500, LG 31.545, LG 30.597) were used as material. The FAO values of these varieties vary between 500 and 640 and they are in the early, middle-early group.

The experiment of the study was conducted in Bingöl University Genç Vocational School Application and Research Area. The average altitude of the Bingöl province Genç district is 997 m above sea level and has a warm and temperate climate. The annual average temperature of Genç district is 13.3 ^{0}C, and the annual average total rainfall is 765 mm (Figure 1).

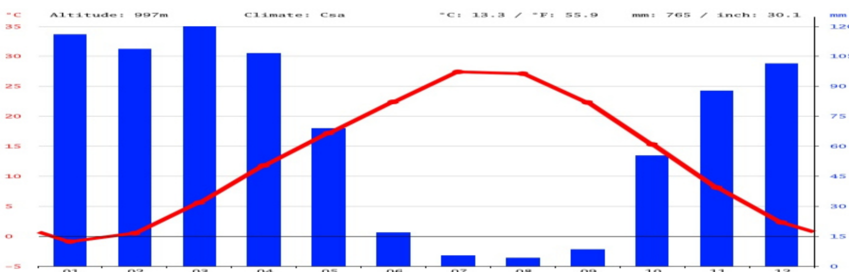

Figure 1. Annual average temperature and total annual precipitation amount of Bingöl province Genç district (Anonymous, 2020)

The soil structure of the research area is sandy-clayey-loam, slightly alkaline, slightly salty, low lime, high in potassium, and low in organic matter and phosphorus (Çaçan and İşikten, 2019).

The trial of the study was established on April 21, 2020, according to the randomized blocks trial pattern, in three replications. The plot lengths are 5 m, the row spacing is 70 cm, and the distance above the row is 15 cm (Anonim, 2018). With sowing, 15 kg nitrogen and 8 kg phosphorus were given as pure substance per decare (Çaçan and İşikten, 2019). All of the phosphorus and one-third of the nitrogen was given with sowing, one-third of the remaining nitrogen with throat filling when the plants reached 40-50 cm, and the remaining third at the tassel removal stage. The harvest was made on August 25, 2020. Plant height and first stem height were measured by meter on 5 plants taken from each plot and repetition. Stem diameter was measured with a hand caliper. Green leaf ratio, green stem ratio, green cob ratio, and forage yield were also obtained by weighing. Dry matter yield was calculated with the dry matter rate obtained after the plants were dried at 70 ^{0}C for 48 hours (Seydoşoğlu and Cengiz, 2020).

Variance analysis was applied to the data obtained through the JMP program according to the random blocks trial pattern, and the significant means were compared with the LSD test. Correlation analysis was performed to determine the relationship between the features examined with the same program (JMP 5.0.1, 2002).

RESULTS and DISCUSSION

Plant height, stem diameter, first cob height, leaf ratio, stem ratio, cob ratio, forage yield, and dry matter yield of silage maize varieties are given in Table 1. It was observed that the difference between maize varieties was statistically significant in terms of plant height, first cob height, forage yield, leaf ratio, stem ratio, cob ratio, and dry matter yield. Only the difference between the cob diameters of maize varieties was not statistically significant (Table 1).

The highest plant height and the highest first cob height were obtained from Syngenta atomic and LG 30.597 varieties. The average plant height of the varieties was 232 cm, and the average height of the first cob was 71.0 cm. The stem diameters of maize varieties varied between 17.6-21.6 mm and the average were obtained as 19.7 mm (Table 1).

Plant height in previous studies; It was determined as 264.2 cm in Bingöl ecological conditions (Çaçan and İşikten, 2019), 192.7 cm in Kayseri ecological conditions (Bulut, 2016), 248.8-291.6 cm in Diyarbakır ecological conditions (Seydoşoğlu and Saruhan, 2017), and 323-392 cm in İzmir ecological conditions (Yıldız et al., 2017). The maize plant is a hot climate plant. The minimum germination requirement is 8-10 ^{0}C, and the optimum temperature requirement is above 18 ^{0}C (Geçit et al., 2011). Since maize plant is a hot climate plant, it is seen that plant height gives higher values in hot ecologies such as İzmir and Diyarbakır, and lower values in relatively cold regions such as Bingöl and Kayseri. Of course, features such as the plant's genetic structure, variety characteristics, cultivation methods, and soil structure are factors that affect the plant height. However, among all these features, it should be known that the most prominent feature for the maize plant is the climate.

Table 1. Plant height, stem diameter, first cob height, leaf ratio, stem ratio, cob ratio, forage yield, and dry matter yield of maize varieties

Cultivars	Plant height (cm)	Stem diameter (mm)	First cob height (cm)	Leaf ratio (%)	Stem ratio (%)	Cob ratio (%)	Forage yield (kg/da)	Dry matter yield (kg/da)
Es Armandi	217^{bc}	21.1	59.1^{c}	18.7^{a}	53.1^{a}	28.2^{c}	4013^{b}	1459^{c}
DKC 5741	227^{b}	20.5	60.0^{c}	128^{b}	43.4^{c}	43.9^{ab}	4672^{b}	1854^{bc}
Syngenta Atomik	249^{a}	19.0	84.2^{ab}	13.9^{b}	43.6^{bc}	42.5^{ab}	6095^{a}	2146^{ab}
LG 30.500	230^{b}	17.6	73.8^{b}	12.6^{b}	40.6^{c}	46.8^{a}	4688^{b}	1915^{bc}
LG 31.545	211^{c}	18.1	60.6^{c}	13.^{0b}	39.1^{c}	47.9^{a}	4354^{b}	1909^{bc}
LG 30.597	257^{a}	21.6	88.6^{a}	13.0^{b}	51.0^{ab}	36.0^{bc}	7259^{a}	2506^{a}
Mean	**232**	**19.7**	**71.0**	**14.0**	**45.1**	**40.9**	**5180**	**1965**
CV (%)	3.59	8.17	8.65	14.02	9.17	14.30	14.16	14.43
LSD (0.05)	15.12	--	11.17	3.56	7.53	10.64	1334.16	515.67
Significant	**	--	**	*	*	*	**	*

High stem diameter values are not desirable in maize plants. Because when the stem diameter increases, the dry matter ratio increases during the silage stage, which causes the silage quality to decrease. However, there are advantages to a thick stem diameter. Thick stem diameter prevents the plant from lying down. In cases where the throat filling process is not done properly, the thin stalk causes the plant to lie down in areas with high wind force and especially in the stages where the plant fills the grain. The plant stem diameter values obtained in this study were similar to the 20.9 mm values obtained in Bingöl ecological conditions previously (Çaçan and İşikten, 2019) and 21.9

mm values obtained in Çankırı ecological conditions (Kuşvuran et al., 2015). It was found to be lower than the values obtained in hot regions. For example, stem diameter was determined to be between 20.1-28.4 mm (Seydoşoğlu and Saruhan, 2017) in Diyarbakır ecological conditions and between 21.3-28.3 mm in İzmir ecological conditions (Ayaz et al., 2013).

It is seen that the height of the first cob is directly proportional to the plant height. In varieties with high plant height (LG 30.597 and Syngenta atomic), it is seen that the first cob height is also high. Considering the previous studies, it is seen that the findings obtained from this study give lower values than the findings obtained from other studies (Olgun et al., 2012; Yıldız et al., 2017; Yozgatli et al., 2019). The probable reason for this difference is that LG 30.597 is a variety that is considered directly for silage, while other varieties are considered for grain purposes. However, in terms of being the species that preserve their greenness for a long time, their performance as silage has been tried to be tested. For this reason, it is seen that the first cob heights are low. As a matter of fact, the similarity of the varieties grown for grain purposes with the heights of the first cob (İdikut et al., 2015) supports this claim. From this point of view, it is understood that the height of the first cob is an important criterion to be taken into consideration when evaluating a variety as silage (after yield and plant height).

The highest leaf rate was obtained from Es armandi, the highest stem rate from Es armandi and LG 30.597, and the highest cob rate from DKC 5741, Syngenta atomic, LG 30.500 and LG 31.545. The average leaf ratio was determined as 14.0%, the average stem ratio was 45.1% and the average rate of the cob was 40.9% (Table 1).

Leaf, stem, and cob ratios of a maize plant are important parameters that enable us to obtain information about the silage performance of that plant. Es armandi, Syngenta atomic and LG.30.597 varieties have higher stem ratios than cob rate. This result gives an idea that the silage performance of these varieties is high. However, it is understood that Es armandi variety does not cause a difference in the total forage yield due to the low plant height. It is understood that the remaining varieties stand out in terms of grain yield. The obtained leaf, stem, and cob ratios were found to be similar to the values obtained from previous studies (Keskin et al., 2017; Kuşvuran et al., 2015; Özata et al., 2012).

The highest forage yield and dry matter yield were obtained from varieties named Syngenta atomic and LG.597. The average forage yield was 5180 kg da^{-1} and the dry matter yield was determined 1965 kg/da.

It is seen that Syngenta atomic and LG 30.597 varieties, in which plant height, first stem height, and stem ratio were determined higher than the rate of cob, gave the highest values in terms of forage yield and dry matter yield. While the average forage yield of 5180 kg da^{-1} and the dry matter yield of 1965 kg da^{-1} were similar to the results obtained by Ayaz et al. (2013), it was determined that they were lower than the results (forage yield 7902 kg da^{-1}, dry matter yield 2351 kg da^{-1}) obtained from the study conducted under Bingöl conditions (Çaçan and İşikten, 2019). The absolute reason for this difference is that the varieties used are different. Even if the region and climatic conditions are the same, it is seen that only the variety difference causes a difference of over 50% on forage yield.

Correlation Between Examined Features

The correlation analysis of the properties of the maize plant examined in the study is given in Table 2. It is seen that there is a significant and positive relationship between plant height and first cob height, forage yield, dry matter yield, between stem diameter and forage yield, between first cob height and forage yield, dry matter yield, between leaf ratio and stem ratio and between forage yield and dry matter yield. It is seen that there is a significant and negative relationship between leaf ratio, stem ratio, and dry matter yield, and between stem ratio and cob ratio (Table 2).

Table 2. Correlation between traits examined in maize varieties

	Stem diameter	**First cob height**	**Leaf ratio**	**Stem ratio**	**Cob ratio**	**Forage yield**	**Dry matter yield**
Plant height	0,30	0,89**	-0,21	0,21	-0,09	0,80**	0,66**
Stem diameter		0,09	0,18	0,39	-0,35	0,47*	0,21
First cob height			-0,34	0,05	0,07	0,73**	0,71**
Leaf ratio				0,73**	-0,86**	-0,29	-0,64**
Stem ratio					-0,98**	0,18	-0,21
Cob ratio						-0,04	0,36
Forage yield							0,80**

CONCLUSION

Variety-adaptation studies should be carried out for at least two years in order to make a variety recommendation. However, it is a fact that one-year studies provide us with an idea about the performance of the varieties. Accordingly, when a general evaluation is made, it is seen that the highest plant height, first stem height, forage yield, and dry matter yield were obtained from LG 30.597 and Syngenta atomic varieties. Therefore, as a result of a one-year study, it was concluded that LG 30.597 and Syngenta atomic named varieties should be preferred when cultivation for silage purposes among these maize varieties.

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CHAPTER 18

COMPARISON OF SOME WINTER GRAIN SPECIES IN TERMS OF BIOMASS YIELD AND QUALITY CHARACTERISTICS

INTRODUCTION

Today, while the demand for agricultural products increases with the increase of the world population, it has been determined that there is a decrease in agricultural areas due to the increase in industrialisation and urbanisation (Eren, 2019a). One of the main problems of stock farming in our country is the low production of sufficient and high quality roughage. The fact that the forage crops grown in agricultural areas are not at a level to meet the need causes both a decrease in the productivity of animals and an increase in the burden of the pastures. In order to find a solution to this situation, with the establishment of artificial pasture facilities consisting of lean and mixed sowing of legume and poultry forage crops, recent breeding programs, developing varieties for animal feed and grass production in different environmental conditions have gained importance (Akgün and Kara, 2002; Gökkuş et al., 2017).

Small grains such as wheat, barley, oats, rye and triticale are important roughage sources that can be used by grazing or mowing during the tillering period. The use of grains as animal feed is common in our country as is the case in the whole world. Fresh biomass obtained from grains is dried or fed to animals as silage (Tan and Serin, 1997; Kaplan et al., 2011). Cereals are very tasty and nutritious for animals during their vegetative period. It contains 15-35% crude protein and the digestion rate of nutrients is up to 80%. It has a high amount of carotene; and is rich in vitamin B and minerals, but low in cellulose (Çaçan and Kökten, 2019).

According to Önal-Aşçı and Acar (2018), the amount of fiber in wheat plants is higher than in legume crops (Karadeniz et al., 2020). In wheat plants, roughages are important feed sources in terms of vitamins and minerals, especially energy, and are widely used in the world. Nutritional values of roughage in wheat plants are mainly affected by the genetic structure, climate, soil structure, irrigation and similar environmental factors (Canpolat, 2012).

