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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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TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE (TJRFS)

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After initial evaluation, the manuscripts are sent to at least two reviewers which are determined editor and/or editorial board. If necessary, the number of reviewers can be increased by editor or Editorial Board. The reviewers are chosen from reviewer board according to their expertise.

Reviewers are asked to evaluate the manuscript's originality, methodology, contribution to the literature, presentation of results and support for the conclusions, and appropriate referencing of previous relevant studies. Reviewers might accept the manuscript, reject the manuscript or might require a revision for style and/or content. For publication of articles, two positive reports are required. In case one reviewer report is negative while the other is positive, the article is forwarded to a third reviewer for addition evaluation.

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After favorable opinions of reviewers, Editorial Board is made the final evaluation. The articles accepted for publication by Editorial Board are placed in an issue sequence.

Time of Peer Review Process

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 Article

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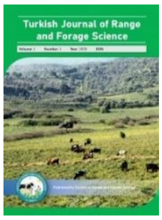

Silage Quality of Second Forage Pea at Different Plant Densities and Cereal Mixtures

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A B S T R A C T

This research was conducted to determine the effects of different plant densities (80, 100, 120 plants m^{-2}) and mixtures of 25 and 50% oat, silage maize, and Sudangrass on the silage quality of forage pea in 2018 and 2019 years. Plant density affected dry matter (DM), crude fat (CF), crude ash (CA), crude protein (CP), neutral detergen fiber (NDF), and acid detergent fiber (ADF) contents significantly. DM and CF content was higher at the densities of 80 and 100 plants m^{-2} while CA content was higher at the density of 120 plants m^{-2}. Increasing plant density caused an increment in CP and NDF contents but CP content did not significantly change between 100 and 120 plants m^{-2} while there was a significant decrease of NDF content at the density of 120 plants m^{-2}. Mixture type significantly affected all of the investigated parameters. The highest dry matter content was observed in the 25 and 50% of Sudangrass mixtures (26,13 and 26,15% respectively). pH value and Fleig score were observed to be lower in the all mixtures of silage maize and Sudangrass. Silages of sole crop forage pea (3,08 %) and oat mixture (2,98% for 25% and 2,90% for 50%) had higher CF content than the silages of pea-silage maize and pea-Sudangrass mixtures. CA content was generally similar within all mixes but it was lower at the 50% of Sudangrass (8,00%). Cereal mixtures increased the NDF content of forage pea silage but except for oat, ADF content of the forage pea silage decreased when mixed with cereals. According to the results, sowing should be carried out using the density of 100 plants m^{-2} and silage maize (25%) or Sudangrass (25 or 50%) could be added at sowing for increasing the silage quality of second crop forage pea.

1. Introduction

Silage is a process that is generally assumed as a preservation method of fresh herbaceous animal foods. Water-soluble carbohydrates are converted to organic acids through the silage process and organic acids reduce pH and initiate the fermentation process (Wilkinson, 1999). Therefore, forages could be preserved freshly to use as a food for ruminants in a time when the fresh forage is not available.

Silages that contain higher dry matter could stabilize at higher pH values so ensilaging forage that contains lower dry matter needs more attention (Jaster, 1995).

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Legumes generally contain lower dry matter and higher crude protein than grasses that causes a deterioration of silage and higher buffering capacity and thus hazardous agents (toxins, hazardous bacteria e.g.) could be a rise in forage legume silages more easily than grass silages (Jaster, 1995; Albrecht and Beauchemin, 2003; Driehuis et al., 2018). However, legume silages result in better animal performance than grass silages (Albrecht and Beauchemin, 2003; Dewhurst et al., 2003). Therefore grass-legume mixtures are widely used for both to have high nutritive value and less deterioration risk of silage (Laidlaw and Teuber, 2001; Dumlu and Tan, 2009; Kavut and Geren, 2017; Can et al., 2019). Researchers determined that corn and various legume intercropping systems increased the crude protein content of silage about 50% with regard to sole crop corn silage (Geren et al., 2008). In another study, Azim et al. (2000) determined that legume intercropping significantly increased the crude protein content of corn silage from 8,52% to 14,90 %, lactic acid content from 9,00% to 10,86%, and dry matter digestibility from 55,70% to 61,80%.

Forage pea is an annual forage legume cultivated widely due to its better yield potential, and higher protein content, and digestibility (Acikgoz, 2001; Fraser et al., 2001). It could be grown as main winter crop (Tekeli and Ates, 2003; Erkovan et al., 2020), second crop (Konuk and Tamkoc, 2018) or catch crop (Dok et al., 2016) under various climatic conditions of Turkey. The plant is also utilized as silage in ruminant nutrition (Mustafa et al., 2002; Borreani et al., 2006) but inoculant additives are indicated as to be necessary for sole-crop forage pea silages to avoid poor fermentation caused due to the low dry matter and buffering capacity of the plant (Weinberg et al., 1993; Fraser et al., 2001; Pursiainen and Tuori, 2008; Canbolat et al., 2019). However, the lodging problem of the forage pea could also complicate the ensilaging because lodging causes a sharp decrease of dry matter and contamination of the plant with clostridia spores (McDonald et al., 1991; Rondahl et al., 2011). Cereal species as a companion crop or higher seeding rates are suggested to avoid lodging problems and to ensure good forage pea silage (Fychan et al., 2000; Fraser et al., 2001). Also, dry matter content and water-soluble carbohydrates are increased by mixing cereal species into legume silage so therefore fermentation process becomes healthier (Dumlu and Tan, 2009; Can et al., 2019; Seydosoglu, 2019). Seydosoglu (2019) indicated that Fleig score, a quality indicator of sole crop forage pea silage significantly increased from 103,8 to 111,50 by barley addition. Dogan and Terzioglu (2019) also stated that the fleig score of forage pea silage increased from 59,7 to 64,8 with the addition of 50% barley. It was also indicated that cereal mixtures increases the silage yield of forage pea (Gilliland and Johnson, 1992).

There are a limited information about the effect of plant density and cereal addition to to stand on silage quality. The aim of this study was to determine the effect of plant density and cereal addition on silage quality of forage pea stand. For his goal, we investigated the silage quality parameters of the stand.

2. Materials and Methods

This research was conducted in the experimental station of Eskisehir Osmangazi University between the years of 2018-2019 in the second crop season and the laboratory studies were conducted in the Department of Field Crops of the faculty.

The soil in 0-20 cm depth of the experimental area was loamy, slightly alkaline, in the class of no salinity, rich in potassium but poor in phosphorus and organic matter, and moderately limy. Meteorological data of the experimental months in 2018 and 2019 were acquired from the Turkish State Meteorological Service and presented in Table 1.

There were differences in precipitation, temperature, and humidity in the experimental field between the years. In general, precipitation was insufficient in the area during the experimental period. The area received less precipitation in the second year of the study especially in August and September and irrigation was applied more frequently due to the requirement of the plants. Temperature average was also lower about 1 ºC in 2019 and humidity in 2019 was also lower than in 2018 regarding the meteorological data (Table 1). Temperature and humidity were not restricting factors during the experiment.

Sowing was carried out on 12 and 22 July for 2018 and 2019 years respectively after wheat harvest in the region. Plots were arranged using 30 cm row spacing and 5 lines of 5 meters (7,5 m^2).

