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Aims and Scope

Turkish Journal of Range and Forage Science is the official publication of Society of Rangeland and Forage Science. The Journal is dedicated to publishing quality original material that advances rangeland management and forage crops production.

Turkish Journal of Range and Forage Science is a peer-reviewed, international, electronic journal covering all aspects of range, forage crops and turfgrass management, including the ecophysiology and biogeochemistry of rangelands and pastures, terrestrial plant–herbivore interactions, rangeland assessment and monitoring, effects of climate change on rangelands and forage crops, rangeland rehabilitation, rangeland improvement strategies, conservation and biodiversity goals. The journal serves the professions related to the management of crops, forages and grazinglands, and turfgrass by publishing research, briefs, reviews, perspectives, and diagnostic and management guides that are beneficial to researchers, practitioners, educators, and industry representatives.

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The peer review process that has long time is an important problem. Naturally, the author(s) wish to take an answer about their submissions. Turkish Journal of Range and Forage Science aims to complete the all peer review process within 8 weeks after submission (one week for initial evaluation, 6 weeks for reviewer evaluation and one week for final evaluation).

The author(s) that submit an article to the Turkish Journal of Range and Forage Science consider accepting of these peer review conditions and procedures.

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Research

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The Determination of Forage Yield and Quality of Some Sorghum and Sorghum Sudangrass Cultivars in Ecological Conditions of Uşak Province

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A R T I C L E I N F O

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A B S T R A C T

This study was conducted to determinate of yield and some quality characters of sorghum (*Sorghum bicolor* (L.) Moench) and sorghum-sudangrass (*Sorghum sudanense* L.) hybrid cultivars in Usak province in 2014. In the study was used four sorghum sudangrass hybrid (Aneto, Sugar Graze II, Greengo, Nutri Honey) and two sorghum cultivars (Teide and Rox). The experiment was carried out in completely randomized block design with three replications. In the study, plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yields, acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrient (TDN) and relative feed value (RFV) were determined. There were significant differences in all the properties examined among sorghum and sorghum-sudangrass hybrid cultivars. According to the results of the research, plant heights of cultivars ranged from 200.1 to 229.7 cm, herbage yields ranged from 57.40 to 77.73 t ha-1, hay yields ranged from 14.11 to 18.95 t ha-1, crude protein ratios ranged from 9.95 to 11.94%, crude protein yields ranged from 1.46 to 2.15 t ha-1, ADF ratios from 36.64 to 42.41%, NDF ratios from 55.79 to 60.12%, total digestible nutrient ratios from 46.60 to 54.05%, relative feed values from 87.14 to 100.56. Greengo cultivar had higher herbage yield, hay yield, total digestible nutrient and relative feed values and lower ADF and NDF ratio than other cultivars. The results revealed that Greengo cultivar can be considered suitable for the Uşak and similar ecological conditions.

1. Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an important crop that can be grown successfully in summer season in hot and dry environment (Prakash et al. 2017). The cultivation of sorghum is gradually increasing due to the efficient water use, low fertilizer requirement, advantages in erosion and weed control. Sorghum is extensively grown as a forage crops and becoming increasingly important in many regions of the world (Miron et al., 2006; Yosef et al., 2009; Glamoclija et al., 2011). Fodder quality is of great important as well as higher forage yield. The fodder quality of sorghum depends on many factors such as

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fertilization, irrigation, genotype, plant density and harvesting time (Saeed and El-Nadi, 1998; Cakmakci et al., 1999; Zulfiqar and Asim, 2002; Ayub et al., 2003; Miron et al., 2006).

Breeding of sorghum cultivars with high adaptability, yield and quality makes sorghum a source of alternative summery forage crop. In addition, sorghum is the best crop adapted to arid ecologies having irregular seasonal rainfall distribution and high temperatures during the summer period. Determining the regional adaptation capabilities of sorghum and sorghum-sudangrass hybrids in the regions where water is limited and extending the cultivation of varieties with well adapted and desired characteristics will benefit the economy of the region and the country (Tiryaki, 2005). Therefore, determining the quality characteristics is very important in sorghum and sorghum-sudangrass hybrid cultivation besides the selection of appropriate and efficient cultivars in the regions.

The objective of this research was to compare forage yield and forage quality of four sorghum-sudangrass hybrid and two sorghum cultivars.

2. Materials and Methods

The research was performed at Usak province in the Aegean region of Turkey in 2014. Total precipitation was 118.4 mm in 2014 (May-September), long-term average is 118.6 mm. Average temperature was 20.28°C in 2014 (May-September), long-term average (May-September) is 20.78°C. According to the results of the soil analysis, the soil of the trial area is loamy, salt-free, rich in phosphorus and sufficient in terms of potassium, but medium in terms of organic matter.

In the study was used four sorghum sudangrass hybrid (Aneto, Sugar Grase II, Greengo, Nutri Honey) and two sorghum cultivars (Teide and Rox). The experiment was carried out in completely randomized block design with three replications. Each plot consisted of 6 rows, each 5 m in length. The row spacing was 50 cm. At the time of harvest, one row at the edge of each plot and 30 cm edges of the two middle rows were not evaluated due to the side effect. The seeding rates were 20 kg ha–1 for each cultivars. Before seeding, 80 kg ha-1 each of N and P_2O_5 was applied. Additionally, nitrogen was top dressed at the rate of 70 kg ha-1 when the plants attained 40-50 cm height (Atis et al., 2012). If necessary, weeds were controlled by hand and harrowing. Depending on climatic conditions, plots were irrigated every 10-14 days when consumed nearly half of the available soil water. Sorghum cultivars and sorghum-sudangrass hybrids cultivators harvested at the soft dough stage (Geren and Kavut, 2009).

In the study, plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yields, ADF, NDF, total digestible nutrient (TDN) and relative feed value (RFV) were determined. Nitrogen content was calculated by using the Kjeldahl method. Crude protein content (N×6.25) and then crude protein yields were calculated. The ANKOM Fiber Analyzer was used for NDF and ADF analysis. Ankom F57 filter bags were used for ADF and NDF analysis in this study (Anonymous 2010). Total digestible nutrients (TDN) and relative feed values (RFV) were estimated according to the following equations adapted from Horroks and Vallentine (1999).

TDN = (-1.291 x ADF) + 101.35

DMI = 120/NDF % dry matter basis

DDM = 88.9-(0.779 x ADF % dry matter basis)

RFV = DDM% x DMI% x 0.775

The data were analysed using the Proc GLM (SAS 1998). Means were separated by LSD at the 5 % level of significance.

3. Results and Discussion

According to the results of variance analysis, statistically significant differences were found among the cultivars in all the properties examined in the study (Table 1).

Plant heights were varied between 200.0 and 229.7 cm depending on the varieties. The tallest plants were obtained from Greengo and Aneto cultivars, while the shortest plants were determined in Teide and Nutri Honey cultivars (Table 2). In previous studies on different sorghum species, different values were obtained in plant heights. Plant heights in sorghum cultivars were found 183-355 cm in Cukurova (Saglamtimur et al., 1988), 300-360 cm in California (Skerman and Riveros, 1990), 261-285 cm in Karaman (Gunes and Acar, 2005), 174 cm in Diyarbakır (Gul and Basbag, 2005), 178-223 cm in Isparta (Balabanli and Turk, 2005), 148-330 cm in Bornova (Geren and Kavut

2009), 245 cm in Bartın (Basaran, 2011), 245.7-266.1 cm in Hatay (Atis et al., 2012), 137-177 cm in Yozgat (Tosunoglu, 2014), 209 cm in Bingol (Özmen, 2017), 197.1-299.4 cm in Igdır (Keskin et al., 2018).

Table 1. The results of variance analysis

Sources of Variation	df	Plant Height	Herbage Yield	Hay Yield	CP Ratio	CP Yield	ADF	NDF	TDN	RFV
Block	2	286.7	220691*	54062	0.04	866.7	25.58	21.22	128.4	112.1
Cultivars	5	448.6*	1778529*	142772**	47.12**	2720.0*	88.49**	96.14**	88.6**	246.5**
Error	10	123.9	51854	43511	0.74	705.7	22.12	19.51	11.2	50.2

Table 2. Mean plant height, herbage yield, hay yield, crude protein (CP) ratio, crude protein yield of some silage sorghum and sorghum-sudangrass hybrid cultivars.

Cultivars	Plant Height (cm)	Herbage Yield ($t\ ha^{-1}$)	Hay Yield ($t\ ha^{-1}$)	CP Ratio (%)	CP Yield ($t\ ha^{-1}$)
Greengo	229.7 a*	77.73 a	18.95 a	9.95 d	1.91 ab
Teide	200.0 b	69.33 b	16.34 b	10.64 c	1.74 ab
Aneto	224.3 a	75.01 ab	18.77 a	11.47 b	2.15 a
Rox	221.3 ab	73.73 ab	18.66 a	10.33 cd	1.90 ab
Nutri Honey	200.0 b	63.66 c	14.53 c	10.03 d	1.46 b
Sugar Graze II	214.0 ab	57.40 d	14.11 c	11.94 a	1.69 ab

*There is no significant difference between the averages indicated by the same letters (P<0.05). CP:Crude protein

The differences among the herbage yields of the cultivars were found to be statistically significant. The highest herbage yields were obtained from Greengo (77.73 t ha-1), Aneto (75.01 t ha-1) and Rox (73.73 t ha-1) cultivars (Table 2). Sugar Graze II cultivar had the lowest herbage yield (57.40 t ha-1). In previous studies on different sorghum species, different values were obtained in herbage yields. Herbage yields in sorghum cultivars were found 45.5-68.3 t ha-1 in Isparta (Balabanli and Turk, 2005), 62.96-76.13 t ha-1 in Konya (Karadas 2008), 44.53 t ha-1 in Bartın (Basaran, 2011), 75-152 t ha-1 in Çanakkale (Yolcu, 2015), 73.23 t ha-1 in Bingol (Ozmen, 2017). The differences between the reported results may be due to the differences in harvest times and ecological conditions of research areas, status of the first and the second crop cultivations, and the genetic characteristics of the cultivars used in studies.

The highest hay yields were obtained from Greengo (18.95 t ha-1), Aneto (18.77 t ha-1) and Rox (18.66 t ha-1) cultivars. Sugar graze II and Nutri Honey cultivars had the lowest herbage yields (14.11 and 14.53 t ha-1). In studies on sorghum, the hay yields were found to be 48-93 t ha-1 by Tosun and Aydin (1985), 43-50 t ha-1 by Iptaş et al. (1997), 45-57 t ha-1 by Acar et al. (2000), 15-20 t ha-1 by Yilmaz (2000), 21-23 t ha-1 by Gunes and Acar (2005), 19-23 t ha-1 by Karadas (2008), 6-12 t ha-1 by Tosunoglu (2014), 5.5-25.6 t ha-1 by Ozmen (2017). The hay yields obtained in this study were higher than Sevimay et al. (2001), Gul and Basbag, (2005), Tosunoglu (2014), lower than Tosun and Aydin (1987), Iptaş et al. (1997), Acar et al. (2002), Gunes and Acar (2005), Karadas (2008) and similar to Yilmaz (2000), Cecen et al. (2005), Geren and Kavut (2009) and Ozmen (2017).