In our country, which has an important potential in terms of animal number, it is seen that the yield potential of meadows and pastures has decreased significantly as a result of excessive and irregular grazing for many years. In order to bring the livestock sector to the desired level, besides the improvement of meadows and pastures and the production of forage crops, importance should be given to the development of forage grain cultivation. When the quality roughage deficit, which is needed by livestock in our country, is eliminated, there will be an increase in the yields from the animal unit (Akkaya and Akten, 1986; Avcıoğlu et al., 2000; Alp, 2009).

In this study, it was aimed to determine the forage yield and some quality characteristics of some cereal species in ecological conditions of Kızıltepe-Mardin.

MATERIAL AND METHOD

This study was carried out in 2018-2019 and 2019-2020 growing seasons in order to determine the yield and quality characteristics of some winter grain types in ecological conditions of Kızıltepe-Mardin. The climate data for the months in which the research was conducted are given in Table 1 and the soil analysis results of the trial area are given in Table 2.

Table 1. Research site temperature, precipitation and humidity data for 2018/2019/2020 *

	Years	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	2018	8.50	10.2	14.3	17.7	21.8	28.1	30.9	30.2	27.0	21.6	13.2	9.1
Temperature (°C)	2019	6.60	8.80	10.7	13.9	22.7	29.5	30.8	31.7	26.3	22.3	13.5	9.9
	2020	3.60	3.80	10.7	14.1	19.9	26.2	31.5	29.9	29.3	22.8	12.0	-
	L.Y.A.	6.90	9.00	12.2	16.0	21.7	28.5	32.1	30.9	26.2	20.5	13.3	8.1
	2018	48.3	35.7	5.2	12.1	103.8	0.80	0.90	0.20	0.10	48.6	32.2	51.5
Precipitatiom (mm)	2019	44.1	27.4	95.8	79.7	49.2	16.3	1.70	0.10	0.30	32.7	11.8	54.5
	2020	75.9	102.8	157.3	51.6	30.5	31.5	4.00	0.00	0.00	0.00	35.7	-
	L.Y.A.	36.03	33.15	59.18	37.62	38.77	3.53	0.73	0.20	1.47	24.51	33.29	33.53
	2018	67.4	70.9	64.1	53.0	60.8	33.9	31.3	38.3	35.3	47.4	77.8	88.1
Humidity (%)	2019	86.5	87.5	86.7	94.3	9.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	2020	71.9	71.4	65.0	59.7	43.4	26.0	20.6	22.1	20.6	22.5	55.8	-
	L.Y.A.	71.6	66.1	69.0	63.0	47.0	25.1	21.0	27.6	30.5	38.3	50.7	65.5

*The data for 2018/2019/2020 were obtained from the records of Mardin Provincial Directorate of Meteorology, **L.Y.A.**: Long Years Average

Table 2. Soil analysis results

Soil features	2018/2019	2019/2020
Texture	CL	CL
pH	7.41	7.45
Salt (%)	0.32	0.35
Organic matter (%)	1.45	1.54
$CaCO_3$ (%)	5.23	6.02
N (%)	0.91	0.94
Phosphorus (kg P_2O_5 da^{-1})	3.02	3.56
Potassium (kg K_2O da^{-1})	272	286

In the experiment, which was established with 3 repetitions in divided plots in random blocks, 1 type of bread wheat (Adana-99), 1 type of durum wheat (Sarıçanak-98), 1 type of 2-row barley (Şahin-91), 1 variety of 6 rows barley (Kendal), 1 type of oats (Albatros) and 1 type of triticale (Tatlıcak-97) were used. The trial was designed to be 1 m of parcel width, 5 m of parcel length, 20 cm between rows, 1 m between parcels and 2 m between blocks.

The amount of seed in all parcels was set to be 600 pieces/m^2, and the trial area was made ready for planting by levelling with rotary tiller after deep plowing with a plow. Planting was done by hand on the rows opened with the marker on the 1st year on November 15, 2018 and the 2nd year on November 13, 2019. With the sowing, 6 kg/da pure phosphorus and 6 kg/da pure nitrogen were applied to the seed bed, and 6 kg/da pure nitrogen fertiliser was applied to the seed bed during the growing period of the plants.

In the study carried out under watery conditions; the harvest was made during the earning period of the plants. Plant height (PH), fresh biomass yield (FBY), dry biomass yield (DBY), crude protein ratio (CPR), crude protein yield (CPY), acid detergent fiber (ADF), neutral detergent fiber (NDF), digestible dry matter (DDM), dry matter consumption (DMC) and relative feed value (RFV) were examined.

The mean plant height was calculated by measuring the part of 10 plants randomly selected from each plot from the soil surface to the end point in cm. For fresh biomass yield, after removing the edge effect from each plot, the fresh biomass obtained by cutting the remaining area was weighed and calculated in kg/da. Samples of 500 g of green herbs harvested from each parcel were dried in the drying cabinet until they reached constant weight, then the calculation was made in kg/da (Pelletier et al., 2010).

Crude protein ratio was determined using Kjeldahl method (%); ADF (%) and NDF (%) ratios were determined by ADF and NDF analysis units developed by Ankom Technology (Ankom 220 Fiber System).

DDM, DMC, RFV and CPY values were calculated by the following formulas.

CPY: crude protein ratio x dry biomass yield

DDM = 88.9 - (0.779 x %ADF)

DMC = 120 / %NDF

RFV = (DDM x DMC) / 1.29 (Morrison 2003).

Statistical Analysis

The research was carried out in 3 replications according to random block design. The obtained data variance analysis was performed using the SPSS 22.0 statistical package program. The differences between two (2) year means and means are grouped by applying Duncan test according to Bek (1986) (Eren, 2019b).

RESULTS AND DISCUSSION

When the values obtained in the study were examined, it was determined that the values of plant height, crude protein yield, crude protein ratio, fresh and dry biomass yield were statistically significant at the rate of $p \leq 0.01$. In the study, the distribution of significance levels between 2-year means and means was given by applying the Duncan test (Table 3).

When the two-year study results are examined; plant height varies between 90.0-115 cm, fresh biomass yield varies between 3321-4123 kg/da, dry biomass yield varies between 1016-1444 kg/da; the highest plant height and fresh-dry biomass yield were obtained from Triticale. Crude protein ratio varied between 7.90-11.1% and the highest value (11.1%) was obtained from Oats. Crude protein yield varied between 84.40-133.8 kg/da, and the highest value (133.8 kg/da) was obtained from durum wheat type (Table 3).

Tablo 3. Means and F values of plant height, fresh-dry biomass yield, crude protein yield and crude protein ratio in some winter cereal species

Variety	Plant height (cm)	Fresh biomass (kg/da)	Dry biomass (kg/da)	Crude Protein Ratio (%)	Crude Protein Yield (kg/da)
Barley (2 rows)	92.2 cd	3321 f	1062 d	7.95 e	84.40 d
Barley (6 rows)	90.0 d	3415 e	1117 c	8.68 d	96.94 c
Wheat (Bread)	97.8 c	3682 c	1248 b	9.15 c	114.2 b
Wheat (Durum)	106 b	3749 b	1273 b	10.5 b	133.8 a
Triticale	115 a	4123 a	1444 a	7.90 e	114.0 b
Oat	110 ab	3597 d	1016 e	11.1 a	112.4 b
F	39.2**	416**	507**	366**	382**

(**) p≤0.01: statistically significant within the error limits

Depending on the growing conditions, the plant height of Triticale plant varied between 110-120 cm (Geren et al., 2012). Kutlu and Kınacı (2011) reported in their research with Triticale varieties in 2006-2007 that the plant height varied between 92.2-116.5 cm in irrigated conditions. Mut et al. (2006) reported in their research with 60 lines, Presto and Tatlıcak-97 triticale (X*Triticosecale* Wittmack) that the plant height varied between 104.5-129.7 cm. Kaplan et al. (2011) reported in their study on some Triticale varieties and lines that the fresh biomass yield varied between 2272.5-3300.0 kg/da and the hay yield between 836.37-1364.70 kg/da. Çaçan and Kökten (2019) reported in their study comparing the yield and quality of bread and durum wheat, triticale, 2 and 6 rows of barley varieties that the crude protein ratio varied between 11.1-12.0% and the crude protein yield varied between 76.2-141.2 kg/da. Parlak and Göçmem (2017) reported that the ratio of crude protein in oat plant planted lean was 11.88%.

When the two-year study results are examined; it has been determined that the ADF, NDF, DDM, DMC and RFV values are statistically significant at the rate of p≤0.01. In the study, the distribution of significance levels between 2-year means and means was given by applying the Duncan test (Table 4).

Table 4. Means and F values of ADF, NDF, DDM, DMC and RFV in some winter grain types

Variety	**ADF**	**NDF**	**DDM**	**DMC**	**RFV**
			(%)		
Barley (2 rows)	43.6 b	63.2 a	54.9 c	1.90 b	80.9 c
Barley (6 rows)	42.7 b-d	62.9 a	55.6 a-c	1.91 b	82.4 bc
Wheat (Bread)	42.1 d	61.8 b	56.1 a	1.94 a	84.4 a
Wheat (Durum)	42.5 d	62.5 ab	55.8 ab	1.92 ab	83.1 ab
Triticale	45.9 a	63.4 a	53.2 d	1.89 b	78.1 d
Oat	43.3 bc	63.2 a	55.2 bc	1.90 b	81.2 c
F	23.2**	4.18**	23.2**	4.28**	18.5**

(**) p≤0.01: statistically significant within the error limits

In different grain types, ADF ratio varied between 42.1-45.9%, NDF ratio varied between 61.8-63.4%, and the lowest values of ADF and NDF were obtained from Bread Wheat. The digestible dry matter ratio varied between 53.2-56.1%; the DMC ratio varied between 1.89-1.94% and the RFV varied between 78.1-84.4%, and the highest DDM, DMC and RFV values were obtained from Bread Wheat (Table 4).

According to the study carried out by Karabulut and Çaçan (2018), where some grain types planted at different times were compared in terms of yield and quality characteristics; ADF (34.6%), NDF (56.1%), DDM (62%) and DMC (2.14%) were determined for bread wheat. In the research conducted to determine the feed quality values of some wheat species, ADF was between 22.9-43.2%; NDF was between 45.9-74.6%; DDM was between 55.3-71.0%; DMC was between 1.61-2.62% and RFV was between 68.9-143.1 (Sayar et al., 2018). When the Relative Feed Value is below 75, it is considered as 5th quality; between 75-86, 4th quality; between 87-102, 3rd quality; between 103-124, 2nd quality; and when it is between 125-150 it is considered as the 1st quality; but if it is above 150, it is accepted as the best quality (Rohweder, 1978).

CONCLUSIONS AND RECOMMENDATIONS

In the research, some winter cereal types (Barley, Triticale, Oats, Bread Wheat and Durum Wheat) were grown in 2018-2019 and 2019-2020 growing periods and some quality parameters were determined. Among the two-year means, the highest plant height, fresh and dry biomass yield was obtained from Triticale plant; the highest crude protein ratio was obtained from oat plant, and the highest crude protein yield was obtained from durum wheat.

The lowest ADF and NDF, the highest DDM, DMC and RFV values were obtained from bread wheat. As a result of observations and analyses, it is thought that it would be more profitable to grow Triticale and bread wheat in agricultural areas in order to meet the roughage needs of animals in irrigated conditions in Mardin plain and to evaluate it in terms of forage crops.

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CHAPTER 19

IMPACT OF DIFFERENT PHOSPHORUS DOSES ON SEED YIELD AND FORAGE QUALITY OF PEA (*Pisum sativum* L.)

INTRODUCTION

Vegetable protein consumption in Turkey has increased due to low and expensive production of animal protein and difficulties in its long-term storage and transportation. Pea (*Pisum sativum* L.) was cultivated on ~7.5 million hectares during 2018 globally, and the leading producers were Canada, Russia, China, India, Ukraine and the USA (Powers et al., 2020). Forage pea is the second most frequently cultivated plant in the world after beans and gives the highest yield among legumes. Production areas of forage pea are constantly increasing in Turkey due to its wide adaptation ability to soil and environmental conditions, high forage yield and quality, and clean field for the cultivation of next crop. Numerous studies have been conducted on forage pea with its increasing importance in Turkey (Ateş and Tekeli, 2017; Tan and Kadıoğlu, 2018). Forage pea is cultivated as a pasture and green manure crop to fulfill forage needs and improve soil fertility (Özkaynak, 1980; Açıkgöz et al., 2001). The fresh and dry biomass and grains of forage peas are utilized for forage and human consumption. Besides many researchers reported that forage peas grown during winter gave promising results for the utilization of fallow lands for increasing feed production (Doğan and Terzioğlu, 2019). Peas are a good source of plant-based proteins for human and animals' nutrition. Dried pea seeds contain 23-33% protein, 58.5% carbohydrate, 1% oil, 4.4% cellulose and 3.3% ash (Özdemir, 2002). In addition to high protein and carbohydrates contents, pea plant is rich in various nutrients including calcium (Ca), iron (Fe) and especially phosphorus (P), and contains various vitamins (Akçin, 1988; Cousin, 1997; Dahl et al., 2012). In addition to high nutritional value of forage pea, it is known as delicious roughage as well. Therefore, it can be cultivated for different purposes, such as seed production, fresh biomass (grazing or green chop), hay (dry fodder) or silage (Bilgili, 2009). Phosphorus is one of the most essential macronutrients desired by plants not only for root growth but also for early plant maturity (Dağhan et al., 2013). Phosphorus is the constituent of nucleic acid, phytin and phospholipids in plants. Recent studies have determined that P compounds play an important role in respiratory and photosynthesis events (Kacar, 1984; Mullins et al., 1996). Therefore, sufficient amount of P is needed for the development of fertilization organs, root growth and early maturity of plants. Modern agriculture focuses on sufficient and quality production through appropriate use of the available nutrients. Turkey transitioned from conventional to modern agriculture. Proper utilization of essential nutrients (macro and micro nutrients) is mandatory for increasing the production and quality of agricultural commodities. On the other hand, climate changes, soil properties, regional planting patterns and their interactions should considered in experiments focusing on reducing the non-judicious use of fertilizers (Eren, 2019a). Hence, region-specific studies are required for successful crop production and increased fertilizer use.