Table 1. Meteorological data of the related months of Eskisehir between 2018 and 2019 years

Months	Precipitation (mm)			Temperature (ºC)			Humidity (%)		
	2018	2019	LYA*	2018	2019	LYA*	2018	2019	LYA*
July	38,3	33,5	14,0	23,0	21,3	23,3	71,4	62,3	75,8
August	25,0	2,4	7,8	23,5	22,3	22,9	62,2	61,0	74,1
September	4,3	5,0	14,4	19,1	18,1	20,0	62,9	62,1	68,1
October	41,0	18,3	27,0	14,0	14,2	12,9	75,5	70,1	79,6
Tot. Ave.	*108,6*	*59,2*	*63,2*	*19,9*	*18,9*	*19,7*	*68,0*	*63,8*	*74,4*

LYA: Average data for long years

Forage pea (cv. Tore) was sown at the rate of 80, 100, and 120 plants/m^2 and mixed with oat (cv. Cehecota), silage maize (cv. Kilowatt), and Sudangrass (cv. Gozde-80) using 30 cm row-spacing on the sown pea plots. Sowing rates of oat (180 kg/ha), silage maize (100000 plants/ha), and Sudangrass (20 kg/ha) were determined due to Basaran et al (2018), Turgut et al (2005), Acikgoz (2001) respectively and mixed with forage pea by reducing 50 and 75% of the suggested rates. Irrigation was carried out using sprinkler when plant colour turn into dark and no fertilizer was applied.

The harvest date of the mixed plots was determined due to forage pea considering the pod fill stage as Fraser et al. (2001) suggested. Harvest was carried out from the 0,9 m^2 area (0,3 x 3 m) of the middle of each plot using a sickle and plants were chopped mechanically. Chopped plant materials were pressed into silage bags without additives and vacuumed to avoid the aerobic microbial activity. Vacuumed and sealed bags were kept in dark to fermentation approximately 60 days. Silage bags were opened in the Laboratory of Field Crops when the samples reached to silage maturation. Silage pH values were measured using a pH meter (Nkosi et al., 2011) and samples were oven-dried at 70 ºC until reached constant weight for determining the dry matter content of the silages (Cook and Stubbendieck, 1986). Dried samples were grounded to pass through a 2 mm sieve and crude fat, crude ash, crude protein, neutral detergent, and acid detergent fiber contents were determined using Near Infra-Red Spectroscopy (NIRS). Fleig score was estimated and classified due to the formula that Kilic et al (1986) suggested as below.

Statistical analyses were carried out using SAS 9.3 statistical software (SAS, 2011). Data were subjected to ANOVA and means were compared using TUKEY multiple range test.

$$\text{Fleig score} = 220 + (2 \times DM\% - 15) - 40 \times pH$$

(100-81 very good, 80-61 good, 60-41 satisfactory, 40-21 medium, 20-0 bad)

3. Results and Discussion

The average dry matter content was 23,65% but it was not significantly varied between the years while pea density (P≤0,01) and cereal mixtures (P≤0,01) had a significant effect on the dry matter content (Table 2). All interactions were significant (P≤0,01) according to the analysis of variance. The dry matter content was 23,82, 24,34, and 22,78% at the densities of 80, 100, and 120 plants m^{-2} respectively. Sudangrass mixtures significantly increased dry matter ratio of forage pea silage up to 26,13 and 26,15% (25% and 50% of Sudangrass respectively) but all oat and 50% silage maize mixtures caused a reduction (Table 2) especially in 2018 (Figure 1a). The variation among the mixtures were more pronounced in the second year of the study (Figure 1a).

Average silage pH was 4,66 and the variation between the years and among the pea densities was not statistically significant. Mixture type significantly (P≤0,01) affected the pH value of the silage but there was not any significant interaction (Table 2). The highest pH (5,09) was measured from the silages prepared using sole crop forage pea as expected and 25% oat mix was not significantly different from sole crop forage pea silage in terms of pH value. There were not any significant pH differences within the 25 and 50% mixes of cereal species (oat, silage maize, and Sudangrass) but it was the lowest when 25% silage maize added to stand (Table 2).

The average crude fat content of the silages was 2,48% and varied significantly between the years (P≤0,01), among the pea densities (P≤0,05) and mixes (P≤0,01). Year x pea density and year x mixture interactions were statically significant (Table 2). Crude fat content was 3,74% in 2018 but it decreased to 1,22% in 2019. Pea density of 100 plants m^{-2} had the highest crude fat content as 2,58 % and it was the lowest (2,40%) at the density of 120 plants m^{-2} (Table 2) but the variation was slight in the second year of the study (Figure 1b). The highest crude fat content was determined from the sole crop forage pea silage (3,08%). The oat mixtures did not cause a significant difference but 25 and 50% of silage maize mixes had lower crude fat content (2,59 and 2,42% respectively). The lowest values were determined from 25 and 50% of Sudangrass mixes (1,84 and 1,54% respectively) but yearly variation was lower at Sudangrass mixtures (especially 50%) than all of the other mixtures and control (Figure 1d).

Table 2. Dry matter content, pH, Fleig score, crude fat, and a crude ash content of silages prepared using different plant densities and mixes in 2018 and 2019.

	Dry matter(%)	pH	Crude fat(%)	Crude ash(%)
Year (Y)				
2018	23,98	4,81	3,74 a	8,29 b
2019	23,32	4,52	1,22 b	9,87 a
Pea density (P)				
80 plants m^{-2}	23,82 a	4,62	2,46 ab	8,18 c
100 plants m^{-2}	24,34 a	4,67	2,58 a	9,23 b
120 plants m^{-2}	22,78 b	4,71	2,40 b	9,82, a
Mixture (M)				
Sole Crop Pea	24,11 b	5,09 a	3,08 a	9,00 a
Pea + 25% Oat	20,82 d	4,82 ab	2,98 a	9,06 a
Pea +50% Oat	21,82 cd	4,76 bc	2,90 ab	9,48 a
Pea + 25% Silage maize	24,53 b	4,36 d	2,59 bc	9,41 a
Pea + 50% Silage maize	22,00 c	4,45 cd	2,42 c	9,51 a
Pea + 25% Sudangrass	26,13 a	4,69 bc	1,84 d	9,10 a
Pea + 50% Sudangrass	26,15 a	4,50 cd	1,54 d	8,00 b
Mean	*23,65*	*4,66*	*2,48*	*9,08*
ANOVA				
Y	ns	Ns	**	**
P	**	Ns	*	**
M	**	**	**	**
Y x P	**	Ns	**	**
Y x M	**	Ns	**	**
P x M	**	Ns	ns	**
Y x P x M	**	Ns	ns	**

ns: non-significant, *: P≤0,05, **: P≤0,01

Crude ash content varied significantly between years (P≤0,01), among the pea densities (P≤0,01) and mix type (P≤0,01). Mean crude ash content was 9,08 % and all of the interactions were statistically significant (P≤0,01) (Table 2). The value was 8,29 % in 2018 but it was higher (9,87%) in the second year. Increasing forage pea densities caused a decrement in crude ash content of the silage (Table 2). Mixes were not statistically varied from the control (sole crop forage pea) silage in terms of crude ash content except 50% Sudangrass mix (Table 2) but variation among the mixes was quite higher in the second year especially at the higher plant densities (100 and 120 plants/m^2) (Figure 1c).