As seen in Table 2, the highest value of CP ratio (11.94%) was found in Sugar Graze II cultivar. The lowest CP ratios were determined in Greengo (9.95 %) and Nutri Honey (10.03%) cultivars (Table 2). In previous studies on different sorghum species, different values were obtained in CP ratios. Crude protein ratios in sorghum cultivars were found 10.10% in Cuba (Cacares ve Santana, 1987), 8.35% in Samsun (Aydin and Albayrak, 1995), 9.3-15% in Tokat (Iptaş et al., 1997), 7.2-8.7% in Van (Hosaflioglu, 1998), 4.41-5.15% in Karaman (Gunes and Acar, 2005), 9.5-10.2 % in Poland (Kozlowski et al., 2006), 5.60-6.63% in Konya (Karadas, 2008), 7.2% in New Mexico (Marsalis et al., 2010), 7.1-9.7% in Antalya (Arslan and Cakmakci, 2011), 7.2-8.8% in Bursa (Canbolat, 2012), 2.5-7.0% in Bingöl (Ozmen, 2017). The findings obtained in this study are in consistent with the results of Cacares and Santana (1987), Iptaş et al. (1997), Kozlowski et al. (2006), Arslan and Cakmakci (2011).

The CP yields were varied between 1.46 and 2.15 t ha-1 depending on the varieties in this research. The CP yields obtained in this study were higher than Hosaflioglu (1998), Yilmaz and Hosaflioglu (2000), Gunes and Acar (2005), Keskin et al. (2005), Yılmaz and Sağlamtimur (1997), Tosunoğlu (2014), Ozmen (2017), Atis et al. (2012) and similar to Iptaş et al. (1997), Kir and Dursun Sahan (2019). Crude protein yield, which is directly related to dry matter yield and crude protein ratio, is very important in animal nutrition (Keskin et al., 2005). Since protein is one of the most costly supplements for livestock, the total amount of protein produced per unit area is one of the most important quality characteristics as suggested by Assefa and Ledin (2001) and Lithourgidis et al. (2006).

In this research, the lowest ADF ratios were determined Nutri Honey (36.64%) and Greengo (36.68%) cultivars, while the highest ADF ratios were found in Sugar Graze II (42.41%) and Rox (41.81%) cultivars (Table 3). In studies on sorghum, the ADF ratios were found to be 27.3-36.5% by Siefers et al. (1997), 32.5-34.6% by Kozlowski (2006), 24.9-32.6% by Canbolat (2012), 34.1-40.1% by Tosunoglu (2014), 36.4-45.1% by Akdeniz et al. (2003), 36.89-49.65% by Ozmen (2017), 30.1-37.4% by Kır and Dursun Şahan (2019). The difference between the ADF ratios obtained in this study and the ADF ratios in the other studies was probably related to the differences in cultivars used and ecologies of experimental sites. The ADF ratio is inversely proportional to digestibility, thus cultivars with low ADF ratio can be expressed as cultivars of higher quality. The high NDF ratio in forage decreases the forage consumption by animals (Yavuz, 2005; Kır and Dursun Şahan, 2019).

Table 3. Mean ADF, NDF, TDN and RFV values of some silage sorghum and sorghum-sudangrass hybrid cultivars.

Cultivars	ADF (%)	NDF (%)	TDN (%)	RFV
Greengo	36.68 d*	55.79 d	54.00 a	100.56 a
Teide	40.29 b	58.69 b	49.34 c	91.14 c
Aneto	38.71 c	57.78 c	51.38 b	94.55 b
Rox	41.81 a	60.12 a	47.37 d	87.14 d
Nutri Honey	36.64 d	56.51 d	54.05 a	99.33 a
Sugar Graze II	42.41 a	57.54 c	46.60 d	90.29 c

According to the results, Rox cultivar had the highest NDF ratio (60.12%). Nutri Honey (56.51%) and Greengo (55.79%) cultivars had the lowest NDF ratios in this research (Table 3). In studies on sorghum, the NDF ratios were found to be 45.1-58.0% by Siefers et al. (1997), 55.7-59.3% by Kozlowski (2006), 66.2-75.9% by Karadas (2008), 50.3% by Marsalis et al. (2010), 46.6-55.9% by Canbolat (2012), 62.7-72.1% by Tosunoglu (2014), 62.5-74.0% by Akdeniz et al. (2003), 55.81-76.11% by Ozmen (2017), 44.6-57.2% by Kir and Dursun Sahan (2019). The ADF and NDF ratios are the best indications of the energy capacity of a forage. The high NDF ratio in forage decreases the forage consumption by animals (Yavuz, 2005). Delaying the harvest time of sorghum increases the ratio of cellulosic structures, a cell wall component. The differences among the NDF ratios reported by different researchers may be due to the differences in the ecologies of research areas, as well as the harvesting during different maturity periods.

The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage (Surmen et al., 2011). As ADF increases, there is a decline in TDN which means that animals are not able to utilize the nutrients that are present in the forage (Aydin et al., 2010). The differences among the TDN values of the cultivars were found to be statistically significant in this research. The highest TDN values were obtained from Greengo (54.00%) and Nutri Honey (54.05%) cultivars. Sugar Graze II

(46.60%) and Rox (47.37%) cultivars had the lowest TDN values (Table 3).

The RFV is an index that is used to predict the intake and energy value of forages. This index is derived from the digestible dry matter (DDM) and dry matter intake (DMI). Forages with a RFV value of >151, 150-125, 124-103, 102-87, 86-75, and <75 are categorized as prime, premium, good, fair, poor and rejected, respectively (Lithourgidis et al., 2006). In this research, the highest RFV values were determined Greengo (100.56) and Nutri Honey (99.33) cultivars, while the lowest RFV value was found in Rox cultivar (87.14). The relative feed value is not a direct measure of the nutritional content of forage, but it is important for estimating the value of forage (Van Soest, 1982). Ozmen (2017) reported that RFV values of sorghum varied between 61.39 and 99.87 in Bingöl. Researcher stated that the highest RFV value was obtained from Greengo cultivar (99.87). These results are similar to our results. Canbolat (2012) reported that RFV values of sorghum varied between 105.8 and 138.7 in Bursa. These values are higher than our results.

4. Conclusion

In this study, the yield and quality components of sorghum and sorghum-sudangrass hybrid cultivars were determined in Uşak ecological condition. Greengo cultivar had higher herbage yield, hay yield, total digestible nutrient and relative feed values and lower ADF and NDF ratio than other cultivars. The results revealed that Greengo cultivar can be considered suitable for the Uşak and similar ecological conditions. In addition, the cultivation of sorghum and sorghum-sudangrass hybrid which will be helpful to meet the quality forage need should be increased. This trial should be repeated for at least one more year for the results to be more reliable.

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The Effects of Nitrogen and Vermicomposts Applied in Different Dosages and Combinations on the Triticale Silage (X *Triticosecale* Wittm.) Quality

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This research was conducted in 2019 and 2020 to determine the effects of different doses of nitrogenous and vermicompost on the quality of triticale in Erzurum arid conditions. In the experimental area, 5 doses of vermicompost (0, 2500, 5000, 7500 and 10000 kg ha $^{-1}$) and 4 doses of nitrogen (0, 40, 80 and 120 kg N ha $^{-1}$) were applied in combination in each block. The research was created with 3 replications according to the factorial arrangement in the Experimental Design of Randomized Complete Blocks. Dry matter ratio 38,30%-42,94%, crude protein rate 9.50%-12,28% by applying different amounts of nitrogen and vermicompost in silage triticale according to the findings obtained. ADF, NDF and RFV ratios varied between 22,44%-39,04%, 41,77-58,23%, 93,42-156,49%, respectively. While the pH of the triticale silage varied between 4,18-5,17, the physical evaluation quality class varied from low value to very good. When the results are evaluated as a whole, it comes to the forefront that vermicompost applications alone do not have a significant effect, especially in terms of the quality of silage, using 80 kg N ha^{-1} of nitrogen together with different doses of worm fertilizers of 2500, 5000, 7500 and 10000 kg ha^{-1}.

1. Introduction

For the advancement of animal husbandry in the Eastern Anatolia Region and to fulfill the need for quality roughage, silage is necessary. However, in the Eastern Anatolia region, corn plant that is a good silage plant under irrigated conditions has issues in terms of high altitude, low temperature, and noticeably short vegetation periods. For all these purposes, alternative products for corn plants should be considered in order to satisfy the watery and green feed requirements that are suitable for the winter of the animals in the area. Triticale, which does not have the competitiveness in irrigated agricultural areas with corn and clover plants, is an alternate forage plant, particularly in non-irrigated areas. The plant triticale, which was formed during the milky stage for the production of silage, was estimated to have a higher silage yield than the grains (wheat, rye, and barley) cultivated under

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certain conditions and to have a yield of 3-3,5 tons per decare (Geren and Ünsal, 2008).

The triticale (*xTriticosecale* Wittmack) which is produced by wheat and rye hybridization, typically produces more than 20 percent feed at an unfavorable environment and soil conditions relative to wheat, and its feed content is better than rye and wheat (Koch and Paisley, 2002). While the crude protein ratio in the grass of the triticale plant is 10,39%, the crude protein yield is 30 kg da^{-1} (Albayrak et al., 2004). Grain production takes place on 1,2 million hectares of agricultural land in the province of Eastern Anatolia and triticale is grown on only 1,34 thousand hectares of agricultural land in that region (Topal et al., 2015). To ensure sustained production in the triticale plant, it is important to provide an adequate quantity of nitrogen ingredients in the soil to recover nutrients that are omitted or washed and lost throughout crop harvesting. Different doses (0, 6, 4, 8, 9, 12, 15, 16, and 18 kg ha^{-1}) were used in studies on the amount of nitrogen fertilizer to be provided to the triticale plant and the optimal dose rate for the plant was calculated to be between 8 and 12 kg da^{-1} (Bali et al., 1991; Taşyürek et al., 1999; Üstünalp, 2010). It should be remembered, nevertheless, that the use of less nitrogen in fertilizers causes economic harm to farmers and the heavy use of fertilizers induces groundwater depletion and environmental issues.

Several unnecessary chemical fertilizers, which have been imported in recent years to feed the rising population of the world and our country, have triggered both nutritional and environmental problems. For this cause, in agriculture production, organic fertilizers have begun to be used rather than chemical fertilizers. Many organic compounds (humic and fulvic acid, compost, leonardite, etc.) and organic fertilizers including numerous varieties of microorganisms (algae and enzyme extracts, etc.) have begun to be produced in our country for this reason. Besides these fertilizers, vermicompost fertilizers are also commonly used for this purpose. Vermicompost strengthens the physical composition of the soil and enriches it with mineral substances such as N, P, Zn, K, Ca, Mn (Azarmi et al., 2008). Vermicomposts which are more effective in plant growth and development than barnyard manure (Atiyeh et al., 2000) are also beneficial in improving the physical properties of the soil.

From this point of view, the aim is to obtain high-quality triticale silage by assessing the required dose of worm and nitrogen fertilizer combinations to minimize the nitrogen dose to be applied.