In this study, we aimed to determine the effect of P doses on seed yield and forage quality in forage pea under the ecological conditions of Mardin/Kızıltepe. The results will help to optimize P requirement of the crop at regional scale.

MATERIAL AND METHOD

The field experiments were conducted under the ecological conditions of Mardin / Kızıltepe province for 2 successive vegetation periods (2018-2019 and 2019-2020). The climate data of the vegetation periods are given in Table 1. Besides, soil properties of the experimental site are given in Table 2. The experiments were laid out according to randomized complete block design with split-plot arrangements and three replications. Seeds of "Özkaynak" variety of forage pea were used in the experiments. Four different increasing doses of P_2O_5 (i.e., 0, 40, 80 and 120 kg P ha^{-1}) were used along with a constant nitrogen dose (40 kg N ha^{-1}). Urea and triple superphosphate fertilizerswere used as sources of N and P, respectively. Seed rate was kept 150 kg ha^{-1}. Experimental area was tilled with a cultivator, and then seedbed was prepared with the help of rotary tiller during both vegetation periods. Seeds were planted on November 25 and on November 27 during 1st and 2nd year, respectively. The rows were manually opened and seeds were planted. Each plot had an area of 10 m^2 with 10 rows of 5 m in length. The row to row distance was 20 cm. Five rows from each experimental unit were used to determine the forage yield, whereas the remaining five were utilized to determine seed yield. Data related to plant height (cm), number of pods per plant, number of seeds per pod and pod length were taken from ten randomly selected plants in each experimental unit. The plants on field edges of experimental units were cut and the materials were discarded in order to eliminate the edge effect. Green/fresh biomass (kg ha^{-1}) was calculated by harvesting and weighing the remaining area after removing the edge effect. Later, 500 g of harvested forage samples from each experimental unit were kept in the oven at 55 ^oC constant weight. Dry biomass was then determined and converted to dry biomass (kg ha^{-1}) using unitary method (Pelletier et al., 2010). Similarly, seed yield (kg ha^{-1}) was calculated by harvesting and weighing the seeds from five rows from each experimental unit. For 1000-grain weight (g), 4 samples 1000 seeds were weighed separately and averaged to record 1000-grain weight for each experimental unit. Crude protein ratio (%) was determined by Kjeldahl method. Similarly, acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios (%) were obsessed with ADF and NDF analysis units developed by Ankom Technology (Ankom 220 Fiber System). The samples were taken from dried materials and ground to pass through a 1-mm sieve in order to determine the crude ash ratio. The 0.5 g of sieved material was placed in ash crucibles and burnt in an ash oven at 550 ^oC, then calculations were made by proportioning the remaining amount.

Table 1. Climatic data of the experimental site for both vegetation periods

	Years	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature (°C)	2018	8.50	10.2	14.3	17.7	21.8	28.1	30.9	30.2	27.0	21.6	13.2	9.1
	2019	6.60	8.80	10.7	13.9	22.7	29.5	30.8	31.7	26.3	22.3	13.5	9.9
	2020	3.60	3.80	10.7	14.1	19.9	26.2	31.5	29.9	29.3	22.8	12.0	-
	Mean	6.9	9.00	12.2	16.0	21.7	28.5	32.1	30.9	26.2	20.5	13.3	8.1
Precipitation (mm)	2018	48.3	35.7	5.2	12.1	103.8	0.80	0.90	0.20	0.10	48.6	32.2	51.5
	2019	44.1	27.4	95.8	79.7	49.2	16.3	1.70	0.10	0.30	32.7	11.8	54.5
	2020	75.9	102.8	157.3	51.6	30.5	31.5	4.00	0.00	0.00	0.00	35.7	-
	Mean	36.03	33.15	59.18	37.62	38.77	3.53	0.73	0.20	1.47	24.51	33.29	33.53
Humidity (%)	2018	67.4	70.9	64.1	53.0	60.8	33.9	31.3	38.3	35.3	47.4	77.8	88.1
	2019	86.5	87.5	86.7	94.3	9.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	2020	71.9	71.4	65.0	59.7	43.4	26.0	20.6	22.1	20.6	22.5	55.8	-
	Mean	71.6	66.1	69.0	63.0	47.0	25.1	21.0	27.6	30.5	38.3	50.7	65.5

* Meteorological data were obtained from the records of the Mardin Provincial Directorate of Meteorology

Table 2. Soil properties of the experimental site during both vegetation periods

Soil Properties	2018/2019	2019/2020
Texture class	Clay-loam	Clay-loam
pH	7.35	7.28
Salt (%)	0.30	0.28
Organic matter (%)	1.45	1.51
CaCO3 (%)	4.63	4.41
N (%)	0.84	0.95
Phosphorus (kg P_2O_5 da^{-1})	2.72	2.83
Potassium (kg K_2O da^{-1})	258	262

Statistical Analysis

Analysis of variance (ANOVA) was used to infer the significance in the data (Bek, 1986). Normality in the dataset was tested by Shapiro-Wilk normality test prior to ANOVA, which indicated a normal distribution. Therefore ANOVA was executed on original data. Multiple comparison of means was performed by Duncan's multiple range test (Eren, 2019b). The SPSS 22.0 software was used for the statistical analysis.

RESULTS AND DISCUSSION

The results of field experiments regarding forage pea growth depending on the different phosphorus doses applied are given in Table 3 as means of two vegetation periods (2018 and 2019). Significant differences were noted among P doses for plant height, number of pods per plant ($p \leq 0.01$) and pod length ($p \leq 0.05$) in forage pea (*Pisum sativum* L.) according to the results of variance analysis. However, different P doses had non-significant effect on number of seeds per pod and 1000-seed weight (Table 3).

Table 3. The impact of different phosphorus doses on plant height, number of pods per plant, number of seeds per pod, pod length and 1000-seed weight

P doses (kg ha^{-1})	Plant height (cm)	Number of pods per plant	Number of seeds per pod	Pod length (cm)	1000-seed weight (g)
0	96.7 b	6.45 b	3.77	4.07 b	117
40	93.6 c	7.25 a	3.83	4.09 b	122
80	101 a	7.70 a	4.10	4.19 ab	115
120	101 a	7.55 a	3.93	4.33 a	118
F	19.0**	7.74**	2.46 ns	4.25*	0.95ns.

(*****) Means in the same column followed by different letters are statistically different at p≤0.05, (******) Means in the same column followed by different letters are statistically different at p≤0.01, (**ns**) Means in the same column are not statistically different.

Plant length varied between 93.6 and 101 cm depending on P dose applied in the field experiments. The number of pods per plant varied between 6.45 and 7.70 and the number of seeds per pod varied between 3.77 and 4.10. The highest values for these traits were recorded with 80 kg P ha^{-1}. Pod length increased with increasing P dose compared to control treatment (i.e., 0 kg P ha^{-1}). The pod length was 4.07 cm in control treatment, which reached to the highest value (4.33 cm) with 120 kg P ha^{-1}. Although there was no statistically significant difference between P doses, the highest 1000-seed weight was recorded with 40 kg P ha^{-1} and the highest number of seeds per pod was noted with 80 kg P ha^{-1} fertilizer applications (Table 3). Yılmaz (2010) reported that the number of pods per plant in forage pea varied between 5.56 and 7.93, whereas the number of seeds per pod were in the range of 3.09-3.79. Likewise, pod length varied between 3.93 and 4.04 cm. It was also reported that the highest plant height value was obtained with 90 kg P ha^{-1}, whereas the highest 1000-seed weight was obtained with 60 kg P ha^{-1}. It has been reported that the number of seeds per pod increased with increasing P dose applied in bean plant, and the highest values were obtained with 60 kg P ha^{-1} (Kuralkan et al., 2002). Ahlawat and Sharma (1989) also reported that P application increased 1000-seed weight of bean plant.

Table 4. The impact of different phosphorus doses on seed yield, fresh an dry biomass of forage pea

Phosphorus doses (kg ha^{-1})	Seed yield (kg ha^{-1})	Fresh biomass (kg ha^{-1})	Dry biomass (kg ha^{-1})
0	2040 c	30220 bc	6030 b
40	2380 b	30740 b	6130 b
80	2510 a	32410 a	6820 a
120	2300 b	29900 c	6230 b
F	15.6**	19.6**	5.36**

(**) Means in the same column followed by different letters are statistically different at $p \leq 0.01$

The ANOVA indicated that different P doses (two years data together) significantly ($p \leq 0.01$) altered seed yield, fresh and dry biomass of forage pea (Table 4). Seed yield varied between 2040 and 2510 kg ha^{-1} depending on P application doses. Fresh biomass production varied between 29900 and 32410 kg ha^{-1}, whereas dry biomass ranged between 6030 and 6820 kg ha^{-1}.The highest values of these traits were recorded with 80 kg P ha^{-1} (Table 4). Yemane and Skjelvåg (2003) reported that seed yield of pea increased due to increasing P doses. Soya et al. (1991) stated that P fertilization increased yield in annual legume forage plants. Similar to the current study, Deshpande et al. (1995) reported that the highest seed yield was obtained with 75 kg P ha^{-1} in beans. Similarly, Çelebi et al. (2010) reported that the highest green biomass was obtained from 40 and 80 kg P ha^{-1}in corn, while Lourence (1984) obtained the highest effect with

80 kg P ha^{-1}. Savur and Ceyhan (2011) reported that the highest grain yield in pea as 2640.67 kg ha^{-1}. Ateş and Tekeli (2017) stated that forage pea dry biomass ranged from 10790.1 to 11120.5 kg ha^{-1}. As explained above, the differences between the studies in terms of seed and forage yield are probably the result of differences among cultivation practices and ecological conditions.

Table 5. The impact of different phosphorus doss on crude protein ratio, ADF, NDF and crude ash ratio of forage pea

Phosphorus doses (kg ha^{-1})	Crude protein ratio (%)	ADF (%)	NDF (%)	Crude ash ratio (%)
0	20.8 b	36.7	56.1 b	3.14
40	22.9 a	35.6	56.8 ab	2.77
80	23.0 a	34.7	57.6 a	2.99
120	22.3 a	35.4	54.0 c	3.05
F	8.75**	2.84 ns	7.79**	2.29 ns

(**) Means in the same column followed by different letters are statistically different at $p \leq 0.01$, (ns) Means in the same column are not statistically different, (ADF) Acid detergent fiber, (NDF) Neutral detergent fiber

Significant differences ($p \leq 0.01$) were recorded among P doss for neutral detergent fiber (NDF) and crude protein contents depending on P doses (Table 5). However, ratio of acid detergent fiber (ADF) and crude ash in acid detergent was not influenced by different P doses included in the study.

Depending on applied P doses, crude protein ratio varied between 20.8% and 23.0%, ADF ratio ranged from 34.7 to 36.7%, NDF ratio varied between 54.0 and 57.6% and crude ash ratio ranged from 2.77 to 3.14% (Table 5). Crude protein ratio was improved with all applied P doses compared to the control treatment of the study. In addition, NDF content increased with 40 and 80 kg P ha^{-1} compared to control, while it decreased under 120 kg P ha^{-1}. Although there was no statistically significant difference between P doses, the highest crude ash and ADF ratios were recorded for control (0 kg P ha^{-1}) treatment of the study (Table 5). Ateş et al. (2014) reported that pea plant contains 9.5-23.0% crude protein. However, Ateş and Tekeli (2017) reported that crude protein ratio in dry biomass of forage pea varied between 17.5% and 18.4%. Seydoşoğlu (2013), on the other hand, stated that there is 20% crude protein in dry forage, which was cut at the appropriate period. The differences between the results of these studies explain the differences between the current study and the previous studies. Ateş and Tekeli (2017) determined ADF and NDF contents in forage pea as 31.3-34.1 and 40.2-42.7%, respectively. Some previous studies have reported that P application decreased ADF content in feed peas (Yüksel and Türk, 2019). Indeed, in the present study ADF rates decreased under all P doses compared to the control.