Fleig scores did not significantly vary between the years and among the pea densities. Different cereal mixtures caused a significant (P≤0,01) variance in the Fleig score of forage pea silages (Table 2). The mean Fleig score was estimated as 65,94 and year x mixture interaction was statically significant (P≤0,05). Even though the variation between the years was non-significant, 50% oat and silage maize mixtures showed great variances between the years (Figure 1f). Fleig score of sole crop forage pea silage (51,05) did not vary significantly from 25 and 50% mixes of oat (55,93 and 57,90 respectively) especially in 2018 (Figure 1f) but all mixes of silage maize and Sudangrass had a higher Fleig score than silages of sole crop and oat mixtures.

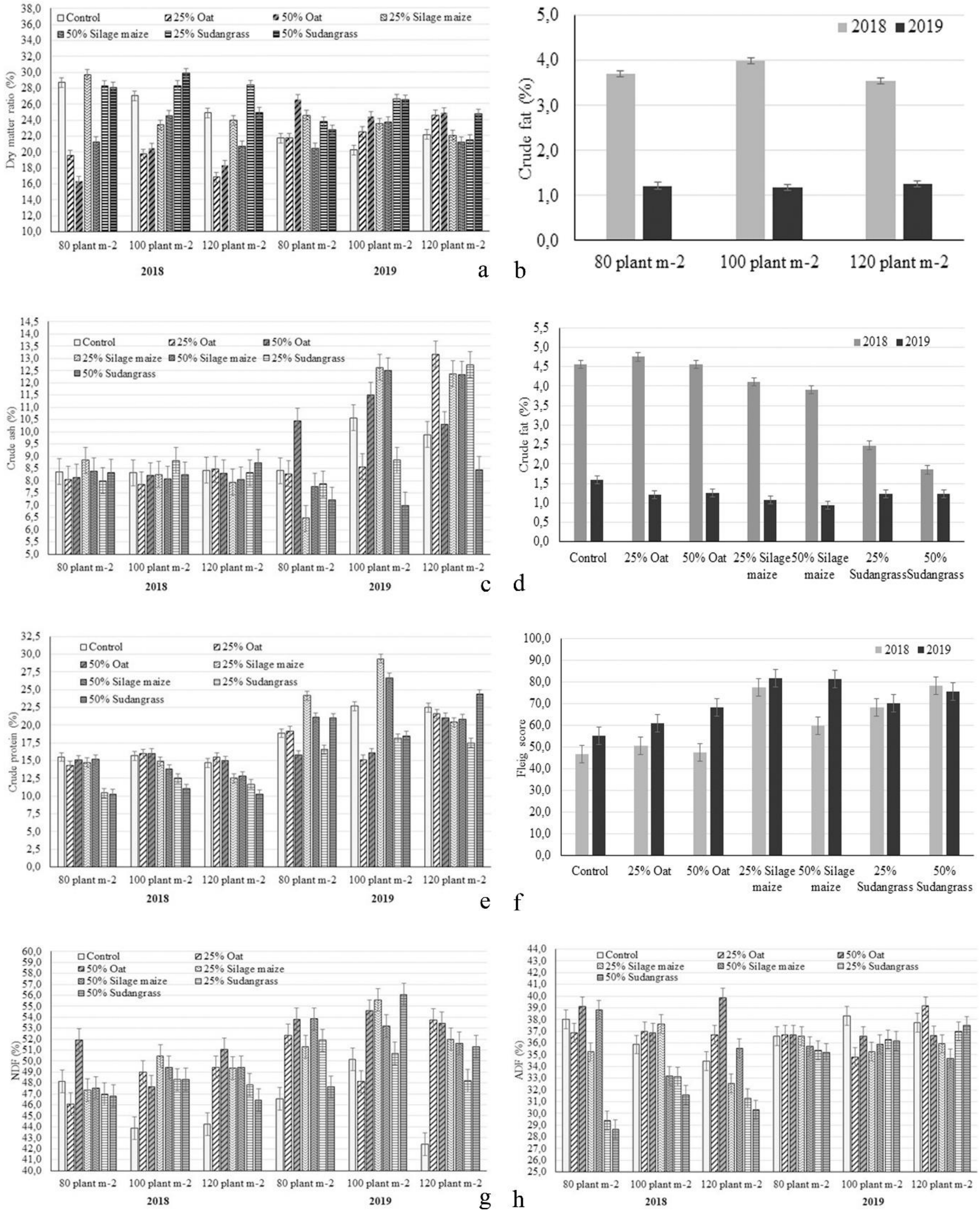

Figure 1. Significant interactions of **a)** DM (three-way), **b)** CF (year x pea density), **c)** CA (three-way), **d)** CF (year x mixture), **e)** CP (three-way), **f)** Fleig score (year x mixture), **g)** NDF (three-way), **h)** ADF (three-way)

Crude protein (CP) content of the silages showed significant variances between the years, among the pea densities and mixtures (P≤0,01). Mean CP content was 17,12% and all of the interactions were statically significant (P≤0,01). In the first year of the study, CP content was quite lower (13,70%) than in the second year (20,54%). CP content of 80 plants m^{-2} pea density was significantly lower but this difference was occured because of the second year results (Figure 1e). The difference between the densities of 100 plants m^{-2} (17,60%) and 120 plants m^{-2} (17,19%) was not statistically significant (Table 3). CP contents of 25 and 50 % silage maize mixtures (19,34 and 18,41% respectively) and sole crop forage pea silage (18,31%) were higher than the silages prepared from the other mixes especially in 2019 (Figure 1e) and silage of 25% Sudangrass mix had the lowest (14,47%) value (Table 3).

NDF content varied significantly between the years (P≤0,05), among the pea densities (P≤0,05) and the mixtures (P≤0,01). The silages had an average NDF content of 49,71% and three-way interaction was statically significant (P≤0,01). NDF content was 48,07% in 2018 and increased to 51,32% in the second year of the study (Table 3). Densities of 80 plants m^{-2} (49,44%) and 120 plants m^{-2} (49,31%) had lower NDF values than 100 plants m^{-2} (50,38%) in general (Table 2) but this variation was not observed in 2018 (Figure 1g). The highest NDF value was determined from the silages prepared using a 50% oat mix (52,07%) but 25 and 50% silage maize mixes (51,00 and 50,83% respectively) were statistically in the same group. Sole crop forage pea silage (control) had the lowest NDF content (45,88%).

Mean ADF content was 35,62% and significantly changed between the years (P≤0,01) and among the mixtures (P≤0,01). All of the interactions were statistically significant (P≤0,01). ADF content was lower in 2018 (34,85%) than in 2019 (36,40%). Pea densities were nearly equal in terms of ADF content (Table 3). The highest ADF content was determined in 50% oat mix but it was statistically in the same group with 25% oat mixture and control (Table 3). The silage maize mixtures (especially mix of 25%) generally had lower ADF content than control or oat mixtures (Figure 1h). Mixes of 25 and 50 % Sudangrass both had the lowest values (33,74 and 33,21% respectively).