2. Materials and Methods

The research was performed in 2019 and 2020 years in dry conditions in the experimental area of Atatürk University Plant Production, Application, and Research Center. In the research, high-yielding triticale (Umranhanim) variety, suitable for the climatic conditions of our region, was used (Karabulut and Çaçan, 2018). Ammonium sulphate containing 20-21% nitrogen and triple superphosphate fertilizer containing 43-44% P_2O_5 as chemical fertilizers in the trial were used and the solid vermicompost used in the experiment was purchased from a production company operating in Erzurum. The organic matter content of the vermicompost used in the study is 65,5%, total nitrogen 1,1%, total phosphorus 0,7% and water-soluble potassium content 1,5% and the pH level is 8,1. The experiment was performed in Erzurum province, which is situated in the area of Eastern Anatolia and has an altitude of 1,869 m. In Erzurum province, winters are cold and rainy while the summers are cool and dry.

The closest meteorology station to the research area is located in Erzurum city center. The mean scores of long-term overall precipitation, temperature, and relative humidity values are given in Table 1, as per the data obtained from this station.

The soil from the research area has the following features respectively; soil structure class is clayey-loamy, pH is 7,56, organic matter ratio is 1,01%, the lime ratio is 1,14%, while the phosphorus amount is 4,41 kg da^{-1} and the potassium amount are 171 kg da^{-1}. As a result, it was observed, according to the data collected, that the soils in the experimental area were mildly alkaline, calcareous, with low levels of suitable phosphorus and organic matter and moderate amounts of potassium suitable for use in plants (Özyazıcı et al., 2016). The research was created with 3 replications according to the factorial arrangement of the Randomized Complete Block Design (RCBD). In the experimental area, 5 doses of vermicompost (0, 2500, 5000, 7500 and 10000 kg ha^{-1}) and 4 doses of nitrogen (0, 40, 80, and 120 kg ha^{-1}) were applied in combination for each block. Besides, 80 kg ha^{-1} phosphorus (P_2O_5) fertilizer was provided to each parcel along with plating (Bozkurt et al., 2001). Inter-row planting was performed within 20 cm in the first half of September (Akkaya and Akten, 1990), the sizes of the planted parcel as follows: the length is 3 m, the width of the parcel is 1,6 m (8 row x 0,2 m) and the parcel area is 4,8 m^2. The planting frequency was planned as 400-450 seeds per m^2 and 20-22 kg of seeds per decare (Genç et al., 1989). Harvesting of triticale silage was carried out when the plants reached the dough stage (Can et al., 2004). The results obtained in the study were subjected to variance analysis according to the SPSS randomized complete block design and Duncan multiple comparison tests were used for determining the differences between the means (Yıldız and Bircan, 1994).

Table 1. Some climatic values of Erzurum province for 2019 and 2020 and long-term average

Months	Monthly Total Precipitation (mm)			Monthly Average Temperature (^{0}C)			Monthly Average Relative Humidity (%)		
	2019	2020	Long Term Average	2019	2020	Long Term Average	2019	2020	Long Term Average
January	13,9	2,8	17,9	-8	-8,8	-10,6	80	79,3	81
February	26,9	14,8	20	-8,4	-6,2	-8,2	84,9	78,3	80,5
March	24,7	46,2	34,3	-3,1	2,3	-0,9	79,3	77,1	74,4
April	68,9	49,2	58,6	4,2	5,5	5,8	73,4	65,4	67,8
May	63,8	118	70,6	11,9	10,9	10,5	60,3	61,1	67,2
June	23,6	34,6	45,1	17,8	15,7	14,9	57,2	55,6	61,5
July	3	30	22,3	19	19,8	19,5	49,4	51,6	53,5
August	11,6	-	18,8	20,3	-	19,9	46	-	49,6
September	28,4	-	20	14,5	-	14,5	51,7	-	52,5
October	11	-	56,9	9,8	-	8,1	56,3	-	67,8
November	14,8	-	25,3	0,1	-	0,4	65,9	-	75
December	23,2	-	19	-3,5	-	-7,2	85,8	-	81,5
Total/Avg	313,8	295,6	408,8	6,2	5,6	5,6	65,9	67,0	67,7

3. Results and Discussion

Dry matter and crude protein rates

The effect of nitrogen, vermicompost, and NxVC applications on dry matter rate was found to be significant at the level of 1% on triticale silage (Table 2). In the study, the dry matter rate in nitrogen applications varied between 40,35-41,88%, while the dry matter rate in vermicompost applications varied between 39,87-42,00% (Table 2).

Based on the variance analysis, the different doses of nitrogen and vermicompost at crude protein levels were statistically effective at 1%, whereas the NxVC interaction was considered to be insignificant.

Since the dry matter content of the silage products should be between 30 and 40% (Bolsen, 1995), the dry matter content of the silage produced increased to quite good values, particularly for different applications of vermicompost. The dry matter ratio (Arslanoğlu et al., 2006), which varies based on the substance used and the environmental factors, was significantly increased due to low doses of nitrogen (0,4 and 8 kg da^{-1}) and high doses of vermicompost. This condition may have affected the nitrogen efficiency of the vermicompost applied in high doses in terms of increasing the dry matter ratio. However, this situation, which arises in terms of the effect of different fertilizer combinations on the dry matter rate showed similarities with the study of Kmeťová et al., (2013). Also, several other studies (Naher, 1999; Stalin and Enzamann, 1990; Gutiérrez-Miceli et al., 2007) have noted that nitrogen and vermicompost applications positively affect the dry matter rate. In the study, NxVC interaction was also statistically significant on the dry matter rate. When we look at this result considering the dry matter rate, it probably stems from the applied nitrogen and vermicompost contents that are increasing the efficiency of each other (Figure 1).

Nitrogen, which is the most missing nutrient in agricultural systems, is completely adequate to achieve optimum yield and sufficient protein content from plants. The triticale plant, which is part of the grain community during its growth phase, needs adequate nitrogen compounds to be present in the soil (Mehrotra et al., 1967). It was determined that nitrogen and vermicompost added at different doses resulted in a substantial increase in the crude protein content of the triticale silage. Since vermicomposts contain more nitrate which is one of the important forms of nitrogen (Atiyeh et al., 2000) this may have increased the nitrogen content in the plant. As a matter of fact, these results obtained in terms of crude protein rate were found to be similar to the results of many studies (Domska et al.; 2006; Çelebi et al., 2009; Takıl ve Olgun, 2020) in which different nitrogen and vermicompost doses were applied.

Table 2. Variance analysis results of dry matter and crude protein content in triticale silage where separate doses of nitrogen and vermicompost were implemented

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1})					Mean
	Dry Matter Rate (%)					
	0	2500	5000	7500	10000	
0	40,44	41,51	41,80	41,86	42,08	41,54 A
40	38,30	41,54	41,90	42,25	42,45	41,28 A
80	39,83	41,48	42,32	42,83	42,94	41,88 A
120	40,90	40,02	39,60	40,73	40,50	40,35 B
Mean	39,87 C	41,14 B	41,41 AB	41,92 A	42,00 A	41,27
F values: N: 8,763 *, VC: 11,970 **, NxVC: 3,153 **, ** Those marked with capital letters are significant at the 0.01 level.						
	Crude Protein Rate (%)					
0	9,50	10,77	10,81	11,12	11,29	10,70 B
40	11,02	11,22	11,47	11,51	11,31	11,31 AB
80	11,37	11,64	11,94	12,24	12,28	11,90 A
120	10,46	10,67	10,84	10,99	11,49	10,89 B
Mean	10,59 B	11,08 AB	11,27 AB	11,47 A	11,59 A	11,2

F values: N: 13,851 **, VC: 6,084 **, NxVC: 4,563 ns, **Those marked with capital letters are significant at the 0.01 level. ns: not significant.

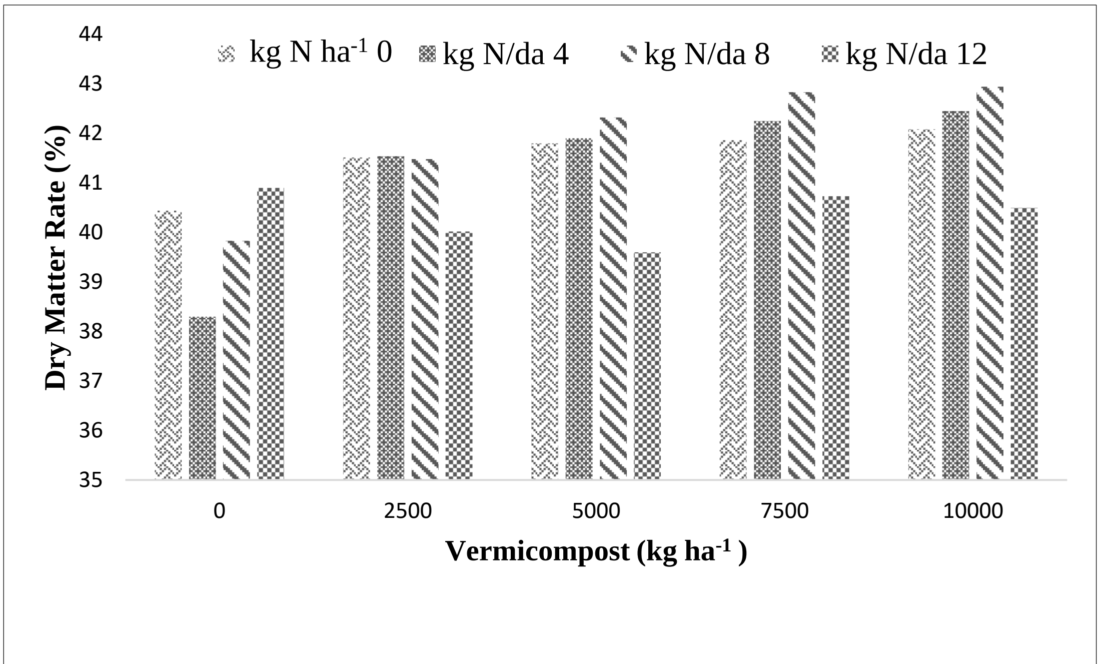

Figure 1. The effect of nitrogen x vermicompost interaction on dry matter ratio

NDF and ADF rates

While the effect of the different nitrogen doses added to the NDF and ADF ratios of triticale silage was statistically differed at a 1% significance level, the effect of the different vermicompost doses varied at a 5% significance level. Besides, the interactions of NDF and ADF rates were statistically insignificant (Table 3).