CONCLUSIONS AND RECOMMENDATIONS

Seed yield, fresh and dry biomass, plant height, number of pods per plant, NDF and crude protein ratio were affected by different P doses. Pod length increased with increasing P doses. Nonetheless, the highest seed yield, fresh and dry biomass, plant height, number of pods per plant, number of seeds per pod and crude protein ratio were recorded with 80 kg P ha^{-1}. Forage pea is widely cultivated as forage legume crop, especially in developed countries of the world. It is among the legume crops increasing their production in Turkey recently. However, pea farming is quite new in the study area and detailed studies are needed. The results indicted that the application of 80 kg P ha^{-1} (in pure form) will be sufficient for high forage and seed yield in the region. Nonetheless, detailed studies with different varieties and locations across the province are needed.

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CHAPTER 20

THE EFFECT OF TOPOGRAPHIC FACTORS ON RANGELAND VEGETATION

INTRODUCTION

The diversity and distribution of plant species in rangeland vegetations are formed by the interaction between various biotic and abiotic factors and some environmental factors. In this sense, topographic factors that trigger other ecological factors in the environment where the plant grows play a significant role in the formation of complex plant communities. In other words, topographic factors such as slope, aspect, and elevation together with the effects of other factors such as climate and soil moisture, soil chemistry determine the diversity, structure, and functioning of plant communities (Enright et al., 2005; Jucker et al., 2018; Sanaei et al., 2019).

The slope is one of the topographic factors that lead to changes in the temperature and soil moisture of the environment by affecting the angle of incidence of sunlight, affect the flow of water and evapotranspiration, and also, lead to the formation of local microclimate (Altın et al., 2011; Nahidan et al., 2015). The aspect is a geographical term that leads to the differentiation of the structure of rangeland vegetation because the aspect, which receives the sunlight, and shady aspects differ with respect to species richness and biomass depending on moisture, temperature, soil depth, and soil organic matter (Gong et al., 2008; Altın et al., 2011). Along with the effect of climatic factors such as temperature and precipitation, the elevation of the rangeland above sea level affects the growth physiology of the species that constitute the vegetation and changes the yield capacity of rangeland vegetations.

It has been emphasized by many researchers that topographic factors such as elevation, aspect, and slope have significant effects on the structure and species diversity of rangelands, the amount of hay produced by rangelands and their feed values (Watkinson and Ormerod, 2001; Altın, 2003; Jafari et al., 2004; Gong et al., 2008; Horwood and Fitch, 2008; Ateş, 2009; Farzam and Ejtehadi, 2017).

On the other hand, even if two basic rules of rangeland management such as grazing capacity and grazing season are followed, it can be observed that some parts of rangelands are grazed excessively while the other part is grazed slightly when the free grazing system is applied. One of the important reasons for this irregular grazing in rangelands is undoubtedly the rangeland topography. The topographic form of the land affects and limits the size of the rangeland, the development and distribution of vegetation, and also the cultural processes to be applied in the rangeland.

Nevertheless, although studies have been conducted to examine the relationships between the topography, soil conditions, grazing intensity, species diversity, total plant cover, and aboveground biomass, we do not have comprehensive knowledge on how the structural properties of the soil and the grazing intensity change across the topography and how they jointly shape the amount and quality of vegetation in natural rangelands (Sanaei et al., 2019).

In this study, the effects of topographic factors on vegetation characteristics such as the diversity and distribution of the species that make up the vegetation in rangelands, botanical composition, total plant cover ratio, and hay yield and quality were discussed.

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The Effect of Slope Degree on Rangeland Vegetation

Since flat and near-flat base land parts of the rangeland can be easily entered and exited and have a deep, more moist and fertile soil structure, they are the first and excessively grazed areas of rangeland by animals because they are the places with high quality and abundant feed. The sloping parts of the rangeland are the areas where the hay yield is less and the vegetation is a little less sparse due to the shallower soil layer and the flow of the fertile topsoil layer towards the base areas depending on the severity of water and wind erosion. Therefore, the slope is an important factor affecting uniform grazing in rangelands. Altın et al. (2011) reported that the base parts in rangelands were more fertile compared to sloping parts, and they explained it with the accumulation of plant nutrients in the base areas in the soil as a result of increased surface runoff in parallel with the increase in slope degree.

On the other hand, animals spend more energy to graze in rangelands with sloping and rugged land structure (Gençkan, 1985), which may also affect the animal health and indirectly animal yield.

Decreases in feed yield and quality are observed due to the increase in slope. In a study conducted in rangelands with different slopes (2%, 8%, 15%, 25%, and 30%), it was reported that the highest values were obtained in terms of fresh and hay yield, crude protein (CP) ratio, and CP yield in rangelands with a slope degree of 8% and 15% and that these characteristics examined after a 15% slope decreased significantly. In the same study, it was determined that acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios contained in rangeland hay increased in parallel with the increase in slope degrees, and consequently, hay with low relative feed values (RFV) was obtained (Sürmen and Kara, 2018). In the results of some studies, it was reported that the ratio of species belonging to other family plants was also higher in rangelands with a high slope degree (Şen et al., 2017; Sürmen and Kara, 2018). In another study, it was determined that the ratio of the area covered with plants decreased depending on the slope degree (Demirhan and Özyazici, 2019).

The Effect of Aspect on Rangeland Vegetation

In rangeland vegetations, the number of species and the distribution ratios of species and families in the botanical composition may differ according to aspects. These differences between the aspects are observed more prominently, especially between the north and south aspects. At the same elevation and in the same precipitation regime, the areas facing north receive less sunlight and are colder, and therefore, temperature and evaporation are less and moisture levels are high in the north aspects, which causes that more herbaceous species and plant species diversity are observed since the north aspects contain higher levels of soil organic matter compared to south aspects, and also, soil fertility is higher due to microbial activity, as it was also indicated by Begum et al. (2010), Sigua et al. (2011), and Mahdavi et al. (2012). Therefore, Mahdavi et al. (2012) indicated that the aspect had a significant effect on plant richness and species diversity. On the other hand, the moisture ratio is much lower in sunny aspects due to stronger solar radiation and high evaporation. Therefore, plant species are more likely to be resistant to drought and radiation in sunny aspects (Xue et al., 2018).

In rangeland studies at the Middle East Technical University located in the Central Anatolia Region of Turkey, Bakır (1970) reported that the same species had different densities in the north and south aspects of the rangeland, that *Onobrychis armena* Boiss. & A. Huet. was found in higher numbers in the north aspect of the rangeland compared to its south aspect, and that *Trigonella monspeliaca* L. was distributed only in the north of the rangeland.

In the study conducted by Türker (2006), it was determined that the ratio of grasses and other family plants did not vary according to the aspects compared to the total plant cover, on the contrary, the ratio of legumes varied significantly according to the aspects, and the ratio of legumes was the highest in the north aspect compared to the total plant cover. In the same study, it was determined that the species that were dominant according to the aspects and the ratios of these species according to the total plant cover were different. Accordingly, it was reported that the dominant species were *Bromus tomentellus* (31.28%), *Galium album* (18.15%) and *Onobrychis* sp. (17.59%) in the northeast aspect, *B. tomentellus* (35.22%), *G. album* (17.58%) and *Asphodeline isthmocarpa* (11.66%) in the southwest aspect, *B. tomentellus* (57.33%), *G. album* (8.70%) and *Daphne oleoides* (6.94%) in the north aspect, and that *B. tectorum* (5.72%), *Medicago sativa* (3.02%) and *Polygonum cognatum* (3.31%) species were found only in the southwest aspect.

In a study conducted in the rangelands in Elazığ province (Turkey), it was determined that the most dominant species in the total plant cover was *Taeniatherum caput-medusae* (16.65%) in the base part of the rangeland, *Aegilops cylindrica* (17.41% and 29.43%, respectively) in the north and east aspects, and *Astragalus adustus* (14.56%) in the west aspect (Taşdemir, 2015).

When the studies conducted in the rangelands in the Eastern Anatolia Region of Turkey were examined, Gökkuş et al. (1993) reported that while grasses were mostly found in the south and east aspects, legumes were found in the south aspect, and other family plants were found in the north and west aspects under Erzurum conditions. Ağın and Kökten (2013) obtained similar results in the rangelands in Bingöl province and reported that while legumes were mostly found in the south (5.3%) aspect, grasses were mostly found in the east (69.5%) aspect, and other family plants were mostly found in the west (52.1%) aspect. In another vegetation study conducted by Çaçan and Başbağ (2016) in different aspects (north, south, east, and west) of the rangelands in Yelesen-Dikme villages of Bingöl Province Central District, they reported that the botanical composition varied statistically significantly according to the cover area among the aspects and that the ratio of grasses was the highest in the north (23.06%) and west (20.79%) aspects, the ratio of legumes was the highest in the south (27.43%) and north (20.08%) aspects, and the ratio of other family plants was the highest in the east (68.95%) aspect according to the cover area. In another study conducted in the rangelands of Van province of the same region (Yıldız and Özyazıcı, 2017), it was determined that the ratio of grasses and legumes in the botanical composition by weight varied significantly according to aspects. In this study, the highest ratio of grasses in the botanical composition by weight was determined in the west aspect by 71.82%, followed by the north aspect by 69.40% and the south aspect by 46.15%, respectively. In the same study, the ratio of legumes, which was 7.61% in the botanical composition across the rangeland, was found to be the highest in the south aspect by 20.32%, this ratio was recorded to be 2.51% in the north aspect, and legumes were never found in the west aspect. In another study conducted by Tutar and Kökten (2019) in the rangelands of Bingöl province in the same region, they reported that grasses were mostly obtained from the south aspect by 80.8%, and other family plants were mostly obtained from the east aspect by 41.2% in the botanical composition by weight. In another vegetation study conducted in the rangelands of Muş province (Kökten and Tanrıverdi, 2020), it was determined that grasses were mostly found in the east and north aspects, legumes were mostly found in the south and west aspects, and other family plants were mostly found in the west, south, and east aspects. In the same study, it was determined that *Aegilops umbellulata* (63.00%, 67.25%, and 68.00%, respectively) was the most common species in the south, west, and east aspects, and *Minuartia hamata* Mattf. (31.75%) was the most common species in the north aspect. As is seen from these research results in the literature, the effects of aspects on the basis of families may also vary according to different locations in a similar ecology.

In another study, it was determined that the aspect with the highest species diversity was the north aspect with 90 species, followed by the west aspect with 83 species and the east aspect with 74 species and that the least species diversity was found in the south aspect with 71 species. In the same study, the west aspect gave the highest value in terms of grass richness with 12 species, followed by the north and east aspects with 10 species. The south aspect gave the lowest value with 8 species. The north aspect was found to be the richest aspect in terms of legumes with 15 species, followed by the west aspect with 14 species, and the south and east aspects gave the lowest value with 11 species. In the study, it was reported that the decreasing species and generally invasive and perennial-annual species were most common in the north and west aspects (Çaçan and Başbağ, 2017).

In the study conducted in the natural rangelands of the Tek Tek Mountains located in the Southeastern Anatolia Region of Turkey (Polat et al., 2018), it was reported that the aspects had significant effects on the ratios of grasses and other family plants in the botanical composition by weight and that grasses were dominant in the east and west aspects, and plants belonging to other families were dominant in the north and south aspects.

In rangeland vegetations, the total plant cover ratio-land cover ratio vary according to aspects. It was reported that the aspects with the highest value in terms of the total plant cover ratio in rangelands were the base and north aspects, respectively, (Erkun, 1972) and that the lowest cover value was found in the south (Erkun, 1972) and east (Taşdemir, 2015) aspects. In a study conducted in the rangelands in Karapolat village of Yedisu district of Bingöl province located in the Eastern Anatolia Region of Turkey (Ağın and Kökten, 2013), it was reported that the effect of aspects (east, west, and south) on the total plant cover ratio was significant and that the highest total plant cover ratio was 90.9% in the south aspect while the lowest value was 82.0% in the west aspect. In another vegetation study conducted in the rangelands in Yelesen-Dikme villages of Bingöl Province Central District (Çaçan and Başbağ, 2016), it was determined that 68.19% of the rangeland was covered with plants, that the highest total plant cover ratio was in the north (72.17%) aspect, followed by the south (70.33%), west (68.63%), and east (61.63%) aspects, respectively, and that this difference between the aspects was significant. In a study conducted in the rangelands of Muş province (Kökten and Tanrıverdi, 2020), it was determined that the highest total plant cover ratio was in the south and west aspects. On the other hand, Türker (2006) reported that the difference between the aspects in terms of the total plant cover ratio was insignificant.

Aspects have significant effects on the yield and quality of the hay obtained from rangelands. The changes in climate and soil conditions depending on the aspect of the rangeland also lead to the differentiation of vegetations, which also affects the quality of rangeland hay (Altın et al., 2011). The south aspects of rangelands are generally dry, and the total plant cover ratio is less, and their north aspects are moister, and the total plant cover ratio is much higher. Therefore, there may be differences in the quality of the feed obtained from the north and south aspects, and also in the utilization rates of this feed by animals (Vavra and Phillips, 1979; Andiç, 1993). Although the west aspects, which receive more rain, produce abundant yields, the east aspects are frequently exposed to the danger of frost (Gençkan, 1985).