Dry matter content of the silage could be affected by many factors as the field and ensiling conditions. Increasing plant density could reduce the dry matter content of the plants (Asik et al., 2020; Shao et al., 2020). In our research, dry matter content of the silages was lower at the density of 120 plants m^{-2} than lower seeding density. Legume species are mixed with cereals to increase silage dry matter and consequently silage quality (Latre et al., 2008; Dumlu and Tan, 2009; Can et al., 2019). In the research, there were significant differences in silage dry matter between sole crop forage pea and cereal-mixed forage pea. Generally dry matter content was higher when the oat, silage maize or Sudangrass mixed with the forage pea that sown at 80 or 100 plants m^{-2} density. However, oat and silage maize mixes did not significantly increase the dry matter content in general. Sudangrass mixes significantly increased the dry matter content of the silages (Table 2). This effect of Sudangrass was more pronounced in the mixes that 100 plants m^{-2} pea density used in both years (Figure 1a). This is possibly due to the competitive effect among the species caused by the limited availability of environmental factors at growth habitat in 2018 (Craine and Dybzinski, 2013). These effects showed differences between years and among sowing types, hence the interactions were significant. The difference in temperature between years (Table 1) was the mean reason for these interactions.

There was not any significant difference between the years and among the pea densities in terms of silage pH, but mixes generally caused a reduction in the pH of forage pea silage (Table 2). Generally, lactic acid bacteria (LAB) cause a reduction in pH in the conditions of sufficient sugars are available (Filya et al., 2007). The sugar content of the legume silage material increases when mixed with grasses. Therefore, silage pH was lower in mixes with regard to sole crop forage pea silage.

The crude fat content of the forage (silage) that is defined as metabolized energy (Grant et al., 2014) was higher in the first year of the study possibly due to the effect of year related varying climate on plants (Table 1). The effect of pea density was only significant between the densities of 100 and 120 plants m^{-2}. Yilmaz et al (2009) stated that silage crude fat content of soybean, another legume species, increases by increasing seeding rate but our results were not consistent with this information (Table 2). Additional researches are needed to understand the reponse of pea density on the crude fat content of silage. Cereal mixtures caused a decrement in the crude fat content of the forage pea silage except 25% oat (Table 2). Jinghui et al (2006), stated that cereals could decrease the crude fat content of legume silages. Wang and Daun (2004) indicated that the crude fat content of pea varieties significantly affected by environmental conditions. The findings of our study also indicated that environmental factors such as climate are more dominant than plant density or mixtures in terms of the crude fat content of forage pea silage. Indeed, the interaction related to years support the idea that yearly variation in climatic conditions affect the crude fat content of plants.

Crude ash was defined as the total mineral content of forage and generally used to determine energy and non-fiber carbohydrate content (Hoffman, 2005). Crude ash content was higher in the second year on the contrary of crude fat. Increasing plant density also caused an increment in crude ash content of forage pea silage (Table 2) that possibly caused by contamination of soil due to lodging etc. (Hoffman, 2005; Rondahl et al., 2011). In the first year, 25% silage maize, 25% Sudangrass, and 50% Sudangrass had higher crude ash content than control at the densities of 80, 100, and 120 plants m^{-2} respectively. In 2019, the crude ash content of the mixes (especially silage maize and Sudan grass mixes) generally showed an increasing trend with the increasing pea densities (Figure 1c). Therefore, it might be concluded that climate was also effective on the crude ash content of mixes in forage pea silage.

Fleig score widely used to classify the silages in quality (Denek and Can, 2006; Balabanlı et al., 2010; Budakli-Carpici, 2016). Generally, Fleig score of sole crop forage pea silages did not significantly vary from the silages prepared from oat-pea mixes (class of satisfactory) but silage maize and Sudangrass mixes caused an increment of the value (class of good). Researchers indicated that cereal mixtures cause an increment in the Fleig score of forage pea silage due to their higher dry matter content (Gelir, 2019; Seydosoglu, 2019). Higher dry matter content of the Sudangrass mixtures (Table 2) might be caused a higher Fleig score of the forage pea silage in the research.

In our study, lower CP results in the first year might be related to protein degradation during the ensilaging process or condition of the plants during the harvest. The protein content of the silages might be broken down to non-protein fractions due to proteolysis caused by the protease enzyme of plant or enterobacteria during the ensiling process (Davies et al., 1998; Collins and Owens, 2003). Besides, maturation and/or leaf ratio of the plant could also affect the CP content of the silage significantly (Fraser et al., 2001; Salawu et al., 2002; Rondahl et al., 2011). CP content was lower below the density of 100 plants m^{-1} possibly due to the decreasing leaf ratio of the plant because leaf ratio increases with the density (Rowden et al., 1981). Researchers determined the CP content of sole crop forage pea silage as 15,9 – 20,3% (Fraser et al., 2001), 17,1 – 20,4% (Mustafa et al., 2002), 17,8% (Mustafa and Seguin, 2003) which was determined as 18,31% in our research (Table 3). Generally, cereal species were indicated as decreasing the CP content of legume silages (Budakli-Carpici, 2016; Can et. al., 2019; Seydosoglu, 2019). Oat and Sudangrass mixtures decreased the CP content of the silage in consideration to control as consistent with the literature but the silages prepared using silage maize – forage pea mixtures were not significantly different from sole crop forage pea silages in terms of CP content (Table 3). Moreover, 25% silage maize mixture had slightly higher CP content than the control especially in 2019 at the pea density of 80 and 100 plants m^{-2} but the difference was non-significant when the data examined at the average of two years (Figure 1e). Years could have significant effects on the relations among the plants that are sown as a mixture (Lauriault and Kirksey, 2006; Eskandari et al., 2009) and this information might be an explanation for our results. Increasement in CP might be due to preventing leaf-loss of forage pea by keeping from lodging

Researchers determined the NDF content of pea silage between the values of 31,7 – 42,8% (Mustafa et al., 2000; Mustafa et al., 2002; Mustafa and Seguin, 2004). In our study, NDF content of forage pea silage significantly varied between the years as 48,07 – 51,35% which was higher than the findings of other researchers. The experiment was conducted in the second crop season when it was warmer due to the main crop season and this explains the difference of NDF content with the literature. NDF content means the cell wall content of the plants and differences in the NDF content attributed to silage maturity (Van Soest et al., 1991;

Mustafa et al., 2000; Adesogan et al., 2002). NDF concentration of the plants is also increased with the temperature increase (Thorvaldsson et al., 2007) and the warm summer period possibly caused a higher NDF content of forage pea material and thereby silage in out study. Pea densities caused a slight but significant difference in NDF contents (Table 3) probably due to the differences in maturity because it was well-known that plant maturity could be affected significantly from different plant densities (Bejandi et al., 2012). Legume silages generally had lower NDF content compared to cereal silages (Mustafa et al., 2000; Adesogan et al., 2002; Mustafa and Seguin, 2004). Therefore, sole crop forage pea silage had lower NDF content than all cereal mixtures in the study (Table 3). Mustafa and Seguin (2004) also found significant differences among the pea silages that mixed with different cereals. This variation was possibly caused by the differences in the NDF content of cereals used in our study. There were significant NDF differences among the mixtures but the variations were quite different both in 2018-2019 years and at different plant densities (Figure 1g). This is because of the different climatic conditions that prevailed between the years.

ADF content is indicated as the non-digestible cell wall fractions of the plants in the literature (Albrecht and Beauchemin, 2003; Collins and Fritz, 2003). Yearly climatic variations affect plant cell wall fractions and ADF content of silage consequently (Collins and Fritz, 2003; Collins and Owens, 2003) and this is the reason of the significant difference between the years in our research (Table 3) as similar with the findings of Salawu et al. (2001). Plant density could also affect the ADF content of the silage by affecting the maturity of the plants (Kavut and Geren, 2017) but the examined plant densities did not vary enough to cause maturity-related significant ADF differences. Sudangrass mixtures gave better results of ADF in the study. Low ADF content desired to have better silage in quality especially digestibility (Collins and Fritz, 2003; Dumlu and Tan, 2009) and therefore it should be concluded that the digestibility of silage was higher when pea was sown together with Sudangrass.