Table 3. ADF and ADF ratios in triticale silage where various doses of nitrogen and vermicompost were implemented

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1}) NDF Rate (%)					Mean
	0	2500	5000	7500	10000	
0	58,23	57,17	56,24	55,29	55,18	56,42 A
40	53,54	52,35	51,01	50,05	50,72	51,53 B
80	47,39	44,84	43,96	42,89	41,77	44,17 C
120	43,96	45,00	45,30	44,31	43,48	44,41 C
Mean	50,78 a	49,84 b	49,13 b	48,13 b	47,79 b	49,13
F values: N: 97,063 **, VC: 3,304 *, NxVC: 0,501 ns, * The mean scores marked with a lowercase letter are significant at the 0.05 level, ** Those marked with a capital letter are significant at the level of 0.01. ns: not significant.						
	ADF Rate (%)					
0	39,04	38,41	37,44	37,30	37,14	37,87 A
40	36,51	33,22	32,22	31,14	31,54	32,93 B
80	28,75	27,22	26,98	25,76	24,31	26,60 C
120	22,70	23,23	23,69	23,27	22,44	23,07 D
Mean	31,75 a	30,52 ab	30,08 ab	29,37 b	28,85 b	30,12

F values: N: 115,370 **, VC: 2,657 *, NxVC: 0,595 ns, * The mean scores marked with lowercase letters are significant at 0.05 level, ** Those marked with capital letters are significant at the level of 0.01 ns: not significant.

It was determined that according to nitrogen and vermicompost content applied in different doses, the NDF rates varied between 44,17% -56,42% and 47,79% -50,78%, respectively, while ADF rates varied between 23,07% and 37,87%, respectively. The ratios of NDF and ADF (Rayburn 2004), an essential cell wall part, vary depending on plant development, leaf/stem ratio, and distinct cultural processes (Lacefield et al., 1999; Ball et al., 2001). In the study, NDF and ADF ratios showed a tendency to decrease due to the increase in nitrogen and vermicompost doses. In particular, low NDF and ADF rates (Budak and Budak, 2014), which are significant quality factors, have been reported to have decreased with increasing fertilizers in studies conducted in various plants (Türk et al., 2019; Atalay and Ateş, 2020; Tobay, 2020).

Relative Feed Value (RFV) and pH

While the relative feed value of triticale silage in the samples taken was statistically very significant (P<0,01) in terms of different nitrogen applications, it showed a significant difference (P<0,05) in different vermicompost applications. In the study, it was determined that different nitrogen and vermicompost combinations do not have a significant effect on the relative feed value of triticale silage (Table 3).

The ADF and NDF values are used in the estimation of the relative feed value and the results of the research showed that the highest NYD value of 156,49 was obtained from the application of 80 kg N + 10000 kg of vermicompost per decare, while the lowest NYD value of 93,42 was observed with the control parcel.

Whereas the various nitrogen dosage applications in the study had a statistically significant effect (P <0.01) on the pH values of triticale considered to be silage, the interaction between the different vermicompost and NxVC did not have a significant effect (Table 3). While pH values of nitrogen varied between 4,32 and 5,03 at 0, 40, 80 and 120 kg ha^{-1}respectively, the pH values of vermicompost varied between 4,50 and 4,72 at 0, 2500, 5000, 7500 and 10000 kg doses.

Research has shown that nitrogen and vermicomposts have induced a decrease in the rate of ADF and NDF of triticale and an increase in the rate of crude protein and NYD, and this case can imply that the nitrogen and vermicomposts applied had a positive impact on the quality of triticale silage. The NYD value, which is agreed as 100 based on the clover plant, increased in parcels where separate doses of nitrogen and vermicompost were used in the study. In terms of relative feed value, this condition has led to an increase in quality as it is above 100 which was also reported by Richardson (2001). Several studies (Demirel ,2016; Türk and Alagöz, 2019; Ertekin et al., 2020) support this situation.

According to the results, nitrogen fertilizer applications caused a significant decrease in pH values. As it happens, previous studies (Kandi et al., 2011; Salehi et al., 2015) that indicate fertilizers provided to plants in certain amounts increase the soluble sugar ratio in the plant, and this, in turn, causes the pH of the soil to decrease (Sadigfard, 2016) confirms the results of our research.

Table 3. RFV and pH values in triticale silage treated with different doses of nitrogen and vermicompost

Nitrogen doses (kg N ha^{-1})	Vermicompost (kg ha^{-1}) RFV Rate (%)					Mean
	0	2500	5000	7500	10000	
0	93,42	95,97	98,78	100,65	101,07	97,98 C
40	105,13	111,97	116,35	120,33	117,95	114,35 B
80	130,67	140,53	143,92	149,95	156,49	144,31 A
120	151,08	148,87	144,61	148,58	152,98	149,23 A
Mean	120,08 b	124,34 ab	125,92 ab	129,88 a	132,12 a	126,47

F values: N: 115,403 **, VC: 3,445 *, NxVC: 0,649 ns, * The mean scores marked with lowercase letters are significant at 0.05 level, ** Those marked with capital letters are significant at the level of 0.01. ns: not significant.

	pH					
0	5,17	5,12	5,10	4,89	4,85	5,03 A
40	4,79	4,73	4,73	4,58	4,65	4,69 B
80	4,52	4,42	4,25	4,18	4,22	4,32 C
120	4,40	4,37	4,39	4,36	4,38	4,38 C
Mean	4,72	4,66	4,62	4,50	4,53	4,61

F values: N: 16,264 **, VC: 1,033 ns, NxVC: 0,160 ns, ** Those marked with capital letters are significant at the 0,01 level. ns: not significant.

Physical Quality Features

We have determined that the color, structure, and smell characteristics of triticale used as silage varied between 1-2, 3-4, and 5-14, respectively**.** As a result of the physical evaluation, while the highest scores were obtained from the parcels where 8 kg N + 0 and 250 kg vermicompost per decare and 12 kg N + 750 and 1000 kg vermicompost per decare were applied**,** the lowest scores were obtained from parcels with no nitrogen application + 0 kg N and 250 kg vermicompost. That is being said, there is no absolute homogeneity between the physical properties in Table 4, which are subject to physical assessment following the tests made in the study.

Table 4. Evaluation of the physical quality features of triticale silage applied with different doses of nitrogen and vermicompost

Nitrogen (kg N ha^{-1})	Vermicompost (kg ha^{-1})	Color	Structure	Smell	Total	Quality class
0	0	1	3	5	9	Poor
	2500	2	3	9	14	Good
	7500	2	4	11	17	Good
	10000	2	4	12	18	Very Good
40	0	1	3	13	17	Good
	2500	1	4	11	16	Good
	7500	2	3	13	18	Very Good
	10000	2	4	12	18	Very Good
80	0	1	4	14	19	Very Good
	2500	2	4	13	19	Very Good
	7500	2	4	11	17	Good
	10000	2	4	12	18	Very Good
120	0	1	3	13	17	Good
	2500	2	3	13	18	Very Good
	7500	2	4	13	19	Very Good
	10000	2	4	13	19	Very Good

When all results are analyzed together, the various doses of vermicomposts used for environmental degradation and sustainable agriculture have both positively impacted the measured properties of triticale, which is generally deemed as silage and has a beneficial impact on the reduction of the nitrogen dose used. The results suggest that it would be more appropriate to use an 80 kg ha^{-1} dose of nitrogen used together with different doses of 2500, 5000, and 7500, and 10000 kg of vermicompost. It will, however, be more useful to carry out a study for another year to provide more accurate and comprehensive guidance on this.

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Research

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Determination of Landscapable Plants That Can Be Used For Recreation in Pasture Areas of Şenyurt Village of Tortum District of Erzurum Province

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A B S T R A C T

Pastures are important natural resources in terms of hosting different plant communities, animal feeding, erosion control and providing many benefits to human beings in different areas, especially in terms of being the gene source of many plants in natural balance. As a result of the developing world and the policies implemented, these resources have reached the point of rapid depletion. In order to preserve, develop and, above all, manage these natural resources and the characteristics of the plant species they contain must be identified. For this purpose, the field studies make it possible to identify the plant species that can be used for recreation. With this project, data of different plant species were collected and determined whether they carry landscape value or not. This study was conducted in 2019. During the project, a field survey was conducted in the designated area and a database was created for the plants with annual, biennial or perennial with landscape value at least once a month for five months (April-August) during the season. In this study, a total 80 different plant species were found and 41 of them could be used in the landscaping and their usage in the landscape planning were determined.

1. Introduction

Pasture areas reach 3.5 billion ha on the earth's surface. Pasture areas in the world correspond to 27% of the world's land and 72% of the total agricultural land (Anonymous 2006). Although pastures are natural resources that provide benefits to humanity in many different areas from feeding livestock to erosion control, they also have the characteristic of being the gene source of many different plants (Çomaklı and Menteşe 1999; Çomaklı 2001; Dumlu 2010). Pastures are not only cost-effective roughage resources, but also a strategic area in terms of recreation, biological wealth, erosion control, protection of wildlife, development and protection of water resources (Gökkuş and Koç 2001).

Planting works constitute an important part of landscape architecture studies. In the article published Dönmez et al., (2016) stated that the environmental demands of the plant material to be used in landscape planning should also be taken into account. Likewise, the natural style landscape design approach, in which the diversity of species, uniform arrangements are minimized, natural

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elements and species are used in high proportions and exotic species and artificial elements are used in minimum amounts, are brought to the fore by many modern landscape designers and planners (Özgüner 2001).

In landscaping studies, it is desirable that the plant material used should be at high quality and should have high adaptability to the ecological conditions of the region in order to make the facility and maintenance costs economical (Korkut et al., 2017). Yazgan et al., (2005) stated that all plants in nature could be used as ornamental plants. With this understanding, many plant species expected to be used as ornamental plants in our country.

With the increasing interest in solving ecological problems and the increasing interest in environmental issues, the importance of the use of natural plant species in landscaping works gradually increases, and the use of natural plants that do not require much care in modern landscape works gains importance (Deniz and Şirin 2005). In design studies, especially in landscaping where the use of water is essential due to vegetative plantation, the current that regulates the design rules that minimizes the use of water was defined as "Xeriscape" (Welsh 2000; Wilson and Feucht 2007).

Yılmaz (2009), in his study on the aesthetic and functional examination of the plant species that grow spontaneously (native) on the slopes on the Erzurum-Uzundere highway, emphasized the need for culture and reproduction of the determined plant species in provinces with similar environmental conditions. As a result, in this study, it was determined as the main target to determine the naturally growing single or perennial plants that are thought to represent Erzurum province due to their different altitude values, which are found in the pasture areas of Şenyurt village and have landscape value.

2. Materials and Methods

Turkey is located between the northern latitudes (northern hemisphere 260 – 450 east longitude 360 – 420). Our country, which is geographically divided into seven regions, Erzurum province, which is our study area, is located in the Eastern Anatolia Region of Turkey. The city of Erzurum in the northeast of the Eastern Anatolia Region is located between 39°54′35″ north latitudes and 41°16′32″ east longitudes. Tortum District and Şenyurt Village, on the other hand, are located in the "Georgian Strait" area with its historical name, which connects Erzurum to Artvin and Rize in the north of the province. The city of Erzurum covers an area of approximately 25 066 km² and the city center is 1959 m above sea level. More than 60% of the urban land consists of meadows and pastures. Although some parts of this natural vegetation have become unproductive with rattleweed (wild liquor ice) communities, there are fertile pastures suitable for pasture livestock in large areas (Figure 1).

The study was conducted in Erzurum province Tortum district Şenyurt village pasture areas, where such a study was not conducted before, at approximately 31,259 da. Depending on the development period of the plants in the area, a pasture scan was carried out during April - August in 2019.