Walburger et al. (2000) reported that the nutritional value of the hay obtained from the south aspects of rangelands was higher in the early period, that the quality decreased towards the end of the grazing period, and that the nutritional value of the hay was better towards the end of the grazing season in the north aspect. Similar results were also reported by Ateş (2009), and the researcher determined that the morphological and feed quality characteristics of legumes such as *Trifolium arvense* L., *Trifolium campestre* Schreb., *Trifolium dubium* Sibth., *Trifolium medium* L., and *Trifolium hybridum* L. in the botanical compositions of rangelands differed significantly according to north and south aspects and that the clover species grown in the south aspect, which has more favorable conditions for plant growth in terms of light exposure and other climatic parameters compared to the north aspect, had high crude cellulose (CS), Ca and K contents, while their CP contents were high in the north aspect. In the studies conducted in different rangeland aspects in Turkey's Van province (Yıldız and Özyazıcı, 2017) and Bingöl province (Tutar and Kökten, 2019; Tarhan and Çaçan, 2020) located in the Continental Climate zone, it was reported that there were very significant differences between the aspects examined in terms of fresh herbage, hay and CP yield and CP, ADF and NDF ratios. In these studies, Yıldız and Özyazıcı (2017) reported that the highest values in terms of fresh herbage yield, hay yield, and CP yield were obtained from the south aspect, that the hay obtained from the north and south aspects gave the highest values in terms of the CP ratio, and that the lowest NDF ratio was obtained from the hay in the south aspect. Tutar and Kökten (2019) determined that the highest values were obtained from the south aspect in terms of hay and CP yield and from the south and west aspects in terms of the CP ratio. Tarhan and Çaçan (2020) reported that the south aspect gave the highest results in terms of green herbage yield, while the north, south, and east aspects gave the highest results in terms of hay and CP yield and CP ratio, and that the lowest ADF and NDF ratio was found in the rangeland hay obtained from the north aspect. In another study conducted in Van region (Özyazıcı and Yıldız, 2017), it was determined that aspects had significant effects on the phosphorus (P) and Ca content contained in rangeland hay, and the rangeland hay with the highest P ratio was obtained from the north aspect, while the rangeland hay with the highest Ca ratio was obtained from the south and north aspects.

In a study examining the change in aboveground biomass according to the east, west, north, and south aspects, it was reported that the lowest and highest average amounts of aboveground biomass were found in the south aspect and the north aspect, respectively, and that values close to each other were measured in the east and west aspects (Babalık and Sönmez, 2009).

In some studies, researchers reported that aspects had no significant effect on hay yield and quality. Nevertheless, in these studies, it was reported that the highest hay yield was obtained from the north-facing aspects by Uslu (2005) and Taşdemir (2015), from the northeast aspect by Türker (2006), from the south aspect by Çaçan and

Kökten (2014), from the east aspect by Çaçan and Başbağ (2016), and from the west aspect by Polat et al. (2018).

The Effect of Elevation on Rangeland Vegetation

As the elevation increases, the air temperature decreases, the temperature difference between day and night and the degree of moisture and cloudiness increase (Gençkan, 1985). With every 100 m increase in elevation above sea level, the temperature decreases by 1 °C in dry weather conditions and 0.6 °C in moist air conditions, and consequently, the plant species in the vegetation vary (Jones, 1997). In some studies, it was concluded that the highest amount of plant species and diversity was at medium elevations (Hegazy et al., 1998; Vaseghi et al., 2011; Mahdavi et al., 2012). The low species richness and diversity at low elevations can be explained by the more significant and higher effect of grazing pressure and human factors since these areas are more accessible areas. Indeed, Reekie (1998) also indicated that grazing and chewing of plants by animals at high elevations decreased, and Gençkan (1985) stated that as the elevation increased, the vegetation period and consequently the grazing time decreased. On the other hand, many researchers determined that leaf length, leaf width, and leaf area decreased in parallel with the increase in elevation and that leaf thickness increased in plants (Chandra, 2004; Hovenden and Vander Schoor, 2006; Kofidis et al., 2007).

In a study in which elevations were compared (Çaçan and Başbağ, 2017), the species diversity decreased with increasing elevation, and while a total of 102 species were found at an elevation of 1704 m, 85 species and 80 species were found at elevations of 1876 m and 1992 m, respectively. In the same study, it was determined that grass varieties increased in parallel with the increase in elevation, and the species belonging to legume and other family plants and the decreasing, invasive and perennial-annual species decreased.

Different results were also obtained regarding the variability of the total plant cover ratio according to elevation. In a study conducted in rangelands at elevations of 1900 m, 2200 m, and 2500 m in Hakkari and Van provinces located in the Eastern Anatolia Region of Turkey (Erkun, 1971), it was reported that the total plant cover ratio increased due to the increase in elevation. Similar results were also obtained in a study conducted in the Southeastern Anatolia Region of Turkey (Seydoşoğlu, 2018), and in this study, the total plant cover ratio was 52.0% at an elevation of 535 m; however, this value was measured to be 85.0% at an elevation of 1135 m.

In the rangeland vegetation studies conducted at elevations of 2000 m, 2500 m, and 3000 m in Palandöken Mountain located in the Eastern Anatolia region of Turkey (Çomaklı et al., 2012), it was reported that the land cover ratio was higher at an elevation of 2500 m (42.65%) compared to other elevations. In the vegetation studies conducted at elevations of 1992 m, 1876 m, and 1704 m in the rangelands in Yelesen-Dikme villages of Bingöl Province Central District located in the same region (Çaçan and Başbağ, 2016), it was reported that the total plant cover ratio was higher at low elevations and decreased with higher elevations and that the total plant cover ratio was measured to be 72.69 at an elevation of 1704 m and 65.56% at an elevation of 1992 m.

The ratio of grasses, legumes, and other family plants in the botanical composition varies significantly according to different elevations. In the vegetation studies conducted at elevations of 2000 m, 2500 m, and 3000 m in Erzurum Palandöken Mountain (Turkey) (Çomaklı et al., 2012), in the botanical composition, grasses and legumes were found to be the highest at an elevation of 2500 m by 64.05% and 11.75%, respectively, and other family plants were found to be the highest at an elevation of 2000 m by 42.65%. Çaçan and Başbağ (2016) and Seydoşoğlu (2018) reported that the ratio of grasses and legumes in the botanical composition decreased as elevation increased; however, the ratio of other family plants increased.

In the study examining the changes in rangeland vegetation due to short-range elevation (1900 m, 2000 m, and 2200 m) increases in natural rangelands above the forest within the borders of Aydın village of Ardanuç district of Artvin province located in the Eastern Black Sea Region of Turkey (Bilgin and Özalp, 2016), it was determined that while grasses showed the highest distribution at an elevation of 2200 m by 55.50%, legumes showed the highest distribution at an elevation of 2000 m by 15.98%, and other family plants showed the highest distribution at an elevation of 1900 m by 53.09%.

The difference in elevation also has effects on the hay yield and quality of rangelands. Morecroft and Woodward (1996), who investigated the effects of different elevations on the nutrient content of *Alchemilla alpina* L. leaves, determined that nitrogen (N) and K concentrations and N/C and N/P ratios increased with elevation, while total phosphorus in the leaf decreased. It was reported that the antioxidant content of some species increased as the elevation increased and that the plants grown at high elevations were affected by factors such as low temperature and high radiation, low air pressure and wind (Wildi and Lütz, 1996).

In a study examining the effects of elevation on the feed quality of different clover species in rangeland vegetation, it was determined that the CP, CS, Ca, and K ratios of the clover species were significantly affected by the elevation and that the CP, CS, and K contents of the species increased, while their Ca content decreased as elevation increased (Ateş, 2009). While Bilgin and Özalp (2016) reported that the fresh and hay yields at elevations of 1900 m and 2000 m were significantly different and lower compared to the elevation of 2200 m, Çaçan and Başbağ (2016) reported that the hay yield did not vary much by elevation; however, the highest values were obtained at medium elevations.

In the study conducted in rangelands at eight different elevations between 1013-1887 m in Karacadağ (Diyarbakır-Turkey), it was determined that the differences between CP, ADF, NDF, Ca, Mg, and K ratios contained in rangeland hay were significant according to different elevations and that the ADF and NDF ratios were higher at high elevations; however, the RFV was lower (Aydın and Başbağ, 2017).

The hay yield of rangeland vegetations decreases as the elevation increases, and low-value vegetation is also formed. In this sense, elevation and climate change, as well as infertile soil factors, affect the change in vegetation.

The Effect of Topographic Factors on the Soil Properties of Rangeland Vegetations

Factors such as soil structure, basic soil fertility status, and nutrient content affect differences in vegetation (Callaway, 2007; Özyazıcı and Yıldız, 2017). In a study conducted in different rangelands in Texas, it was reported that high ratios of climax grasses species were found in rangelands with high lime content and soil pH (Helm and Box, 1970). According to the results of the study conducted in a semi-arid rangeland, facing south and with a slope of approximately 20% in the Central-Western Black Sea Region of Turkey, it was determined that the pattern of variation in the number of plant species in the parallel and perpendicular direction to the slope was quite different and that the variability was much higher along the line perpendicular to the slope. In the same study, it was emphasized that there was an inverse relationship between the number of plant species and the lime content of the soil and that areas with high lime content in the study area were more sensitive to desertification (Dikmen et al., 2012).

In the study conducted by Koç (1995) to determine the effects of slope, aspect and elevation and soil moisture and temperature on some characteristics of the rangeland vegetation, it was reported that there were significant differences between the moisture and temperature regimes of soils belonging to different rangeland parts, that the highest humidity and the lowest humidity were found in the base aspect and south aspect, respectively, and that the soil temperature was the highest in the south aspect and lowest in the north aspect.

In the study conducted by Çomaklı et al. (2012) in rangelands at different elevations (2000 m, 2500 m, and 3000 m), the organic matter content of the soils was found to be 2.30%, 4.10%, and 6.84%, respectively, at three different elevations, and it was determined that the soil pH varied between mild acid and neutral and that the K content was very rich and the P content was insufficient at all three elevations.

According to the results of a study in which some physical and chemical properties of soils in the rangelands in different slope and aspect groups were determined, it was observed that slope and aspect had significant effects on some soil properties such as sand and clay content, pH and organic matter of soils, and the soil respiration and soil mineralization. In the study, it was reported that while the clay content decreased as the slope increased in rangelands, the amount of sand was between 65-70% and 38-67% in the shady aspect and sunny aspect, respectively, the amount of clay varied between 14-20% in the shady aspect and 18-48% in the sunny aspect, the pH values in the medium slope group were higher compared to the low slope group, the pH values varied between 6.70-7.13 in the shady aspect group and 6.38-7.41 in the sunny aspect group in rangelands, the amount of organic matter was generally high in areas with low slope, and when the evaluation was performed according to aspect groups, the amount of organic matter was found to be higher in the sunny aspect in rangelands up to 15 cm depth level and in the shady aspect at other depth levels. In the same study, it was determined that the soil respiration was higher in sunny aspects in rangelands. Furthermore, as a result of the study, it was emphasized that in rangeland vegetations where microorganism activities and N fertility in the soil were high, topographic factors such as slope and aspect had a partial effect on these properties of soils (Küçük, 2013).

In a study conducted by Bilgin and Özalp (2016) at elevations of 1900 m, 2000 m, and 2200 m, it was found out that the organic matter, volume weight, and pore volume values among the soil properties of rangelands showed significant differences between elevation levels.

In a study conducted in rangelands in the Eastern Anatolia region of Turkey, it was determined that there was no significant variation between rangeland aspects in terms of basic fertility characters of rangeland soils, especially soil texture and pH value. Nevertheless, it was reported that the lime content of the soil was the highest in the west aspect and the lowest in the north aspect of the rangeland. In the same study, it was also emphasized that all rangeland soils contained very low amounts of available P and that the inadequate level of available P content of rangeland soils had an effect on the low ratio (7.61%) of legumes in the botanical composition by weight in the rangeland examined (Özyazıcı and Yıldız, 2017).

CONCLUSION

Topographic factors play a vital role in sustainable rangeland management and also affect the quality and quantity of vegetation, and in this sense, they are decisive and also decide on the applicability of rangeland management principles. It is of great importance to know the vegetation interaction under different topographic structures in applying effective management and improvement methods in rangelands to a dynamic vegetation structure under the influence of topographic factors such as slope, aspect, and elevation. In other words, the relationship between topography and vegetation is the main guide for making use of rangelands properly and correctly.

On the other hand, topographic factors also affect the circulation of nutrients in the soil. Microbial activity in the soil is much better in rangeland vegetations compared to other vegetations. Therefore, it is necessary to monitor the fertility of rangelands continuously and to create a database for up-to-date soil and plant species and diversity. The regulation of grazing and controlled livestock activities will be possible by continuous monitoring of the fertility power of rangelands.