4. Conclusion

Forage pea could also be conserved and utilized as silage in animal nutrition. According to the results of our study, the density of 100 plants/m^2 should be used at sowing for high-quality forage pea silage production. Besides, it was determined that cereal mixtures provided a better fermentation and therefore silage in better quality but the oat mixtures were not effective enough in terms of the evaluated characteristics of forage pea silage. Silage maize (with a mix of 25%) or Sudangrass (with a mix of 25 or 50%) could be sown with forage pea to increase the silage quality. Besides new researches are needed to determine sowing density and proper cultivar of silage maize and Sudangrass for adding to the forage pea stand.

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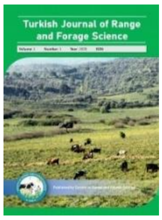

The Effect of Harvest Time and Urea on Yield and Yield Components of Different Grain-Legume Forage Crops

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A B S T R A C T

This study was carried out by applying different amounts of urea (0, 10 DAP 15 Urea, 10, 20 kg da^{-1}) to 5 feed mixture (Hungarian vetch (*Vicia pannonica* Crantz.), Field pea (*Pisum arvense* L.), oat (*Avena sativa* L.), Triticale (*Triticosecale* Wittmack), Wheat (*Triticum aestivum* L.) and harvesting in three different periods. It was made to determine the effect of some plant characteristics and forage yield the plants. It was carried out in 4 fields in the towns and villages of Erzincan Province during the 2019-2020 season. In the study, delaying the harvest time caused a decrease in plant characteristics and an increase in hay yield, although the effect of different applications on these properties is important, the difference in herbage yield (3712 kg da^{-1}) compared to other applications was significant (P <0.05) in the field where 10 DAP 15 Urea kg da^{-1} was applied.

1. Introduction

Animal products constitute an important and large part of human nutrition in the world. Ruminants can digest coarse feed that people can't assess and can convert them into quality animal products. Meadows and pastures are the places where quality coarse feed can be provided in terms of cheap, high quality, legume and grass species feed plants variety. With the fact that meadows and pastures become inadequate due to excessive, early, and late grazing, ruminant animals are not able to meet the need for roughage. In the case of roughage deficiency, the need for ruminants started to be farmed to eradicate this deficiency has been tried to be met. In recent years, mixed plantings have started to be involved rather than pure cultivates to obtain this variety.

The mixed feed plant cultivation method has been widely implemented to meet the growing food needs of an increasing population (Çiftçi and Ülker, 2005). The legume-grain combination has been used in various mixed planting systems, including feed and cover plants (Ramos et al., 2011). Forage crops can be planted mixed with two or more species. With mixed cultivation of forage crops; reducing pests, diseases, and weed harms (Barsila, 2018), reduce the need for fertilizer, increasing the efficiency of the next product (Ross et al., 2004), affecting the growth rate, yield, and quality of oats, wheat and vetch plants according to lean cultivation (Lithourgidis et al., 2006), enhanced soil structure and root depth to provide

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access to water (Capstaff and Miller, 2018) and increasing production per area (Ghosh, 2004) there are advantages such as.

Various fertilizer applications are carried out to improve the soil before or after planting and to increase plant nutrients that the plant will receive from the top. Urea, which is involved in various fertilizer applications; it is a very good food source for meeting the nitrogen (N) needs of plants. The urea applied to the surface is easily transported downwards by rain or irrigation water due to the easy resolution of the urea in the water. Freely roams the soil until it becomes hydrolysed in the soil, to create NH_4+ (ammonium ion). Unwanted N losses can cause decreases in product efficiency and quality (Anonymous, 2020). Fertilizer-produced urea contains 45-46% nitrogen. The use of urea has become widespread due to the low unit cost price compared to other nitrogen fertilizers. The use of urea in the soil can be used in autumn fertilization as well as in spring during certain developmental periods of plants. It has been reported that urea has a stature-makers and root-growing effect on plants, as well as affects grain development, and can be easily used in all kinds of plants with these properties (İşler ve Kılınç, 2016). Another commonly used DAP (Diammonium phosphate) fertilizer is a great source of P and N for feeding plants. It is highly soluble, which gives the plant the ability to quickly reach the root area of phosphate and ammonium (Anonymous, 2020).

The desired properties and quality of the produced forage crops, in addition to the use of fertilizer at the appropriate rate and variety, are also effective in different harvest times of the plant. It has been reported that the quality of forage crops increases with early harvesting and the amount of the product decreases, and when the form is delayed, the efficiency increases in quantity, but the quality and flavor of the forage decreases with lignification (Gürsoy and Macit, 2020).

This study was carried out to determine the effect of different harvest time and urea used in different doses to some herbal properties of the five forage mixture seeded as winter intermediate product.

2. Materials and Methods

The study was carried out during the 2019-2020 season in 4 fields located in Altınbaşak Town (2 Fields), Uluköy (1 Field), and Çatalören (1 Field) village within the borders of Erzincan Province. It was analyzed by taking soil samples 0-30 cm deep from each field. The results of the analysis of soil samples are given in Table 1.

The DAP project of the Provincial Directorate of Agriculture and Forestry is made up of 5 forage mixtures, 35% Hungarian Nuts (Tarm beyazı), 35% Feed Peas (Szarvasi andrea), 10% Oats (Kahraman), 10% Tritikale (Karma 2000) and 10% Wheat (Sönmez 2000) feed plants donated to farmers in support of feed plants.

Applications in the Study;

Control: 1. To the field, no fertilizer application has been made as a control. It was processed and raked with a crowbar before planting. On 20.09.2019, 15 kg of seeds per decare were sown with a seed drill. In total, 11 flood irrigation was carried out on the cultivated field once until harvest.

10 DAP, 15 Urea kg da^{-1}: 2. To the field before planting, 10 kg DAP was given to the second field and plowed with a plow and a rake. 15 kg of seeds per decare was planted on 01.12.2019 with a drill. 15 kg da^{-1} of urea was added to the field on 28.03.2020. Flood irrigation was carried out once until harvest on the field where 5 of them were cultivated.

10 Urea kg da^{-1}: 3. The field is mixed with gear by plowing with a plow before planting. 15 kg of seeds per decare were planted on 15.11.2019 with a seeder. 10 kg da^{-1} of urea was added to the field on 07.04.2020. Flood irrigation was carried out once until harvest on the field where 5 of them were cultivated.

20 Urea kg da^{-1}: 4. The field was plowed with a plow and pulled with a rake before planting. 15 kg of seeds per decare were planted on 15.11.2019 with a seeder. 20 kg da^{-1} of urea was added to the field on 05.04.2020. Flood irrigation was carried out once until harvest on the field where 5 of them were cultivated.

Different urea doses and DAP application were made in line with the preferences of the breeders in the fields where the feed mixture was grown. No fertilizer application was made in a control field either.