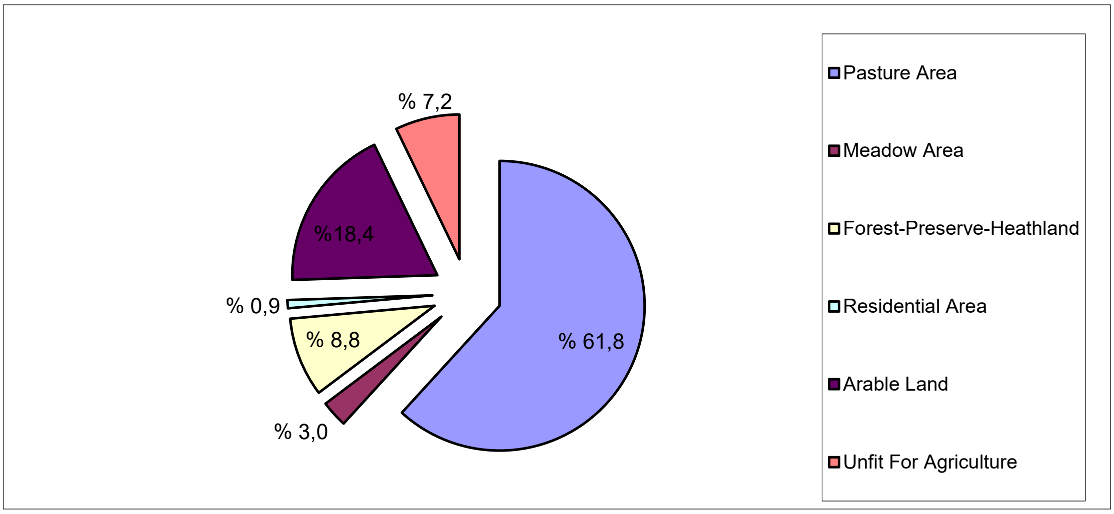

Figure 1. Erzurum Province land distribution.

The research area is located at an altitude ranging from 1250 meters to 2100 meters (Figure 2). In this area, tree formation is formed in places where ecological conditions and vegetation period are suitable, while grass formation has developed densely in places where there is less rainfall and high evaporation with temperature. On the other hand, due to the misuse and excessive use of vegetation over time (cutting, burning, grazing and cultivation) and climate factors, forest areas have been replaced by bush communities and invasive species. Rattleweeds, which have become dominant in this deteriorating structure, are known to be drought-resistant with deep root systems and as the last plants and soil holders of vegetation.

Plants with landscape value that can be used in urban spaces were determined and recorded. In the selection of plants to be used in landscape studies, the criteria should consist some features such as plant form, leaf beauty, flower beauty, fruit beauty (Irmak 2008; Özhatay 2009). The photographs of the plants that may have landscape value were taken and the coordinates of the points they were determined and recorded via GPS. Marking was made on the map with the help of the coordinates taken in the field studies. Information was given on the life span (single-perennial), habitus (vertical-leaning, herbaceous-woody), natural habitat and landscape characteristics of the identified landscape plants (Irmak and Yılmaz 2016a).

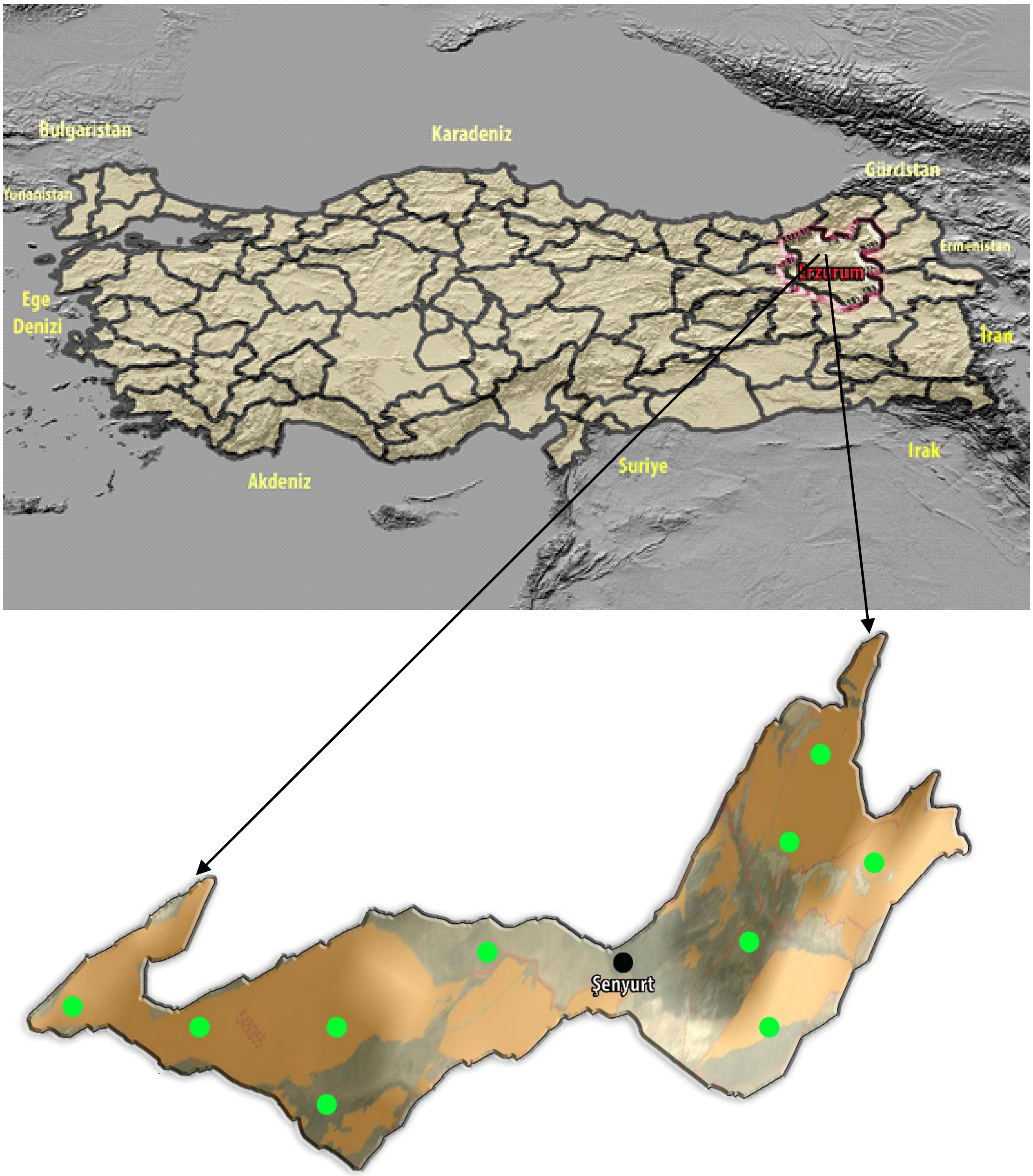

Figure 2. Şenyurt village satellite view and operating points

Study Area

Field work started in April 2019. At least once a month during the year, a field survey was conducted in the area and the necessary information was collected. Village pasture area is 31,259.5 da. and expressed as 18 different parcels in the records of the Provincial Directorate of Agriculture and Forestry (Figure 3). Our field studies have been carried out in this area and plants that can be used in landscaping have been identified in ten (10) different pasture plots of eighteen (18) studied.

The pasture area consists of wide plains and it is surrounded by the mountains (Figure 4). The farmers are using this area to graze their animals.

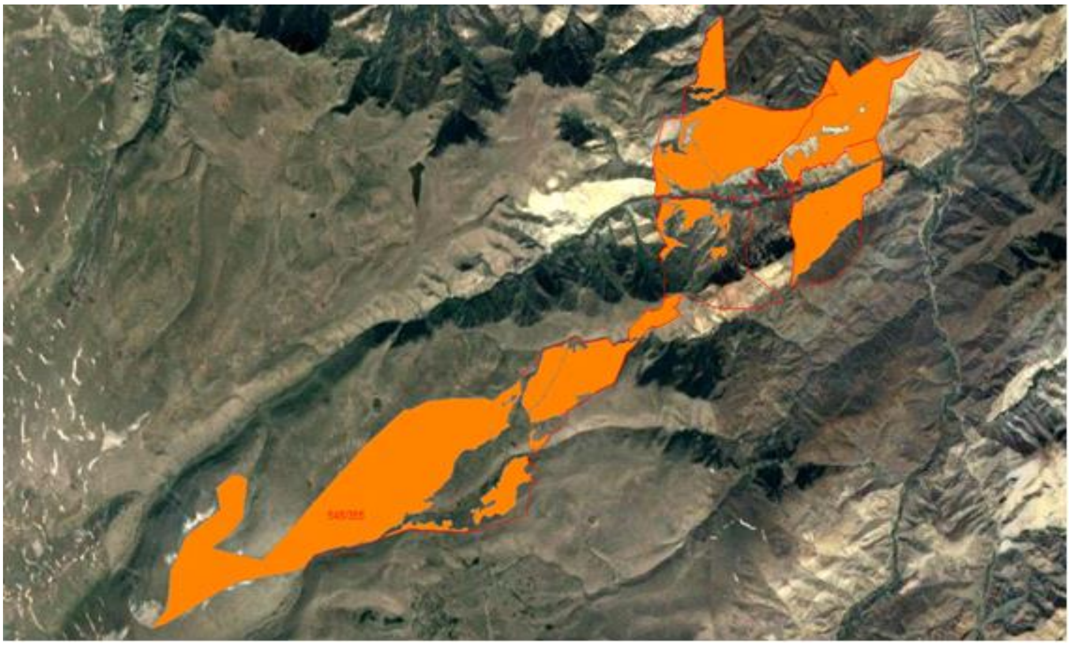

Figure 3. Şenyurt village pasture plots

Figure 4. Wide plains and mountain ranges in the plateau area.

Livestock grazing were identified in the plateau part of the pasture area. Plants considered to have landscape value were found and identified in these areas (Figure 5).

During these studies, dialogue with the farmers was initiated and information was obtained on their daily lives, how they make use of pasture and how they evaluate the plants that are not consumed by animals but have landscape value.


Viola altaica


Hypericum hyssopifolium


Ajuga orientalis


Juniperus communis


Coronilla orientalis


Erigeron caucasicus

Figure 5. Some landscape plants found in field work

3. Results

As a result of the studies, the plants that can be used in landscape planning have been identified (Table 1).