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CHAPTER 21

THE EFFECT OF NITROGEN FERTILIZER DOSES ON SEED YIELD AND SOME QUALITY COMPONENTS OF FORAGE RAPE (*Brassica napus* L. ssp. *oleifera* Metzg)

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INTRODUCTION

The rapeseed plant is in the top three among produced oil plants in the world. Compared to other oil plants, it has superior features such as having summer and winter varieties suitable for different regions, high oil ratio and oil quality, and not being selective in terms of soil requirements (Açıkgöz, 2001; Acar et al., 2005; Gürsoy et al., 2019). The rapeseed plant, which takes an important place in the oil industry and therefore in human nutrition due to these features, is also used in animal feeding with its feed varieties developed recently. In ruminant feeding, the use of the forage rape (*Brassica napus* L. ssp. *oleifera* Metzg) plant as green herbage, hay, and silage is becoming widespread, as well as by adding its seeds to feed rations (Balakhial et al., 2008; Neely et al., 2009; Khodaparast et al., 2011; Özyazıcı et al., 2020). In addition to these, the pulp remaining after the oil is taken from the seeds can be used as animal feed (Gül et al., 2008).

The rapeseed plant can grow rapidly, and it matures in approximately 4-5 months and is harvested for seed. Rapeseeds harvested as a product contain about 38-50% of oil, depending on the variety properties and growing conditions. The pulp remaining after oil is extracted from rapeseed seeds is a valuable animal feed since it contains 29.5% to 57.5% protein (Öğütçü and Kolsarıcı, 1979; Mag, 1990; Süzer, 2014). Rapeseed pulp containing medium or low amounts of glucosinolates is shown as a suitable protein source to replace soy products in poultry breeding (Palander et al., 2004).

On the other hand, since *Brassica* species used as forage have higher dry matter digestibility and metabolic energy than many Poaceae and legumes (Barry, 2013) and forage rape is among the plants least affected by climate change, it makes it potentially an alternative forage crop (Zeybek, 2017). In the major countries producing rapeseed in the world, in addition to increasing the seed yield, studies such as improving the secondary substances contained in the seeds, increasing the nutritional value, and increasing the feed value of the pulp obtained as a by-product are becoming increasingly important. In this sense, the fertilization applications, which is included in the cultivation technique practices, is important for improving the yield and quality. Nitrogen (N) is one of the basic nutrient elements in fertilization, and it has important functions in seed yield and quality and plays a role in vegetative development in plants. Thus, Gül et al. (2008) reported that nitrogen fertilization in rapeseed cultivation was very important for yield and affected all the compounds contained in the seed.

This study was conducted to determine the effects of different nitrogen fertilizer doses on seed yield and some quality components of seed in forage rape (*B. napus* L. ssp. *oleifera* Metzg), which has a high potential to be grown as a forage crop in field agriculture.

MATERIALS AND METHODS

The study was carried out under the ecological conditions of Siirt province in the Southeastern Anatolia Region of Turkey with a semi-arid climate during the 2019-2020 vegetation period (Figure 1).

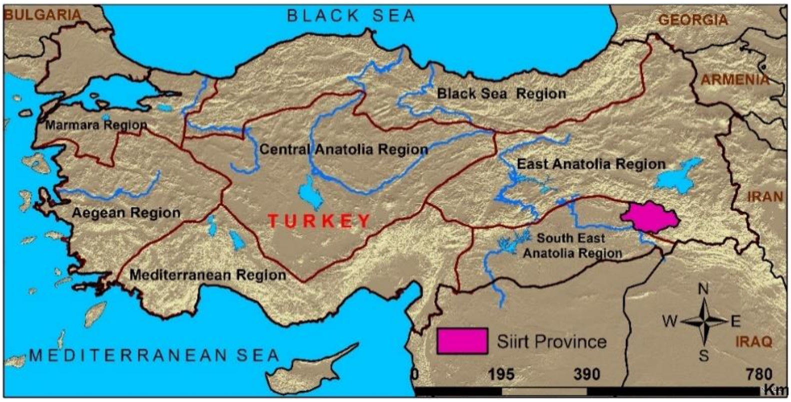

Figure 1. The location where forage rape are grown

In the study, the analysis results of the soil samples taken from a depth of 0-20 cm before the field trial was established are presented in Table 1. According to the classification reported by Ülgen and Yurtsever (1995), it was determined that the research soils with clayey texture, salt-free and slightly alkaline character have "calcareous" lime content, "low" organic matter content, "high" and "excess" levels of available phosphorus (P) and potassium (K), respectively (Table 1).

Table 1. Some physical and chemical properties of the research site soils (0-20 cm)*

Soil property	Value
Sand, %	43.1
Clay, %	38.9
Silt, %	18.0
pH	7.70
Electrical conductivity, dS/m	0.180
Lime ($CaCO_3$), %	2.8
Organic matter, %	1.64
Available P, kg P_2O_5/ha	112
Available K, kg K_2O/ha	1880

*: Analyses were conducted in the Science and Technology Application and Research Center Laboratory of Siirt University.

When some climate data of Siirt province for long years and the vegetation period of November 2019-June 2020 when the study was conducted were examined, it was observed that the average temperature in the eight months covering the sowing-harvest period was slightly lower than the long-term average in the same period, and the relative humidity values were higher than the average of the study period and the long-term average. While a total of 778.2 mm of precipitation was recorded during the vegetation period when the study was conducted, it was determined that the total precipitation average for long years in the same period was 632.5 mm (Table 2).

Table 2. Some climate data of Siirt province for long years (1990-2020) and the study year (2019-2020 vegetation period) (Anonymous, 2020a)

Vegetation period	Average temperature (°C)		Relative humidity (%)		Total precipitation (mm)	
	2019-2020	Long years	2019-2020	Long years	2019-2020	Long years
November	11.9	10.6	50.2	62.7	51.4	74.3
December	7.5	5.1	75.0	72.5	75.8	90.6
January	3.5	3.2	72.7	72.5	70.6	81.0
February	3.7	4.7	73.0	67.5	158.6	98.4
Mart	11.1	9.2	63.1	61.3	222.4	112.5
April	14.1	14.2	60.2	58.4	158.8	103.5
May	20.8	19.7	47.1	50.1	40.4	63.1
June	27.2	26.5	26.6	33.9	0.2	9.1
Average/Total	10.4	11.6	63.0	59.9	778.2	632.5

In the study, Lenox variety of forage rape was used as a plant material. In the study, field trials were established with three replications according to the randomized block trial design, and five different doses of nitrogen (N) (N_0= 0 kg N/ha, N_1= 50 kg N/ha, N_2= 100 kg N/ha, N_3= 150 kg N/ha and N_4= 200 kg N/ha) constituted the subject of the study. Urea (46% pure N) was used as a nitrogen fertilizer source. Half of the nitrogen fertilizer was given at the time of sowing, and the other half was given at the time of the plant's bolting in early spring. Plants were sown on November 07, 2019, at a distance of 40 cm between rows (Cacan and Kokten, 2017) and in 6 rows, with a 10 kg/ha sowing norm (Anonymous, 2020b). Accordingly, a parcel size is 2.4 x 4.0= 9.6 m^2.

Weeds in the parcels were controlled mechanically. In the harvesting process, 0.5 m parts from the parcel heads and one row from the parcel edges were removed as edge effects. Accordingly, harvesting was performed on June 06, 2020.

After the harvested plants were harvested, the seed yield per hectare was found considering the parcel area, and 1000 grain weights of the obtained seeds were calculated. Glucosinolate content, oil and protein ratios in a forage rape seed were determined using a NIRS (Near-Infrared Reflectance Spectroscopy) device in the Laboratory of Ondokuz Mayıs University, Faculty of Agriculture, Department of Field Crops (Brogna et al., 2009). Glucosinolate amount, oil and protein ratio values in seed were given on dry matter.

The data obtained as a result of the study were subjected to analysis of variance according to the randomized block trial design, and the differences between the averages were evaluated according to the LSD test (Yurtsever, 1984).

RESULTS AND DISCUSSION

In the study, the seed yield, 1000 grain weight, glucosinolate content, oil and protein ratios of the forage rape seeds grown at different nitrogen doses are presented in Table 3.

The effect of different N doses on seed yield in forage rape was found to be statistically very significant ($p<0.01$). In the study, it was observed that the seed yield increased up to the N_3 nitrogen dose due to the increase in the N fertilizer dose, and there was some decrease in the next dose. Accordingly, the highest seed yield was obtained at the nitrogen dose of N_3 (1323.0 kg/ha), which is in the first group statistically, and the difference between the seed yields obtained at N_3 and N_4 fertilizer doses was found to be statistically insignificant. The lowest seed yield was determined at N_0 with 626.3 kg/ha (Table 3). In many studies, it has been reported that the seed yield generally increases as the nitrogen dose increases (Turan et al., 1990; Ozer, 2003; Rathke et al., 2005; Koç, 2007; Öztürk and Ada, 2009; Çorbacı, 2011; Köymen and Kara, 2017; Gürsoy et al., 2019).

It was determined that nitrogen fertilizer doses increased 1000 grain weight in the forage rape plant significantly ($p<0.05$) compared to the control. Accordingly, the highest values were obtained at all N doses other than the control in forage rape, and they formed the first group statistically. The 1000 grain weight values of nitrogen fertilizer doses varied between 3.0-3.2 g (Table 3). In some studies on 1000 grain weight in the rapeseed plant, Ozer (2003), Üstuner et al. (2008) and Öztürk and Ada (2009) reported that there was a positive correlation between 1000 grain weight and N dose, Köymen and Kara (2017) reported that there were no significant differences between doses, and Çorbacı (2011) reported that the highest values were obtained in the application of 150 kg N per hectare.

In parallel with the increase in the N fertilizer dose applied, it was observed that the gluycosinolate values in forage rape seeds increased, and the highest glucosinolate value was obtained from the parcels to which N_4 nitrogen dose was applied with 24.21 µmol/g. In the study, the lowest glucosinolate content was obtained in the control (12.83 µmol/g) to which nitrogen was not applied and N_1 (13.93 µmol/g) nitrogen dose application. This difference between N doses in terms of the glucosinolate content of rape seeds was found to be statistically significant at the $p<0.01$ level (Table 3). Cramer (1990), Kessel (2000), Gül et al. (2008), and Türk et al. (2008) reported that the prolongation of vegetation period, regular and long course of rainfall, and N fertilization affected the increase of glucosinolate values.

Glucosinolates are sulfur and N-containing secondary metabolites commonly found in the Brassicaceae and relative plant families. These glucosinolates are known to affect iodine uptake via the thyroid gland, resulting in liver disease and live weight loss in animals (Rowan et al., 1991; Burel et al., 2000; McNeill et al., 2004; Kermanshahi and Abbasi Pour, 2006; Seyis and Aydın, 2014). In some studies conducted to minimize or completely eliminate the harmful effects of glucosinolates on animals, the break down of glucosinolates was ensured by the processing of feed containing glucosinolates, enzymatic hydrolysis, or other chemical reactions (Quinsac et al., 1994; Huang et al., 1995; Jensen et al., 1995; Mi´nkowski, 2002; Tyagi, 2002; Das and Singhal, 2005). To utilize the rapeseed plant as animal feed, it was stated that the limit values of glucosinolate content should be in the 2.3-11.6 µmol/g diet range for livestock (Marangos et al., 1974; Lesson et al., 1987), in the 1.2-2.4 µmol/g diet range for calves in ruminants (Anderssen and Sorensen, 1985), in the 10-15 µmol/g diet range for bulls-calves, in the <11 µmol/g diet range for cows (Laarveld et al., 1981), and in the 1.2-2.2 µmol/g diet range for sheep and goats (Mandiki et al., 2002). In our study, the glucosinolate content of forage rape seeds varied between 12.83-24.21 µmol/g depending on N doses (Table 3). Considering the limit values in the literature, it can be said that the glucosinolate content determined in forage rape seeds poses a risk for animal health in this study carried out under terrestrial climate conditions. Ecological factors are thought to affect the high glucosinolate content of seeds.

Table 3. Change in some agricultural characteristics of forage rape seeds according to different nitrogen fertilizer doses[1]

N doses (kg N/ha)	Seed yield (kg/ha)	1000 grain weight (g)	Glucosinolate content (µmol/g)	Oil ratio (%)	Protein ratio (%)
N_0	626.3 d	2.5 b	12.83 c	50.99 a	18.90 c
N_1	822.9 c	3.0 a	13.93 c	50.47 a	19.66 bc
N_2	999.8 bc	3.0 a	19.23 b	49.23 b	20.79 ab
N_3	1323.0 a	3.2 a	20.06 b	48.95 b	20.83 ab
N_4	1148.0 ab	3.0 a	24.21 a	47.63 c	21.66 a
F test	0.0002**	0.0137*	0.0001**	0.0008**	0.0227*

[1]: The difference between the averages in the same column indicated by the same letter is not statistically significant, *: Significant difference at the p<0.05 level, **: Significant difference at the p<0.01 level.