Table 1. Soil Analysis Results of Research Locations

	Soil Structure	pH	Organic Matter	Lime	Salt	Potassium (K_2O ha^{-1})	Phosphorus (P_2O_5 ha^{-1})
1.Field (Control)	Loam	Slightly alkaline	Middle	Medium lime	Without salt	High	Poor
2. Field (10 DAP+15 Urea kg da $^{-1}$)	Loam	Strong alkaline	Little	Middle lime	Without salt	High	Poor
3. Field (10 Urea kg da $^{-1}$)	Clay – Loam	Strong alkaline	Middle	Excess lime	Without salt	Middle	Poor
4. Field (20 Urea kg da $^{-1}$)	Loam	Strong alkaline	Middle	Limy	Without salt	Little	Poor

Climate data

During the trial period, the temperature, precipitation, and humidity information of Erzincan Province was taken from the General Directorate of Meteorology and given in Table 2. While the temperature was the lowest in February during the study, the highest was in June. Precipitation was less in the province during the trial, and the highest humidity was observed in December. The fact that precipitation is less than years in the province is an extreme situation and it is thought to be caused by climate change due to global warming (Kibar et al., 2014).

Table 2. Erzincan Province 2019-2020 Temperature, Rainfall and Humidity Ratios by Months

	Temperature ^{0}C	Rainfall mm	Humidity %
October	15.47	0.25	46.53
November	6.03	0.42	50.90
December	5.20	0.25	65.78
January	0.28	0.50	57.76
February	0.08	1.37	63.35
March	8.18	1.78	55.27
April	13.6	0.89	46.12
May	15.92	1.94	47.25
June	26.66	0.12	40.52
July	25.67	0.01	34.63

Method

In the study, 3 harvested times were made by considering 3 shaping times. The first harvest of forage peas was made on 13.05.2020 in 4 fields, leaving 50 cm of edge effect from the heads of the plots, and a 5 m^2 area to represent the field with the help of a sickle. The second harvest was realized on 02.06.2020 in a 5 m^2 area with an edge effect representing the field when the flowering of the forage pea is 50%. The third harvest was done on 16.06.2020 in a 5 m^2 area with an edge effect during full flowering.

Plant height (cm) was calculated by measuring and averaging the heights from the soil surface to the plant tip point of 10 plants, representing each plant species from the fields at all three harvest times. The number of leaves (number/plant) was counted by counting the number of branches and leaves of the plants and proportioned to the plant number (Sabancı, 1996; Özyiğit and Bilgen, 2006; Yücel 2019), and the distance from the leaf tip to the base of the leaf blade in cereals was determined as leaf length (cm) (Yurtman, 1969; Sevim, 2013). The stem diameter (mm) was measured in mm with an electronic caliper between the second and third nodes of the longest stem in each plant (Tekeli and Ateş, 2006). Herbage (kg da -1) was weighed by reaping a 5 m2 area from each field with a sickle from the soil level in three harvest periods and the yield per decare was found by calculating from the value obtained (Sevim, 2013). In order to determine the hay yield in each parcel, 500 g of hay samples were taken and dried in the oven set at 78 °C for 24 hours, then weighed and the values obtained were converted to decares and the hay yields were calculated (Yücel, 2019).

In order to compare the data obtained as a result of the study, they were subjected to variance analysis in the SPSS 24 package program, and the Duncan comparison test was applied to compare groups.

3. Results and Discussion

Plant Height

The effect of different harvest times and different urea doses on the plant height of the feeds in the mixture is given in Table 3.

Table 3. Average Values of Feeds in the Mixture of Different Harvest Times and Different Urea Dosages (cm)

	Field Pea plant height				Hungarian Vetch plant height			
	Harvest time				Harvest time			
Urea kg da $^{-1}$	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	90.66	156.33	156.66	**134.55a**	80.33	121.33	124.66	**108.77b**
10 DAP 15	99.83	158.66	158.66	**139.05a**	111.00	136.00	136.00	**127.66a**
10	79.83	102.33	103.66	**95.27c**	75.00	92.00	105.16	**90.72c**
20	65.00	108.33	**159.33**	**110.88b**	40.00	79.00	106.33	**75.11d**
Aver	**83.83 C**	**131.41B**	**144.58A**		**76.58C**	**107.08B**	**118.04A**	

	Oat plant height				Triticale plant height				Wheat plant height			
	Harvest time				Harvest time				Harvest time			
Urea kg da $^{-1}$	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	96.33	102.33	106.66	**101.77ab**	60.16	104.00	104.00	**89.38c**	93.50	128,33	128.33	**116.72b**
10 DAP 15	92.83	111.33	112.33	**105.50a**	106.33	115.33	117.66	**113.11ab**	119.00	130.00	130.10	**126.36a**
10	93.83	97.33	98.33	**96.50b**	114.33	119.66	123.00	**119.00a**	103.00	108.00	108.33	**106.44c**
20	56.33	86.50	98.00	**80.27c**	69.50	104.00	120.33	**97.94b**	77.00	90.33	100.00	**89.11d**
Aver	**84.83 B**	**99.37A**	**103.83A**		**87.58C**	**110.75B**	**116.25A**		**98,12B**	**114.16A**	**116.69A**	

Significant difference between averages indicated by different letters in the same row or column (P<0.05)

In the study, the effect of both the harvest time and the applied urea at different doses on the average height of the plants was significant (P <0.05). The height of the plants in the mixture in the application areas increased as the harvest time was delayed. The average height of Pea vetch, Oat, Triticale and Wheat plants respectively; It ranged between 95.27-139.05 cm, 75.11-127.66 cm, 80.27-105.50 cm, 89.38-119.11 cm and 89.11-126.36 cm (Table 3). The average height of Pea, Vetch, Oat, Triticale and Wheat plants was found to have the highest value in the field where 10 DAP lower than the value found by Doğan (2013), higher than the value found by some researchers (Özköse, 2017; Yücel, 2019) and value found 15 Urea kg da $^{-1}$ was applied (139.05, 127.66, 105.50, 113.11, 126.36 cm). According to these data, it is seen that the plant continues its development with the advancement of the harvest time. The use of DAP fertilizer with the effect of urea to grow height and root growth in plants has shown that it provides a more increase in plant height values in plants. It can be considered that the plant height in the feed mixture is not affected much of Pea vetch crop compared according to other feed crops in terms of plant competition.

The plant height of the feed pea was found to be similar to some study values (Sevim, 2013; Kara, 2016). While the average plant height of Hungarian Vetch was similar to the value found by Orak et al

(2004) it was higher than the values reported by the researchers of Bağcı (2010), Şimşek (2015), Kandış (2019), and Yücel and Bengisu (2019). While the average plant height of oat and triticale plants is similar to some study results (Sevim, 2013; Kara, 2016; Çeri, 2019), oat plant height is lower than the value reported by Çalışkan and Koç (2019). The average Wheat plant height in the study was determined to be similar to the values reported by Doğan (2013) and Sevim (2013).

Side Branch / Number of Leaves

The effect of different harvest times and different urea doses on the number of plant side branches/leaves of feeds in the mixture is given in Table 4. While the number of side branches increased (10-14.25-4.58 units/plant) in the feed pea with the delay of the harvest time, the number in the control group (13.77 units / plant) in the applications was found to be significant compared to the other applications (P <0.05). Different doses of urea application in feed peas had a negative effect compared to the control group. In other words, urea applications did not increase the number of side branches in feed peas. While these values are similar to Öztürk's (2009) study (11.06 <12.24 units/plant), they are lower than Yücel's (2019) (17.26 units/plant) and higher than Ateş and Tekeli's (2017) (4 <6 plants/plant). It was found to be high.