Table 1. Species identified in the study and their families

Sequence No	Plant Species Name	Family Name
1	*Ajuga orientalis*	Lamiaceae
2	*Alcea calverti*	Malvaceae
3	*Alchemilla caucasica*	Rosaceae
4	*Anthemis tinctoria*	Asteraceae (Compositae)
5	*Arabis caucasica*	Brassicaceae (Cruciferae)
6	*Artemisia splendes*	Asteraceae (Compositae)
7	*Astragalus fragrans*	Fabaceae (Leguminosae)
8	*Caltha polypetala*	Ranunculaceae
9	*Campanula strica*	Campanulaceae

10	*Cerastium banaticum*	Caryophyllaceae
11	*Chenopodium foliosum*	Chenopodiaceae
12	*Coronilla orientalis*	Fabaceae (Leguminosae)
13	*Coronilla varia*	Fabaceae (Leguminosae)
14	*Daphne oleides*	Thymeleaceae
15	*Erigeron caucasicus*	Asteraceae (Compositae)
16	*Euphorbia virgata*	Euphorbiaceae
17	*Festuca ovina*	Poaceae
18	*Gagea luteoides*	Liliaceae
19	*Crocus vallicola*	İridaceae
20	*Gentiana flavida*	Gentianaceae
21	*Glaucium leiocarpum*	Papaveraceae
22	*Helichrysum arenarium*	Asteraceae (Compositae)
23	*Hyoschyamus niger*	Solanaceae
24	*Hypericum elongatum*	Clusiaceae (Guttiferae)
25	*Juniperus communis*	Cupressaceae
26	*Malva neglecta*	Malvaceae
27	*Muscari armeniacum*	Liliaceae
28	*Myosotis alpestris*	Boraginaceae
29	*Onobrychis cornuta*	Fabaceae (Leguminosae)
30	*Papaver orientale*	Papaveraceae
31	*Polygala major*	Polygalaceae
32	*Potentilla astracanica*	Rosaceae
33	*Primula veris*	Primulaceae
34	*Rosa canina*	Rosaceae
35	*Scilla siberica*	Liliaceae
36	*Sedum spurium*	Crassulaceae
37	*Stipa pulcherrima*	Poaceae
38	*Thymus praecox*	Lamiaceae (Labiatae)
39	*Tussilago farfara*	Asteraceae (Compositae)
40	*Viola altaica*	Violaceae
41	*Xeranthemum annuum*	Asteraceae (Compositae)

Out of the 80 species 41 species are identified in the field studies belong to 25 different families. 6 species from Asteraceae family, 4 species from Fabaceae family, 3 species from Liliaceae and Rosaceae families were determined (Table 2).

Table 2. Numbers of species in families.

Sequence No	Family Name	Numbers of Species
1	Asteraceae (Compositae)	6
2	Boraginaceae	1
3	Brassicaceae (Cruciferae)	1
4	Campanulaceae	1
5	Caryophyllaceae	1
6	Chenopodiaceae	1
7	Clusiaceae (Guttiferae)	1
8	Crassulaceae	1
9	Cupressaceae	1
10	Euphorbiaceae	1
11	Fabaceae (Leguminosae)	4
12	Gentianaceae	1
13	İridaceae	1
14	Lamiaceae (Labiatae)	2
15	Liliaceae	3
16	Malvaceae	2

17	Papaveraceae	2
18	Poaceae	2
19	Polygalaceae	1
20	Primulaceae	1
21	Ranunculaceae	1
22	Rosaceae	3
23	Solanaceae	1
24	Thymeleaceae	1
25	Violaceae	1

Researchers named Irmak 2008 and Özhatay 2009 have taken into consideration criteria such as leaf beauty, flower beauty, and form beauty in determining the plant species that can be used in the landscape. In this study, the project team scored the plants according to the determined criteria. Landscape values table of the plants that grow naturally in the research area on the basis of species is presented (Table 3).

Table 3. Landscape values of the plants identified over the species.

Plant Name	**Landscape Value**			
	Form Beauty	**Leaf Beauty**	**Fruit Beauty**	**Flower Beauty**
Ajuga orientalis	+	+		+
Alcea calverti	+	+		+
Alchemilla caucasica	+	+		+
Anthemis tinctoria	+			+
Arabis caucasica	+	+		+
Artemisia splendes	+	+		
Astragalus fragrans	+	+		+
Caltha polypetala	+	+		+
Campanula strica	+	+		+
Cerastium banaticum	+	+		+
Chenopodium foliosum	+	+	+	
Coronilla orientalis	+	+		+
Coronilla varia	+	+		+
Daphne oleides	+	+	+	
Erigeron caucasicus	+			+
Euphorbia virgata	+	+		+
Festuca ovina	+	+		
Gagea luteoides	+			+
Crocus vallicola		+		+
Gentiana flavida	+	+		+
Glaucium leiocarpum	+	+	+	+
Helichrysum arenarium	+			+
Hyoschyamus niger	+	+		+
Hypericum elongatum	+			+
Juniperus communis	+	+	+	
Malva neglecta	+	+		
Muscari armeniacum	+	+		+
Myosotis alpestris	+	+		+
Onobrychis cornuta	+	+		+

Papaver orientale	+	+	+	+
Polygala majör	+			+
Potentilla astracanica	+	+		
Primula veriş	+			+
Rosa canina	+		+	+
Scilla siberica	+	+		+
Sedum spurium	+	+		+
Stipa pulcherrima	+	+		+
Thymus praecox	+	+		+
Tussilago farfara	+			+
Viola altaica	+			+
Xeranthemum annuum	+			+

As a result of the investigations carried out in 2019 in the pasture areas of Şenyurt Village of Tortum District, 41 species belonging to 25 different families were identified. The studies were carried out in the form of field scans made in the aforementioned area during April - August during the year as envisaged in the project. During each visit, land scans were made in different pasture sections and plants thought to have landscape value that could be used for recreational purposes were identified.

During the study, the pasture area was scanned two (2) times a month, and these scans were carried out from low altitude (1714 m.) to high altitude (2366 m.) sections. As a result, in ten (10) of the 18 pasture parcels, 41 species from 25 different families were found to have landscape value. The number of species identified in different pasture sections and different altitudes is given in Table 4.

Table 4. The number of species found in different pasture areas.

Pasture Parcel	Altitude (m)	Number of Species (Pieces)
1	1714	3
2	1801	4
3	1826	5
4	1966	3
5	2075	4
6	2128	4
7	2135	5
8	2241	4
9	2360	5
10	2366	4
TOTAL		41

4. Discussion

Many arrangements are made both indoors and outdoors in the world and in our country, and different plant groups are used in these arrangements. However, the development, maintenance and cost of maintenance labor of the plants used in the arrangements are not sufficiently examined. It is quite common to use mostly foreign origin (exotic) plants with limited adaptation and high annual maintenance costs in landscape arrangements (Irmak and Yılmaz 2016). However, instead of these plants, the use of plants that require less maintenance and are suitable for the ecological conditions of the landscaped area in terms of water and soil requirements will reduce both the project cost and post-project maintenance costs.

The biggest deficiency observed in landscape planning and vegetative plantation studies in urban and rural areas is that the natural vegetation potential is not used sufficiently in the selection of herbaceous and woody plant species (Irmak 2016). With this project, it was aimed to identify naturally grown plant species that can be used in our city and other regions with similar ecological conditions, with relatively low maintenance costs.

According to the results of the research, *Juniperus communis*, *Rosa canina*, *Daphne oleides*, *Onobrychis cornuta* and *Thymus praecox* species in bush form can easily be used for area limitation in landscaping. Again, with these plants, attractive plant curtains can be created. It is possible to create visual effects in herbal application, especially with *Juniperus communis,* which preserves its green appearance in all seasons. Zencirkıran M. (2009) stated in his study of determination of native woody landscape plants in Bursa and Uludağ, that these plants can be used in landscape applications.

Arabis caucasica, Cerastium banaticum, Astragalus fragans, Chenopodium foliosum, Coronilla orientalis, Coronilla varia, Festuca ovina and *Stipa pulcherrima* can be considered as ground cover and soil protector in sloping areas. Among these plants, *Festuca ovina* type, which is relatively resistant to frequent cutting and chewing, can be used in grass mixtures.

In landscape planning, *Crocus vallicola, Gagea luteoides, Muscari armeniacum, Scilla siberica* species can take place in geophyte gardens. On the other hand, *Alchemilla caucasica, Potentilla astracanica, Artemisia splendes, Sedum spurium, Malva neglecta* species can be used both as ground cover plants and in rock gardens. Some work has been carried out by researchers from various regions of Turkey. Especially Tutu et al., (2019), Dönmez et al., (2016), Ekici (2010), Deniz and Uğur (2005), and Eroğlu (2015) found similar results in their studies.

As a result; In the coming years, it will be appropriate to research the possibilities of the plants identified within the scope of this study to be taken into culture and to investigate their usage areas in landscape planning.

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Review

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Nitrogen Requirement of Italian Ryegrass (*Lolium multiflorum*): A Review

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A B S T R A C T

Nitrogen is an essential nutrient for ryegrass but excess of it may lead to accumulation of nitrate in plants which may be lethal for ruminants. Irrigation, seed rate, variety, quality, cutting time and frequency, location altitude and fertilizer types were selected as variable in this review, which were selected to see the response of Italian ryegrass to different nitrogen doses. A series of comments were also mentioned in the conclusion part of this article to improve future studies in this area.

1. Introduction

Italian ryegrass (*Lolium multiflorum* Lam.) is a rough forage crop which is widely cultivated in cool and temperate regions for its high productivity and digestibility. Nitrogen (N) is an essential nutrient for ryegrass growth but excessive N fertilizers may lead to over accumulation of nitrate-N in plants, which may be lethal for ruminants (Tan et al., 2021). Italian ryegrass has high production capacity and feed quality under N fertilization (Rechițean et al., 2018). This crop is often fertilized with high levels of N to increase dry matter (DM) yields. High amount of N application increases the N content in herbage (De Villiers and Van Ryssen, 2001).

A study was conducted to determine whether N content of Italian ryegrass affects the performance of South African Merino lambs. 100, 200, 400, 600 or 800 kg N ha^{-1} were applied to the pastures. N fertilization increased the total N and nitrate-N and decreased non-structural carbohydrate concentrations in the plants. Rumen ammonia-N concentration increased with increasing N concentration in twelve and four-month-old lambs. A quadratic relationship was observed between N content and DM intake of twelve-month-old lambs, while a negative linear relationship was observed for four-month-old lambs. A quadratic relationship was observed between the N content of ryegrass and average daily gain for lambs of both age groups. The equations Show potentially negative effects of high concentrations of N and nitrate-N on intake and growth rate of lambs (De Villiers and Van Ryssen, 2001).

Italian ryegrass parcels were received three irrigation applications at field capacity 1) once

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every two weeks, 2) once a week, 3) twice a week in the study of Abraha et al., (2015). Also three N levels were applied for topdressing after each harvest 1) at a rate of 0 kg N h^{-1} cycle−1, 2) at a rate of 30 kg N h^{-1} cycle−1, 3) at a rate of 60 kg N h^{-1} cycle−1. Yields were increased with the amount of water and N fertilizer applied. DM content, in vitro organic matter digestibility (IVOMD), crude protein (CP) and metabolisable energy (ME) increase with the irrigation application once every two weeks. With high N application, higher irrigation levels significantly increased DM yield, while water stress improved to some extent pasture quality by increasing DM content, IVOMD, CP and ME values.

3 different seed ratios (10, 15 and 20 kg ha^{-1}) and 4 different nitrogen levels (0, 30, 60 and 90 kg N ha^{-1}) in *Lolium multiflorum* had been tested in a study conducted by Bora et al. (2020) in India. Seed rates and N levels significantly affected the quality values of Italian grass. 20 kg ha^{-1} seed rate was superior for quality at all (three) cuts. Highest CP yield was obtained with 20 kg ha^{-1} seed rate. CP content, crude fat content, crude fiber content of the ryegrass were also significantly higher at seed rate of 20 kg ha^{-1}. 90 kg N ha^{-1} application resulted with higher quality parameters. Highest CP yield was obtained by 90 kg N ha^{-1} application. The crude protein content, crude fat content, crude fiber content of the ryegrass were significantly higher at 90 kg N ha^{-1} application.