Nitrogen fertilizer doses had a statistically very significant ($p<0.01$) effect on the oil ratio of forage rape seeds. It was determined that the oil ratio of rape seeds decreased with increasing nitrogen doses. While the highest oil ratio was detected at the dose of N_0 with 50.99%, the lowest oil ratio was obtained from the parcels to which N_4 nitrogen dose was applied, with 47.63% (Table 3). In the studies on the oil ratio of rape seeds, it has been reported that as the N dose increases, the oil ratio in the seed decreases, as in our study findings (Holmes and Ainsley, 1978; Potts and Gardiner, 1980; Taylor et al., 1991; Başalma, 1999; Ozer, 2003; Gül et al., 2007; Çorbacı, 2011).

It is observed that due to the increase in N fertilizer doses, the protein ratio in the forage rape plant increases, and the highest protein ratio is obtained with the application of N_4 nitrogen dose with 21.66%. Furthermore, the difference between N_4 dose and N_2 and N_3 doses in terms of protein ratio was found to be statistically insignificant. In terms of protein ratio, the lowest value was determined in parcels (N_0), to which nitrogen was not applied, with 18.90%. This difference between nitrogen doses in terms of protein ratio was found to be statistically significant at the $p<0.05$ level (Table 3). The protein ratios determined in the forage rape seeds in the study were lower than the values of 23.4-26.6% found by Öztürk (2000) and compatible with the values 18.9-21.7% found by Sargın (2012) and the values of 16-24% found by Arslan et al. (2007).

CONCLUSION

It gives the impression that the forage rape plant, which is grown as a winter plant under terrestrial climate conditions, will contribute as an alternative plant in winter intermediate crop cultivation and can be used in feed rations considering the high protein ratio of its seeds. However, the glucosinolate content in the seed above the limit values restricts its use.

When the use of seed material of forage rape as feed is considered, it is important to select a variety with low glucosinolate content. Furthermore, considering that there are very important changes in the quality components of forage rape seeds due to nitrogen fertilization, the effect of the applied cultural processes should not be ignored. In other words, although high seed yield is obtained with nitrogen fertilization, the oil and protein ratios and glucosinolate content of the seeds should be taken into account when using forage rape seeds in feed rations.

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CHAPTER 22

A STUDY ON FARMER'S CONSCIOUSNESS ON FORAGE CROP CULTIVATION

INTRODUCTION

This study was conducted to determine farmer's consciousness on forage crop cultivation in Aşağı Yarımca, Binekli, Yukarı Yarımca, Göktaş, Serince and Yenice villages of Harran town of Şanlıurfa province. Compulsory crop rotation of the Ministry of Agriculture was applied during the study year. This study was conducted to determine farmer's consciousness on forage crop cultivation from sowing to harvest. A survey was designed and questionaries were applied to 60 farmers in randomly selected 6 villages served by Harran Town Directorate of Agriculture through face-to-face meetings. Resultant data were arranged, analyzed and interpreted.

Although a large increase was projected in forage crop cultivated lands, realized ratio was below the targeted levels. Measures should be taken to solve general problems encountered in forage crop cultivation, problems encountered in development of new cultivars and seed production of these cultivars and measures should also be taken about forage crop cultivation incentives. Recommendations were provided to improve farmer success in forage crop cultivation.

Present findings revealed that local farmers had insufficient level of knowledge on forage crop cultivation, state supports were insufficient, farmers were not practicing forage crop farming before, thus were not experienced in forage crop farming. Therefore, they experienced various difficulties and were not able to achieve desired outcomes.

Increasing populations and resultant food demands generate serious problems for mankind to deal with. Nutritional needs of mankind are tried to be met with various animal and plant production activities. Although Turkey has a great potential for livestock farming, desired production levels have not been achieved, yet. The primary problem in livestock raising is insufficient feeding of animals. Roughage needs of the animals in the region are generally met from pasture-meadows with quite a low yield levels, fallow lands and plant production residues.

Forage crop cultivation is the most important way of providing continuous and reliable roughage supply (Akman and Kara 2007). Forage crops have a significant place in agricultural activities and have important contributions to plant and animal production. Roughage produced over the agricultural fields are initially used by animals, then converted into meat, milk and etc products and humans benefit from these products (Soya et al. 2004). Forage crops offer a cheap source of feed for animals, contain nutrients required micro flora of ruminants, rich in minerals and vitamins, improve reproduction capacity of the animals, thus play an important role in proving high-quality animal products (Serin and Tan 2001). Forage crop cultivation will alleviate the excessive grazing pressure on pastures and meadows, will narrow fallow lands through incorporation into cropping rotations and also reduce soil erosion in long-run. With increasing forage crop cultivation, degraded pasture and meadows will have a chance to restore themselves. Besides, forage crops incorporated into crop rotations will provide contributions to subsequent crops. Efficiencies and importance of forage crops in crop rotations could be summarized as follows (Soya et al. 2004).

MATERIAL and METHODS

This study was conducted through the questionaries on randomly selected 60 farmers practicing forage crop cultivation in Yenice, Binekli, Aşağı Yarımca, Göktaş and Serince villages of Harran town of Şanlıurfa province. Terrestrial transitional climate is dominant in these villages of Harran Plain. Summers are hot and dry and winters are cold and precipitated. Distribution of precipitations is generally irregular.

Site studies and questionnaires were performed in 2020. Within the scope of a policy of Ministry of Agriculture, indicating that farmers practicing the same crop in 3 consecutive years will not be supported, farmers tended to main crop after the harvest of cotton, of which almost half of country production is practiced in Şanlıurfa province. Since such a compulsory policy is applied over the entire Harran Plain, this region was selected as the study area. The primary objective of survey questions is to have an idea about farmer's consciousness on forage crops and cultivation. The data gathered through questionnaires were arranged and supported with relevant graphs to better comprehension.

Survey questions were asked to farmers in face-to-face meetings. Compulsory forage crop cultivation has emerged a different cropping pattern to which farmers were not accustomed, thus farmer's response to forage crop cultivation was sought in this study. Economic and phycological conditions and forage crop cultivation techniques of farmers were questioned.

RESULTS and DISCUSSION

1. Forage crops cultivated by farmers during the growing season

Of the participant farmers, 74% were growing vetch, 23% were growing alfalfa and 3% were practicing mixture sowing. Such a case is presented in Figure 1.

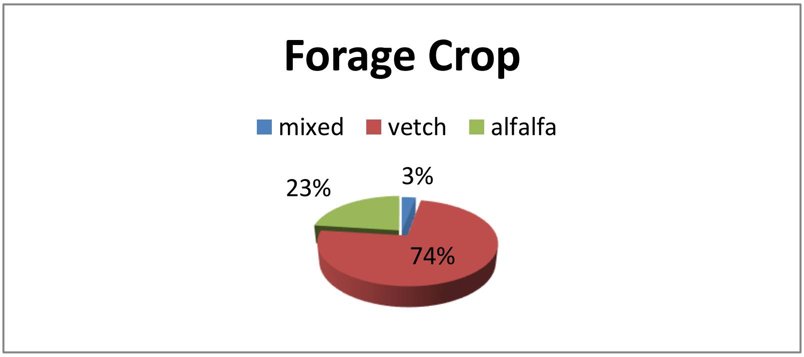

Figure 1. Cultivated forage Crops

2. Land possession statuses

Considering the land possessions of the participant farmers, it was observed that 63% were landowners, 29% were sharecroppers and 8% were renters. The sharecroppers (29%) were mostly brothers and they were practicing together since lands have not yet been inherited. Such a case is presented in Figure 2.

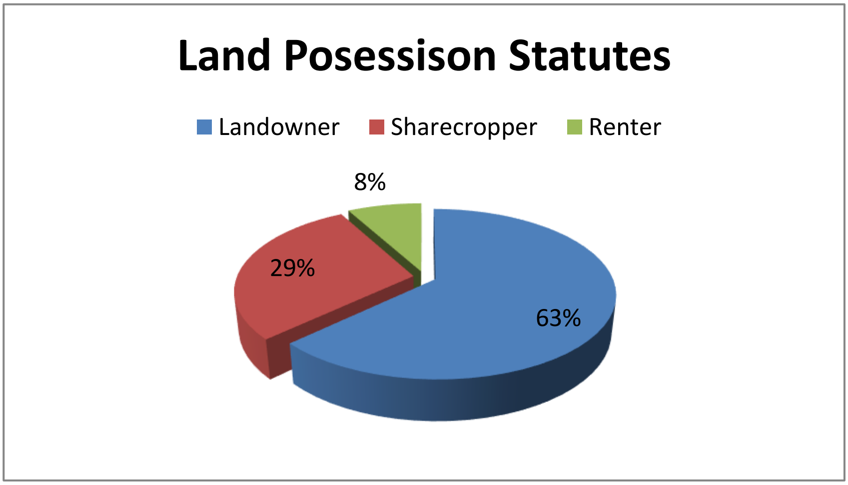

Figure 2. Land possessions of the farmers

3. The greatest problems of the farmers

Farmers were asked about their greatest problems and 52% were complaining about insufficient state supports, 35% were complaining about expensive input prices and 13% were complaining about not marketing at worthy prices. Such a case is presented in Figure 3.

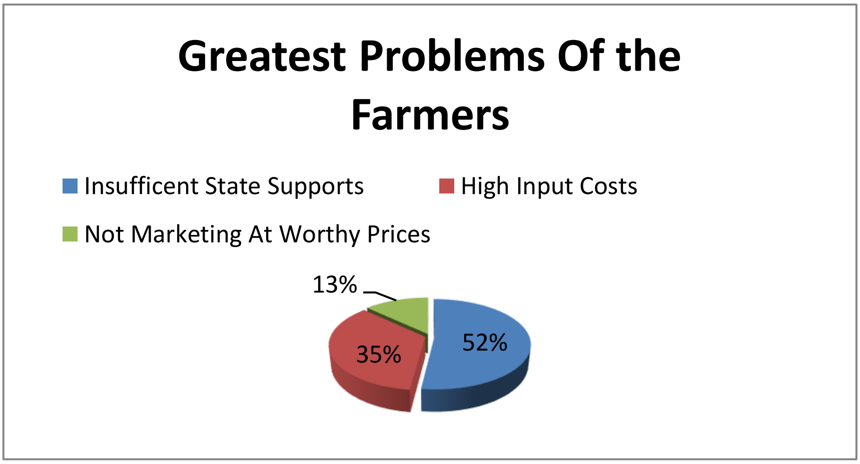

Figure 3. The greatest problems of the farmers

4. Are the technical stuffs of Provincial-Town Directorates of the Ministry of Agriculture sufficient and are you able to sufficiently benefit from them?

Farmers were asked about technical stuffs of the Ministry of Agriculture and 42% indicated that they benefited from them, 38% indicated that they saw them couple times in a year and 20% indicated that they did not benefit at all. Such a case is presented in Figure 4.

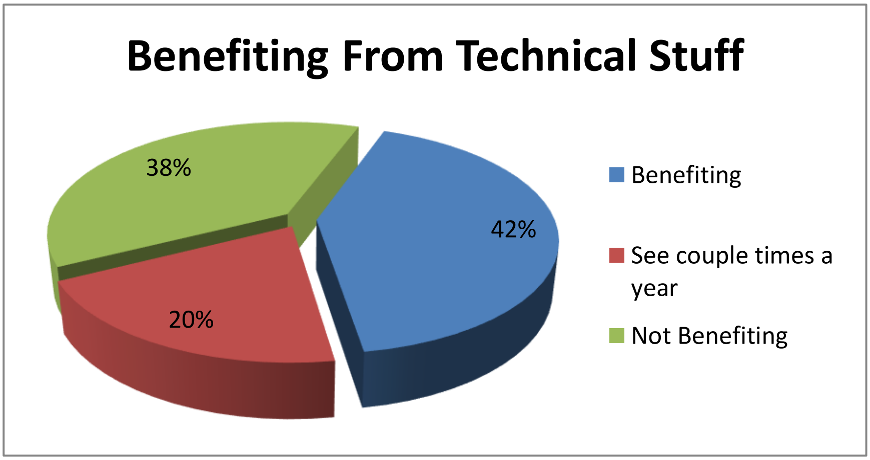

Figure 4. Benefit from technical stuff

5. Tools-equipment acquired by the farmers in years

Farmers were asked about tools-equipment they acquired in years and it was observed that 95% had a tractor, 95% had a cultivator, 90% had a holder, 83% had a sowing machine, 80% had a plough, 67% had a harrow, 49% had a disc harrow, 2% had a rotary harrow and 2% had a combine-harvester. Such a case is presented in Figure 5.