While there was no difference between applications in the number of side branches of Hungarian vetch in the mixture, it got the highest value at the second harvest time (14.83 units/plant) (P <0.05). In Hungarian vetch, it is thought that as the plant matures, the side branches dry and fall off. The number of Hungarian vetch side branches in different applications is similar to the values found by Yücel (2019) but higher than the results of Orak et al. (2004).

While there was a decrease in the number of leaves with the delay of harvest time in cereals, the difference between the second group and the other groups was found to be significant in the applications of Oat and Triticale plants (P <0.05). No difference was found between the applications in thewheat plant (P> 0.05). Oat, Triticale and Wheat plant leaf counts decreased as the harvest time was delayed. While the second group urea application shows a positive effect in the oat plant, In the triticale plant, it was observed that 10% and 20% urea applications were effective in the number of leaves. The number of oat plant leaves (3 <4 units/plant) was lower than the values found in the studies of some researchers (Çalışkan ve Koç, 2019; Çeri, 2019) (4.49-5.8 units/plant).

Leaf Length

The effect of different harvest times and different urea doses on the leaf length of the creals in the mixture is given in Table 5. Significant differences were observed in the leaf length of the creals in the mixture, being more in the second group between applications (P <0.05). The effect of harvest time on leaf length of plants was significant (P <0.05). Oat and Triticale leaf length decreased with the delay of harvest time, but there was no difference between the second harvest time and the third harvest time. Leaf length decreased with the delay of harvest time in wheat plants (Table 5). This is thought to be due to the drying and shedding of some leaves as the harvest time is delayed.

Oat leaf size was similar to the values reported by Sevim (2013) and Çeri (2019), but lower than the value reported by Çalışkan and Koç (2019). Triticale leaf length is similar to the results determined by Kara (2013), higher than Sevim's (2013) leaf length results, Wheat leaf length is lower than Doğan's (2013) leaf length results, higher than Sevim's (2013) results, Kara et al. (2008) showed a similar value with the results of.

Stalk Thickness

The effect of different harvest times and different urea doses on stalk thickness of feeds in the mixture is given in Table 6. In plants, it is preferred that the stem diameter is thin (Dogan, 2013). The effect of different applications on the stalk thickness of plants was significant in Hungarian vetch and Oat plant (P <0.05). It was determined that with 10% urea application in Hungarian vetch the stem thickness was the thinnest (2.52 mm). The application with the thickest stem thickness was seen in the second application (3.64 mm).

Table 4. Average Values of Different Harvest Times and Different Urea Dosages Regarding the Number of Plant Side Branches / Leaves (unit/plant) in the Mixture

	Field pea side branches				Hungarian vetch side branches			
	Harvest time				Harvest time			
Urea kg da $^{-1}$	1	2	3	Aver	1	2	3	Aver
0	10	16	15.33	**13.77a**	11.33	14	13.33	**12.88**
10 DAP 15	9.33	14.33	15	**12.88ab**	12.66	15.66	13.33	**13.88**
10	11.66	13	13.66	**11.88b**	11.33	14	13.66	**13**
20	10	13.66	14.33	**13.22ab**	11.33	15.66	14.33	**13.77**
Aver	**10B**	**14.25A**	**14.58A**		**11.66C**	**14.83A**	**13.66B**	

	Oat leaf count				Triticale leaf count				Wheat leaf count			
	Harvest time				Harvest time				Harvest time			
Urea kg da $^{-1}$	1	2	3	Aver	1	2	3	Aver	1	2	3	Aver
0	4	5	3	**4b**	4.66	5.66	5.33	**5.22a**	4.66	5	4.66	**4.77**
10 DAP 15	4.66	5	4	**4.55a**	5	4	3.66	**4.22b**	4.66	5	3.33	**4.33**
10	4	4.33	3.33	**3.88b**	5.33	5.66	4	**5a**	4.66	5	4	**4.55**
20	4	4.33	4	**4.11b**	5	5.66	4	**4.88a**	4.66	4.66	3.66	**4.33**
Aver	**4.16B**	**4.66A**	**3.58C**		**5A**	**5.25A**	**4.25B**		**4.66A**	**4.91A**	**3.91B**	

There is a significant difference between the means indicated by different letters in the same row or column ($P < 0.05$) ($P<0.05$

Table 5. Average Values of Different Harvest Times and Different Urea Dosages Regarding the Leaf Size of the Creals (cm) in the Mixture

	Oat leaf height				Triticale leaf height				Wheat leaf height			
	Harvest time				Harvest time				Harvest time			
Urea kg da $^{-1}$	1	2	3	Aver	1	2	3	Aver	1	2	3	Aver
0	13.16	19.93	18.66	**17.25b**	22.66	23	20.66	**22.11c**	26.33	26.66	24.33	**25.77a**
10 DAP 15	19.83	25.66	25	**23.5a**	27	29	29.66	**28.55a**	25	26.66	25.66	**25.77a**
10	18.33	19	18.8	**18.71b**	15.66	19.53	16.83	**17.34d**	20.5	23.83	19.66	**21.33b**
20	18.66	19.5	18.66	**18.94b**	19.5	28.10	27.66	**25.08b**	21.66	27.76	25.5	**24.97a**
Aver	**17.5B**	**21.02A**	**20.28A**		**21.20B**	**24.90A**	**23.70A**		**23.37B**	**26.23A**	**23.79B**	

There is a significant difference between the means indicated by different letters in the same row or column ($P < 0.05$)

While the difference between oats stalk thickness and applications was not significant, the thinnest stalk thickness was realized in the control group (2.63 mm). While the effect of harvest time was significant ($P < 0.05$) in all plants, stem thickness of Oat and Triticale plants decreased significantly (3.70-4.08 mm) as the harvest time was delayed (Table 6). As the harvest time was delayed, stem thickness values generally decreased.

The stem thickness of the feed pea was similar to the results of some researchers (Sevim, 2013;

Ömeroğlu, 2016) higher than the results of Yolcu et al. (2009) and lower than the results of Doğan (2013).

The Hungarian vetch has been higher than the results of Bağcı (2010). While oat plant stem thickness from cereals was higher than the results of some researchers (Çeri, 2019; Çalışkan and Koç; 2019), it was determined to be similar to the stem thickness found by Yolcu et al. (2009) and lower than the results of Sevim (2013). While the stem thickness of Triticale and Wheat plants were found to be lower than the value determined by Sevim (2013), it was determined that the Triticale plant stem thickness was similar to the values found by Yolcu et al. (2009) and the wheat plant by Doğan (2013).