Eckard et al. (1995) established annual ryegrass (variety Midmar) pastures on three locations for a period of four years (1987-1990). N fertilizer was topdressed at 0, 200, 300 or 400 kg N ha^{-1} y−1 and at intervals of 4 or 6 weeks. DM yield indicates a little benefit from applying more than 40 kg N ha−1 per application in autumn, and exceeding 50 kg N ha^{-1} per application the doses during spring. Pastures fertilized every 4 weeks at the above rates produced equal or higher yields than pastures fertilized at 6-week intervals.

Three sources of N fertilizer (urea, limestone ammonium nitrate (LAN) and ammonium sulphate) showed no consistent significant trends in terms of the dry matter yield and nitrogen or nitrate-N content of *Lolium multiflorum*. Ammonium sulphate acidified the soil clearly, while LAN was the least acidifier (Eckard, 1990).

N fertilizer application levels of 0, 150, 300 and 450kg N ha^{-1} were applied in combination with different defoliation intervals (every 2, 4, 6 and 8 weeks and twice a season) to by Theron and Snyman (2004), to observe the digestibility and fiber component of *L. multiflorum* cv. Midmar. Organic Matter Digestibility (OMD), NDF and ADF significantly changed by levels of N, defoliation intervals and the interactions of these two factors. N dozes were less effected OMD, NDF and ADF than defoliation interval due to influence of defoliation interval on plant growth stage and maturity than N level. OMD decreased with increasing N levels and lengthening of the defoliation interval. Defoliation interval being 4 weeks or less due to the increase in N levels resulted in a decrease in ADF and NDF content.

In a study of Hides (1978), four Italian ryegrass varieties with different origin and winter hardiness were grown at lowland and an upland location to subject to two N levels and five autumn cutting treatments. Winter kill was increased by increasing levels of N fertilizer and by late or frequent autumn defoliations.

Sunaga et al. (2006) were developed a simple technique to estimate the nitrate (NO_3) N concentration of Italian ryegrass crop under field conditions. Using a hand-held chlorophyll meter (SPAD-502) at the heading stage is a rapid method for estimating the NO_3-N concentration in the crop to feed cattle safely and to escape high levels of nitrate and poisoning of ruminants. SPAD readings increased with increasing NO_3-N concentrations. However, the relationship was not a linear curve. A critical value for the SPAD reading was 47 for a NO_3-N concentration of 2.0 g kg^{-1} DM, a critical value for the acute nitrate poisoning of ruminants.

In a study of Casals et al. (2007), the effects of different levels of N on seed yield and yield components of Italian ryegrass were assessed in three locations (two in France and one in Belgium), during three growing seasons (1998 to 2000). N rates was from 40 to 130 kg N ha^{-1}, with a reference zero N treatment. A good relationship between N level uptake at ear emergence and seed yield was observed with a maximum yield obtained at about 110 kg ha^{-1} N uptake. Soil born nitrogen, measured by N uptake at ear emergence on non-fertilized treatments, varied from 25 to 75 kg ha^{-1} between trials. Results show that the estimation of soil born nitrogen is necessary for the calculation of N supply.

In Brazil, at four years (2013, 2014, 2015 and 2016), four harvest times and seven N doses (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) application on natural re-sown ryegrass, use of N as topdressing showed little effect on the persistence of ryegrass plants in the four years of study. The efficiency of N utilization was inversely proportional to the increment of the nitrogen doses used (Silveira et al., 2020).

A two year field experiment with diploid (cv. Tur) and tetraploid (cv. Kroto) Italian ryegrass were carried out differentiation of N fertilization and cutting frequency by Koter and Krawczyk (1981). Highest green matter yields were obtained from the five-fold cutting treatment with 30-35 days cut intervals at the earing stage. The highest yields of DM were obtained from 4 and 5 cuts during the season with 35-40 days cut intervals at full earing or at the beginning of anthesis. N application at 80 kg ha cut^{-1} (400 kg ha year^{-1}) optimized the yields of DM in the high frequency cutting treatments (intervals of 25-30 days). The tetraploid variety of ryegrass produced higher yields of green matter compared to diploid variety.

A study was conducted to investigate the optimum N fertilizer amount for the green forage production of Italian ryegrass in Korea in 1987 and 1988. Three levels of N fertilizer were applied (4, 8 and 12 kg N ha^{-1}). Green yield and nitrate content of green forage were observed at three cuttings (April 30, May 20 and June 10). Yield of green forage at all cutting times were highest at highest dose of N and lowest at lowest dose of N application. Nitrate content in the green forage at all cutting times was high with increasing amount of nitrogen fertilizer and with decreasing ratio of K/(Ca+Mg) in green forage (Lee et al., 1990).

Türk et al. (2019) conducted a study with three annual ryegrass varieties (Alberto, Devis, and Baqueano) and applied seven different N doses (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) to see the yield and quality under Isparta ecological conditions of Turkey during 2017-2018 and 2018-2019 growing. N applications increased plant height, stem thickness, hay yield, CP ratio, CP yield while decreased ADF and NDF ratios. Plant height and ADF ratio were highest at Devis variety; stem thickness, hay yield, CP ratio and CP yield values were highest at Alberto variety. 250 kg ha^{-1} N dose produced highest forage yield and quality under Isparta ecological conditions.

Variation of N content of *L. multiflorum* cv. Midmar by applied N (0kg N ha^{-1}, 150kg N ha^{-1}, 300kg N ha^{-1} and 450kg N ha^{-1}) and defoliation intervals (every 2, 4, 6 and 8 weeks and twice a season) was determined in a field trial of Theron et al. (2002). Four N levels were combined with five defoliation intervals. Total N, non-protein N and true protein were significantly influenced by N level, defoliation interval and their interactions. Total N content varied from 0.68% to 3.38%, the true protein from 0.57% to 2.74% and the non-protein N from 0.11% to 0.65%. Assimilated N in the herbage ranged between 9.8 kg N ha^{-1} to 423.0 kg N ha^{-1}. Linear relationships between total N, true protein and non-protein N, respectively, were detected.

Trevino et al. (1980) conducted a ryegrass N fertilization study in Central Spain with N levels of 1) 0 kg N ha^{-1}, 2) 40 kg N ha^{-1}, 3) 80 kg N ha^{-1}, 4) 120 kg N ha^{-1} applied after each cut. Total N, protein N, non-protein N and alcohol extractable N contents at each of the three cuts were increased with increasing N rate but nitrate content was not affected. Total N contents increased from 1.87, 1.31 and 1.38 g g 100^{-1} DM to 2.78, 2.55 and 3.02 g and CP contents from 1.50, 0.98 and 1.06 g N 100^{-1} DM to 2.17, 1.98 and 2.40 g at each of the 3 cuts, respectively.

Karatassiou et al. (2010) studied the effects of water stress on N partitioning and leaf area of Italian ryegrass in pots. Plants were subjected to three water applications: 1) well-watered, 2) water stressed, 3) re-watered after establishment. Measurements were applied during the growing season. Water regime was significantly affected leaf area and N contents. After seventeen days of water stress, N loss increased in leaves, stems and roots of well-watered plants, while it significantly decreased in stems of water stressed and re-watered plants. Negative correlation between leaf area and nitrogen content was found, suggesting that Italian ryegrass may develop mechanisms to adapt to drought.

Influence of N fertilization to the mineral composition of Italian ryegrass was evaluated at three successive cuts from February to May in Northeast Portugal in 1994-1995 with four varieties factorial combined with five levels of nitrogen: 1) 0 kg ha^{-1}, 2) 40 kg ha^{-1}, 3) 60 kg ha^{-1}, 4) 80 kg ha^{-1}and 5) 100 kg ha^{-1}applied at seeding and topdressed after the first two cuts in a study of Fernandes and Moreira (2000). Effect of cuts and plant maturity were more effective on N, Ca, Mg, P and K concentrations compared to N fertilization while there were no significant differences between varieties. Higher levels of N fertilization resulted with higher N and K concentrations at three cuts.

2. Conclusions

Italian rygrass is a nitrogen responsive high yielding quality crop with its high adaptation. Irrigation improves its yield. T o escape from feeding animal injuries, it is important to apply in well a balanced quantity.

Amount of available water in root zone and root zone wetting frequency is an important determiner for the nitrogen uptake speed and efficiency, utilization, leaching, transformation into different forms of nitrogen. In relation with this, evaporation during the season is another important determiner nor just for *L. multiforum* but for all nitrogen fertilizer studies. Due to interactions between micronutrient and nitrogen contents of soils, it is important to determine and apply deficient amount of micronutrients to soils during studies. Also, to do this, it is important to put a yield target before the planning of the studies. This yield target may be the 25-50% higher yield levels of the averages of the study location to make farmers benefit from the study. As readers and engineers, we may also benefit more from these studies if these parameters can be mentioned in abstracts of the research studies.

It was interesting to see the SPAD instruments as a valuable farmer tool to determine the fertilization correct time and amount both to increase yield and escape from animal nitrate injury.

There is a deficit of information fort he determination of approprirate type of nitrogen fertilizer type for this species in drought and well watered conditions. Also seed production trials are very less. Researchers need to plan their future studies in the light of these friendly critics to be valued by more researchers and different regions of the world.

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Review

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Roots of Crops from the Window of a Forage Expert

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A B S T R A C T

Less known infos like the effect of wounding faba bean roots by high temperature, how maize roots climb up slopes, effect of cold on Medicago spp., effect of drought on soybeans, effect of active microbe species diversity in rhizosphere-plant interface on complex interactions on roots, allelochemicals, axial water flow, gravitropism, fine and coarse roots, salt-responsive mechanisms, transport in root cells, phototropism, hormones, nutrient acquasition, hydrotropism and many other important physiologic processes attracting a forage crops academician's attention and interest were extracted from international studies and reviewed in this article.

1. Introduction

It was really interesting to read in the fresh study of Gao et al. (2020) that the forage crop alfalfa's roots are containing potential anticancer macromolecules in their tissues. Two new polysaccharides were purified from roots of alfalfa by these researchers. The conducted structural analysis showed that RAPS-1 was composed of rhamnose, xylose, arabinose, galacturonic acid, mannose and glucose. And RAPS-2 was composed of rhamnose, xylose, galacturonic acid, mannose, glucose and galactose. These two polysaccharides possesses superior antioxidant and anti-tumor activities (Gao et al., 2020). The hidden parts of forage crops and in general all crops and plants - the roots - will probably help humanity to solve many accumulated problems of the world in the future. Because, it looks like the roots are living in an environment of a highly diversified genetic soup of microorganisms. Root microbiome of model plant Arabidopsis thaliana indicates that its composition is strongly effected from location, inside section of the root, outside section of the root and soil type (Lundberg et al., 2012). Microbial diversity associated with roots of plants is enormous. Tens of thousands of species microbes are active in rhizosphere-plant interface. This complex community is referred as the second genome of the plant which is critical for plant health.