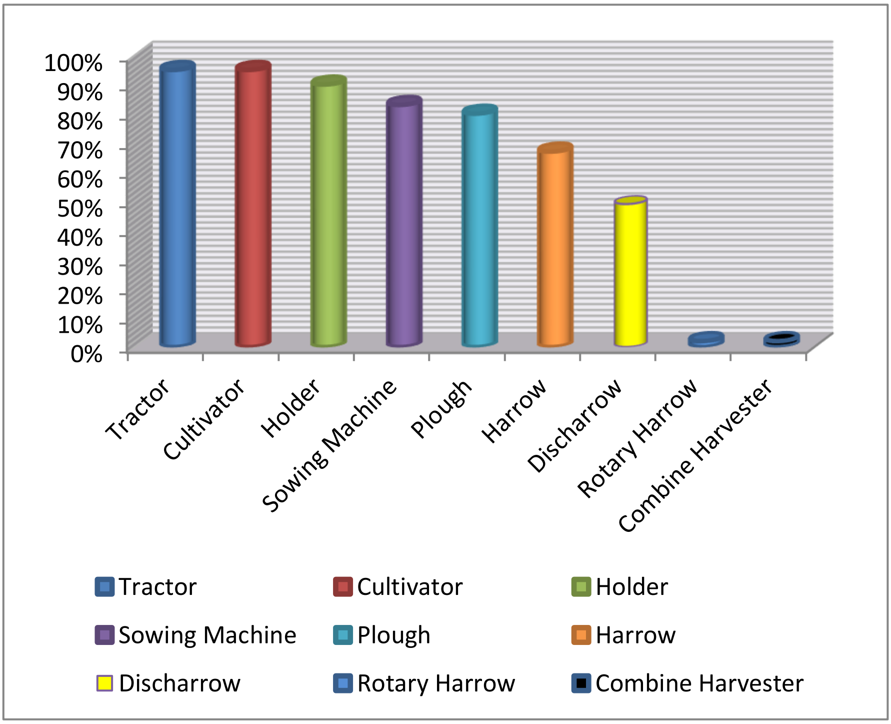

Figure 5. Tools-equipment acquired by the farmers in years

6. Occupations of forage crop growers

It was observed that forage crop cultivation was mainly practiced by farmers. Of the participant farmers, 78% were not dealing with a non-agricultural activity and 22% were dealing with non-agricultural activities. Some were working in other places, some were artesian in city or town center and some others were public officials. Such a case is presented in Figure 6.

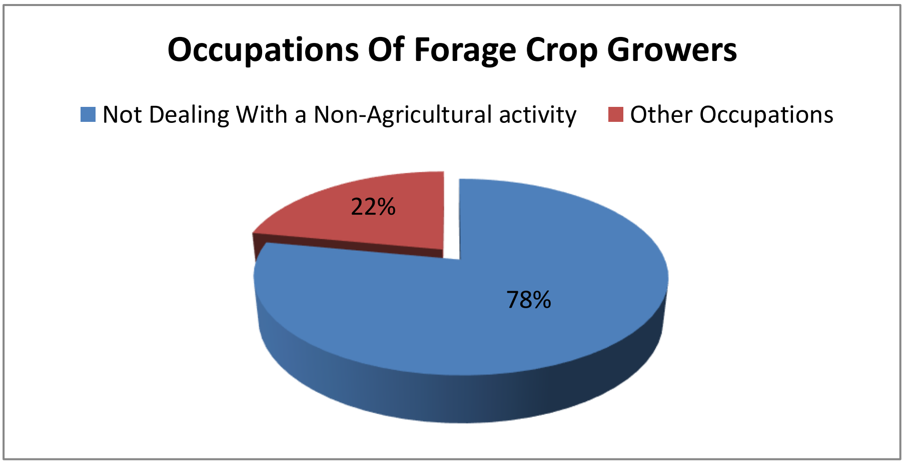

Figure 6. Occupations of the forage crop growers

7. Experience in forage crop cultivation

Knowledge and experience in forage crop cultivation will of course increase the chance of success in growing practices. Of the participant farmers, 72% had a weak level of experience in forage crop cultivation. On the other hand, 20% had moderate level of experience and 8% were highly experienced in forage crop cultivations. In general, they had knowledge and experience in forage crop cultivation. Such a case is presented in Figure 7.

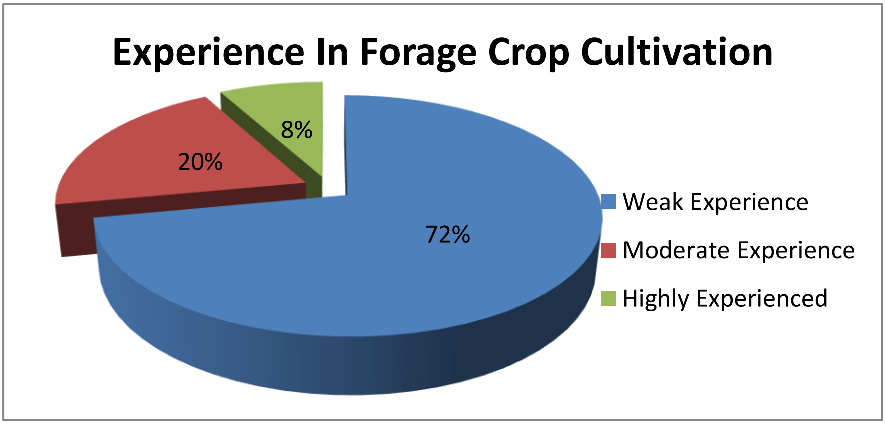

Figure 7. Experience in forage crop cultivation

8: Seed supplies of the farmers

Majority of the producers were splaying seeds from private companies. About 85% of the growers were purchasing seeds from seed companies and 15% were using the seeds from the previous year. Producers mostly preferred registered varieties. Such a case is presented in Figure 8.

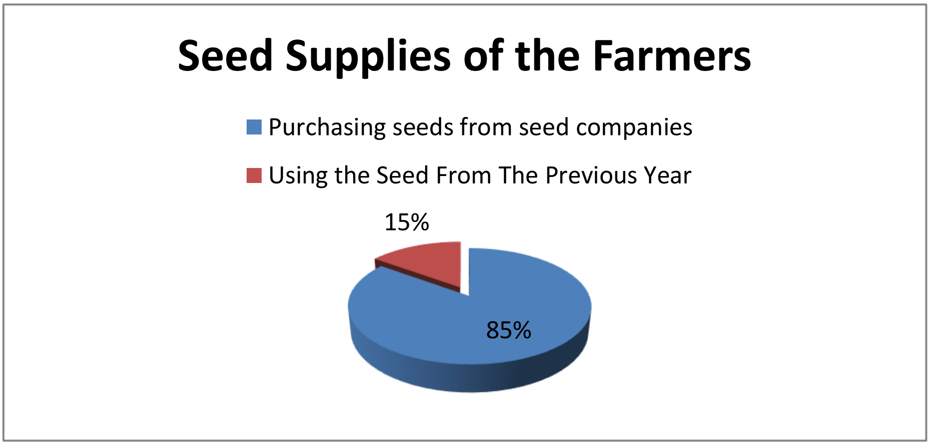

Figure 8. Seed supplies of the farmers

9. Purpose of forage crop cultivation

Of the participant farmers, 89% indicated that they grew forage crops due to compulsory crop rotation, 9% indicated that they grew forage crops for their animals and 2% for commercial purposes. Such a case is presented in Figure 9.

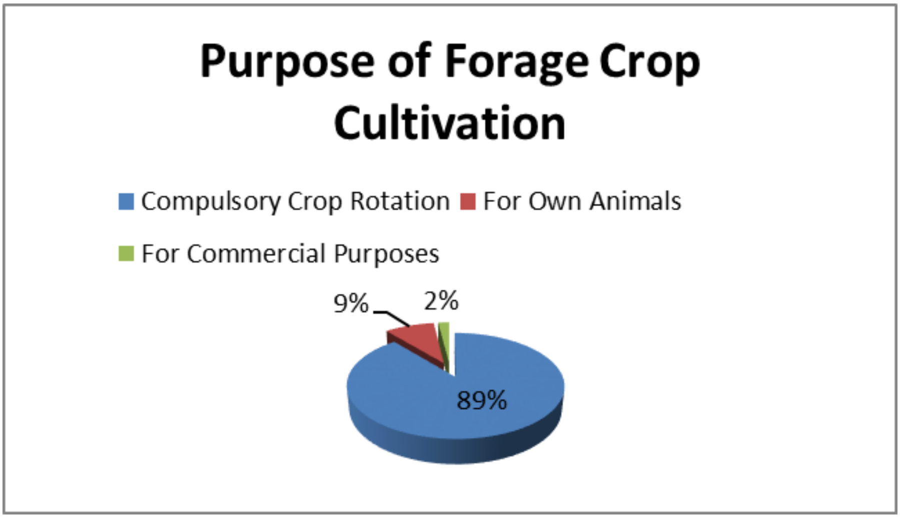

Figure 9. Purpose of forage crop cultivation

10. Support demands about forage crop cultivation

About 56% of the participant farmers indicated that they did not receive any supports from anybody and made their practices with their own knowledge. On the other hand, 30% indicated that they practiced forage cultivation along with the directives of the firms from where they supplied seeds and 14% indicated that they received supports from Provincial Directorate of Agriculture and University. Such findings revealed that majority of the farmers did not demand the support of research institutes. Reasons of this case should be comprehensively assessed. In this case, farmers were considered to hesitate consulting to research institutes or to find easy to get information from the other sources. When this 14% applying to the institutes were asked if they were satisfied, 65% replied as “yes” and 35% replied as “no”. Such a case is presented in Figure 10.

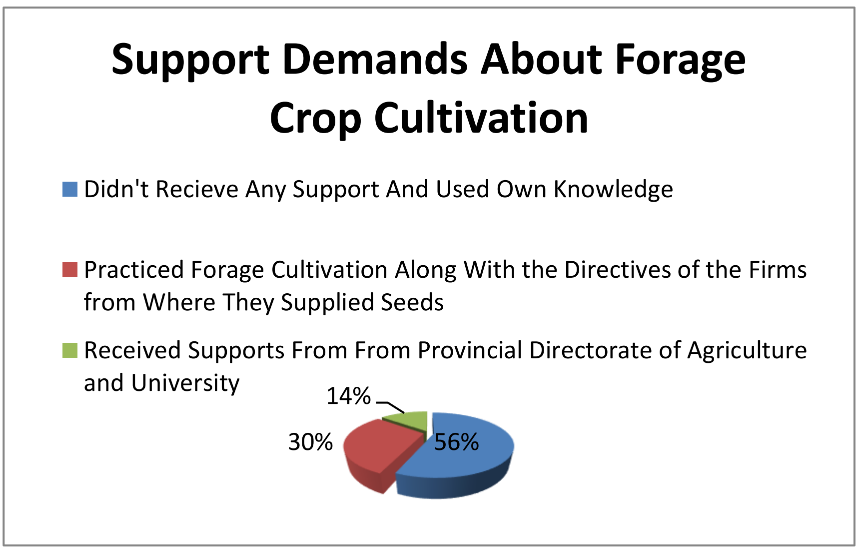

Figure 10. Support demands about forage crop cultivation

CONCLUSION AND RECOMMENDATIONS

This study conducted on farmers of Aşağı Yarımca , Binekli, Yukarı Yarımca, Göktaş, Serince and Yenice villages in Harran town of Şanlıurfa province. Compulsory crop rotation was applied in the study year. Since the local farmers were faced to uncommonly grown forage crops, their consciousness level on forage crop cultivation from the sowing to harvest were investigated in this study. It was observed that pontification of the farmers resulted in negative outcomes. Producers should demand the supports of experienced technical stuff and engineers. Trust to technical stuff is low in regions with low educational levels. Farmers were found to be indecisive in ceding their fields to technical stuff. In other words, lands were mostly owned by the farmers and they employ their own personnel.

Forage crop cultivation is generally practiced over small irrigated fields and such a case then increases production costs. In fact, profitability increases as the production sites get larger. Therefore, optimal land sizes should be determined and forage crop cultivation should be widespread on these lands. Forage crop production lands are under the pressure especially of cereal crops. Therefore, cereal cultivation lands should be re-evaluated in favor of forage crops. Differences in productions, ecological structure, sustainability, availability, social rules and pressures also influence farmer decisions in tending different production practices. Besides, individual attitudes, feelings, perceptions, recalls and outcomes of a case also consciously or unconsciously influence farmer decisions. It was clearly seen that agricultural policies should not solely depend on monetary policies.

Producers should be informed about seed supply and use, should be convinced about the advantages of certified seeds and use of unknown seeds should be prevented. Present farmers mostly preferred registered seeds, thus had positive outcomes.

Forage crop producers generally had low educational levels. Majority of the farmers were practicing traditional forage crop cultivation with quite a low knowledge and without any supports of anyone or any institutes. Farmers who desire to improve productivity and levels of success should be supported with technical information and knowledge. Local farmers generally had low training levels on new crops. In fact, producer experience and knowledge, quality and quantity of labor express quality of facilities. Therefore, these traits should be taken into consideration to improve the quality in production activities.

Majority of the growers wish to benefit forage crop supports. Supports should be provided until a certain culture is achieved since farmer perception of forage crop cultivation as a principle practice is quite significant for sustainability of forage crop cultivation. Inexistence of a serious change in forage crop farming for years is a well indicator of such a case. Therefore, forage crop cultivated lands and production quantities should be increased. Throughout the growing season, other agronomic practices should be identified and applied timely. Ownership of production tools and equipment may improve productivity and sustainability.

In general, present findings revealed that farmers haven't adopted this compulsory crop ration, yet. They experienced several deficiencies and seemed to be unhappy. Farmer's consciousness on forage crop cultivation was low and they experienced difficulty in growing practices. Technical stuff of the Ministry and university colleagues should offer consultancy services to local farmers.

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