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2. Interaction of Roots with Rhizosphere Microbes

In nature, plants are in a rich ecosystem with numerous and diverse microorganisms in the rhizosphere. Mycorrhizal fungi and nitrogen fixing symbiotic bacteria play important roles in plant performance by assisting mineral nutrition. An additional great progress has been made on composition of rhizospheric microbiomes and their dynamics in last decade. It is clear that plants also shape microbiome by root exudates. Bacteria developed various adaptations to survive in the rhizospheric environment (Jacoby et al., 2017).

Interaction of roots and beneficial bacteria in rhizosphere shapes the bacterial diversity, enhances plant growth and pathogen defense of plants. Plant growth promoting rhizobacteria shape cell division and differentiation to trigger changes in root system. Changing plant endogenous signaling pathways are included in this interaction. Many plant growth promoting rhizobacteria can produce phytohormones and effect plant development by molecules. Several fungi also have the same effects on roots which may be a part of a mechanisms conserved across kingdoms (Verbon and Liberman, 2016).

Plant roots determine carbon uptake and agricultural yield as a vegetation carbon pool of the World (Cabal et al., 2020). Decomposing fine roots is a large potential soil carbon source. Fine and coarse roots differ in morphology, nutrient concentrations, functions and decomposition mechanisms (Zhang and Wang, 2015). Vegetation type, fine root dynamics and rhizomorph dynamics influence soil respiration in addition to changes in temperature, light and humidity (Vargas and Allen, 2008). Plant roots are frequently experience local anaerobic stress which decreases level of ATP. But enhanced sugar delivery to the affected root part regenerate the needed ATP by anaerobic respiration (Cleland et al., 1994).

Allelochemicals released by plants play important roles in rhizosphere signalling, plant defence and stress responses. Plants use a variety of excreation mechanisms to release bioactive molecules into the rhizosphere (Weston et al., 2012).

Crop root systems can be defined by root length density, root length per soil layer of depth, sum of root length in the soil profile (total root length) or rooting depth (Ehlers et al., 1991). Winter wheat has a very productive root system. Tipically a wheat crop produce 1.5 t/ha roots with a total length of 300,000 km/ha when produced 20 t/ha total dry matter (Barraclough et al., 1991).

3. Interacting Network of Sensing Chemicals in Inner Tissue of Roots

An important adaptation of plants for colonization of lands was gravitropic growth of roots to reach water and nutrients by fixing theirself in the ground (Zhang et al., 2019). Terrestrial plant roots grow and explore underground by sensing many stimuli such as gravity, humidity, light, mechanical stimulus, temperature and oxygen. All of these stimuli are sensed in the root cap (Cassab et al., 2013). Roots exhibit gravitropism, phototropism and hydrotropism (Miyazawa et al., 2011).

The Cholodny-Went theory explains root gravitropism as a classical theory, basing on asymmetrical distribution of polar auxin transport carriers, auxin asymmetry following gravistimulation and generation of auxin response. But this classical model is inadequate to explain initiation of curvature, which occurs outside the region of most rapid elongation and is driven by differential acceleration rather than differential inhibition of elongation. Evidences indicates that there are two motors driving root gravitropism, one is not regulated by auxin (Wolverton et al., 2002).

Phytohormones regulate development and architecture of plant roots. Root cap synthesize Cytokinin (CK) to promote cytokinesis, vascular cambium sensitivity, vascular differentiation and root apical dominance. Young shoot organs produce Auxin (indole-3-acetic acid, IAA) to promote root development and induce vascular differentiation. Both CK and IAA regulate root gravitropism. CK and IAA hormones act together with ethylene to regulate lateral root initiation (Aloni et al., 2006). Whereas, strigolactones are secondary metabolites produced in plants for hormonal activity. In last decade, these compounds were shown to regulate shoot branching and leaf senescence, but now different researchers suggests that these hormones play important roles in root architecture (Matthys et al., 2016).

The plant hormone auxin regulates various developmental processes including gravitropism, root formation and vascular development (Bennett et al., 1996). Re-orientation of Arabidopsis seedlings produces a fast, asymmetric release of auxin from gravity-sensing columella cells at the root apex. Gravitropic curvature in roots is mainly driven by the differential expansion of epidermal cells in response (Swarup et al., 2005). Gravity sensing in the root caps occurs mainly in the columella cells. After reorientation by the gravity field, root-cap amyloplasts sediment, that promotes the development of a curvature at the root elongation zones (Rosen et al., 1999). Plants use a special transport system made up of separate influx and efflux carriers to move plant hormone auxin between its synthesis sites to action sites (Marchant et al., 1999). Root gravitropism drives the relative distribution of plant roots in soil layers which probably influence the acquisition of soil resources such as phosphorus, too (Liao et al., 2004).

Deep root systems that extend into moist soil can significantly increase plant productivity (Watt et al., 2008). Plant root tips sense moisture gradient in soil and growing towards higher water potential named as root hydrotropism, which is needed by plants to survive when water is deficit (Chang et al., 2019). By hydrotropism, roots forage for water, a process depends on abscisic acid (ABA) (Dietrich et al., 2017). Root architecture and shoot parameters were determined under well watered and drought conditions under field conditions in three soybean cultivars by Fenta et al. (2014). A positive correlation was observed between nodule size, above-ground biomass and seed yield under well-watered and drought conditions.

As roots penetrate soil more, they enter a different environment where different resources (water and nutrients) are heterogeneously distributed in space and time. Many plant species react to this heterogeneity by changing their root development to colonize the resource-rich parts of soil. Roots have the ability to respond in complex ways by integration of multiple external signals, which may be a kind of behaviour (Forde and Walch-Liu, 2009).

Roots normally grow in dark, but if they exposed to light, roots bend to escape from light (root light avoidance) and reduce their growth (Silva-Navas et al., 2016). While gravitropism is the major tropistic response in roots, phototropism also help to orient growth of this organ in flowering plants. The interactions between tropisms can be important in determining the final form of plants and plant organs. In blue or white light, roots show negative phototropism, but red light trigger positive phototropism. In Arabidopsis, the photosensitive pigments phytochrome A (phyA) and phytochrome B (phyB) mediate this positive red-light-based photoresponse in roots (Kiss et al., 2003). Plant shoots typically grow opposite of gravity to access light, roots grow into the soil to absorb water and nutrients, but these gravitropic responses can be altered by developmental and environmental signals (Su et al., 2017). If maize roots placed on slopes in the dark, they climb up the slope. But if roots are illuminated, roots try to grow down along the gravity (Burbach et al., 2012). Based on studies on white mustard (*Sinapis alba*) seedlings, botanists thought that all roots are negatively phototropic. This “Sinapis-dogma” was changed a century ago, when it was shown that more than half of the tested 166 plant species does not behave like *S. alba* (53% displayed no phototropic response) (Kutschera and Briggs, 2012).

4. Root morphology

Watt et al. (2008) assessed root systems of wheat, barley and triticale in soils. 6% of deep roots were axile roots originated from the base of the embryo and 94% were branch roots. Selection for more deep penetrating axile roots and deep branches was found benefiting. Fageria (2005) conducted 10 greenhouse experiments to see the effect of root dry weight and root length on shoot yield of corn (*Zea mays*), rice (*Oryza sativa*), soybean (*Glycine max*), common bean (*Phaseolus vulgaris*) and wheat (*Triticum aestivum*). It was concluded that dry weight of roots is a good indicator for shoot dry matter accumulation prediction in annual crops. Shoot dry matter production efficiency (shoot dry weight/root dry weight) was in the order of common bean > soybean > wheat > upland rice > corn. Roots of legumes better in dry matter production efficiencies than cereals.

Increases in shoot density produce increases in root densities which result in an exponential decrease of erosion flow rates. Protection of the soil surface in the early plant growth stages is crucial with respect to the reduction of water erosion rates. Increasing the plant root density in the topsoil is a suitable erosion control strategy (Gyssels and Poesen, 2003). Mixtures, as an example, grass with alfalfa are preferred to alfalfa grown alone for soil and water conservation (Woods et al., 1953).

Additional to the mentioned factors, there are many other soil-related environmental factors influencing the growth and function of plant root systems like soil temperature, soil air, soil strength and soil nutrient supply to the developing roots (McMichael and Quisenberry, 1993) Soil temperature can influence roots in many ways. Under adequate soil moisture and nutrient availability, root length extension rates and root mortality rates increase with increasing soil temperature up to an optimal temperature, which changes among species. Root growth and mortality are seasonal in plants with a flush of growth in spring (Pregitzer et al., 2000). Low temperature is a main factor limiting crop growth, development and production (Cui et al., 2019). Enhancement of cold tolerance is an important aspect in breeding forage legumes in view of increasing interest in extending the cultivation of these crops (Ratinam et al., 1994). Cold and low fertility of growing conditions are often associated with root adjustments to increase capture of deficient nutrient resources, but it is unclear if plants produce different type of fine roots in response to these conditions (Zadworny et al., 2017). Soil temperature influence not just its function but also above ground tissues of plants, too. In a study, it was observed that damaging of horse bean (*Vicia faba* L. minor) roots via rapid heating to above 80°C, induced an electric wave to the leaves within 25 s. This wave was then stimulated shoot respiration at a rate of up to 140-160% of its initial value within 70-80 s after the roots were heated (Filek and Kościelniak, 1997). Four plants, *Poa sphyondylodes*, *Bromus inermis*, *Bromus sinensis* and *Elymus nutans* were investigated during winter and spring for enzymatic activities by sampling approximately at 15 days interval during autumn and spring by Lian et al. (2001). Leakage of ions and enzymatic activities were found declined from September with the drop of temperature.

Salinity is a major stresses limiting agricultural productivity globally which roots are the primary site for salinity perception to transmit this signal to the shoot for salt response of the plant (Zhao et al., 2013). Adventitious roots form from any nonroot tissue during normal development (crown roots on cereals) and in response to stress (flooding, nutrient deprivation and wounding). They are also economically important (for cuttings and food production) (Steffens and Rasmussen, 2016).

Uptake of soil resources by root system is important but complex and challenging problem for agriculture, ecology and plant biology. Roots ineract with other organisms (mycorrhizas and N-fixing bacteria), release exudates to modify rhizosphere, uptake and transport nutrients as research interests by plant biologists. Improved understanding of the functional root architecture is required for efficient acquisition of soil resources and adaptation of plants to suboptimal soil conditions (Lynch, 1995).

5. Conclusions

Compared to huge research records based on aboveground plant organs, there is very little information subjecting roots and microbes relaated to them instead of its importance. Technological, methodological and sensor advances might be scanned in details to find more novel single or unified techniques and instruments to study roots and rhizosphere more fast and accurate to discover this hidden world. Compared to gaseous surrounding environment of aerial parts of crops, solid rhizosphere has a very huge contact surface area with plant cells and membranes. Rhizosphere also hosts ultra high diversity of microbes and chemicals from different groups. Hydroponic and aeroponic studies also might be searched and harmonised to develop a new approach to improve yields during these studies in parallel**.**

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