Table 6. Average Values of Different Harvest Times and Different Urea Dosages Regarding Stem Thickness (mm) of Feed in the Mixture

	Forage pea stalk thickness				**Hungarian vetch stalk thickness**			
	Harvest time				**Harvest time**			
Urea kg da $^{-1}$	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	1.06	4.66	4	**3.24**	1.7	4	3.66	**3.12ab**
10 DAP 15	1.1	4	3.66	**2.92**	1.6	5	4.33	**3.64a**
10	1.4	4.33	4.16	**3.3**	1.23	3.33	3	**2.52c**
20	1.6	4	3.33	**2.97**	1.7	3	3.33	**2.67bc**
Aver	**1.29B**	**4.25A**	**3.79A**		**1.55B**	**3.83A**	**3.58A**	

	Oat stalk thickness				**Triticale stalk thickness**				**Wheat stalk thickness**			
	Harvest time				**Harvest time**				**Harvest time**			
Urea kg da $^{-1}$	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	1.23	3.33	3.33	**2.63b**	1.13	5	4.33	**3.48**	1.36	4.6	4	**3.34**
10 DAP 15	1.13	4.66	3.36	**3.15a**	1.3	4.83	3.33	**3.15**	1.43	4.4	4	**3.27**
10	1.4	4.66	3.36	**3.24a**	1.16	5	4.16	**3.44**	1.46	5	5	**3.82**
20	1.36	4.66	4.16	**3.4a**	1.23	4.33	4.5	**3.35**	1.36	5	4,83	**3.73**
Aver	**1.28C**	**4.33A**	**3.70B**		**1.20C**	**4.79A**	**4.08B**		**1.40B**	**4.76A**	**4.45A**	

There is a significant difference between the means indicated by different letters in the same row or column (P <0.05)

Leaf / Stalk Ratio

The effect of different harvest times and different urea doses on the leaf/stalk ratio of feeds in the mixture is given in Table 7. Among the different applications, it was determined that the leaf stalk ratio was higher and significant in the field where 10 DAP 15 Urea kg da $^{-1}$ was applied in Feed pea, Hungarian vetch, Oat, and Wheat plants (P <0.05). The leaf/stalk ratio of the triticale plant did not differ between applications (P> 0.05). The leaf / stem ratios of oat and Hungarian vetch were similar in the control group and the second group of urea application, and they were higher than the other applications, and the difference was significant (P <0.05). The effect of harvest time on the leaf/stalk ratio is significant (P <0.05) in the plants included in the fives feed mixture, and it was observed that the leaf/stem ratio of Feed pea, Hungarian vetch, and Wheat plants decreased as the harvest time was delayed. While the feed pea leaf/stalk ratios are similar to the values reported by Özyiğit and Bilgen (2006), Sevim (2013), they are lower than the values reported by Doğan (2013). Oat, Triticale, and Wheat plant leaf/stalk ratios are lower than the values determined by Sevim (2013), Oat leaf/stalk ratios are similar to the rates specified by Çeri (2019) and Wheat leaf/stalk ratios are lower than those stated by Doğan (2013).

Table 7. Average Values of Different Harvest Times and Different Urea Dosages Regarding the Leaf/Stalk Ratio (%) of the Feed in the Mixture

	Foraged pea leaf/stalk				**Hungarian vetch leaf/stalk**			
	Harvest time				**Harvest time**			
Urea kg da^{-1}	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	0.96	1.42	0.98	**1.12c**	0.93	1.32	1.30	**1.19a**
10 DAP 15	1.28	2.46	1.65	**1.80a**	1.13	1.27	1.19	**1.19a**
10	1.86	2.01	1.13	**1.67ab**	0.77	1	0.69	**0.82b**
20	1.19	1.41	1.14	**1.25bc**	1	1.83	0.88	**1.24b**
Aver	**1.32B**	**1.82A**	**1.22B**		**0.96B**	**1.35A**	**1.02B**	

	Oat leaf/stalk				**Triticale leaf/stalk**				**Wheat leaf/stalk**			
	Harvest time				**Harvest time**				**Harvest time**			
Urea kg da^{-1}	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**	**1**	**2**	**3**	**Aver**
0	0.31	0.57	0.52	**0,47a**	0.12	0.24	0.23	**0.20**	0.24	0.21	0.18	**0.21ab**
10 DAP 15	0.35	0.67	0.44	**0,49a**	0.13	0.24	0.25	**0.21**	0.22	0.26	0.21	**0.23a**
10	0.20	0.31	0.17	**0,23b**	0.21	0.26	0.18	**0.22**	0.16	0.18	0.15	**0.16b**
20	0.25	0.31	0.25	**0,27b**	0.10	0.23	0.13	**0.15**	0.17	0.28	0.15	**0.22ab**
Aver	**0.28B**	**0.46A**	**0.34AB**		**0.14B**	**0.24A**	**0.19AB**		**0.20AB**	**0.23A**	**0.17B**	

There is significant difference between the means indicated by different letters in the same row or column (P <0.05)

Herbage and Hay Yields

The effect of different harvest times and different urea doses on the herbage and hay yields of the five-forage mixture is given in Table 8.

The highest herbage yield of the feed mixture was 50% (2nd harvest) in the flowering period (3352.7 kg da^{-1}) of the forage pea. As the harvest time was delayed, herbage yield decreased. The difference between herbage yield rates at harvest time of forage was found to be significant (P <0.05). The effects of control group and other urea applications on herbage yield of mixed forage plants were the same.

Among the applications, the highest rate of herbage yield (3712 kg da^{-1}) was observed in the field where 10 DAP 15 Urea kg da^{-1} was applied. The difference between this ratio and other applications was significant (P <0.05).

The average values (2731.33 - 2933.66 - 3000.77 - 3712 kg da^{-1}) among herbage yield applications are higher than the mixture herbage yield determined by some researchers (Kara, 2016; Yücel, 2019), lower than some values (Doğan, 2013; Sevim, 2013; Tükel et al., 1991), Tükel and Hatipoğlu (1987) were found to be similar to the value of herbage yield.

While the differences between hay yield in the feed mixture at different harvest times were significant (P <0.05), there was no difference between the applications (P> 0.05). Second and third harvest time hay yield (1094.50 kg da^{-1}, 1057.94 kg da^{-1}) was higher than the first harvest time hay yield (487.41 kg da^{-1}). It has been observed that hay yield increases as the harvest time is delayed. These results were found to be higher than the average hay yield in studies conducted with mixed fodder crops (Kaya, 2012;

Şimşek, 2015; Kara, 2016; Yücel, 2019) and similar (Yavuz and Karadağ, 2016).

Plant height, leaf branch/leaf number, leaf length, stalk thickness, leaf/stalk ratio, herbage yield values and hay yield of the five-feed mixture in the study are different from the values obtained from the studies on this subject, climate change, soil structure difference, feed It is thought that the mixture ratio and variety difference is due to the irrigation time, the number of irrigation and the different types and ratios of fertilizers applied to the soil.

Table 8. Average Values of Herbage and Hay Yield (kg da^{-1}) of Five Forage Mixture at Different Harvest Times and Different Urea Doses

	Herbage Yield (kg da^{1})				Hay Yield (kg da^{1})			
	Harvest time				Harvest time			
Urea kg da^{1}	1	2	3	Aver	1	2	3	Aver
0	2296	3248	2650	**2731.33b**	353.52	1175.72	964.03	**831.09**
10 DAP 15	3686	4000	3450	**3712a**	574.16	1453.94	1169.29	**1065.80**
10	2100	3413	3288	**3000.77b**	651.48	919.53	1063.60	**878.20**
20	1573	2750	2615	**2933.66b**	370.48	828.83	1034.83	**744.71**
Aver	**2413.7B**	**3352.7A**	**3000.7AB**		**487.41B**	**1094.50A**	**1057.94A**	

There is a significant difference between the means indicated by different letters in the same row or column (P <0.05)

5. Conclusion

In Erzincan Province and similar ecologies, depending on the soil content in the sowing of the livestock forage mixture, 10 DAP 15 Urea kg da $^{-1}$ application gives the best results in terms of the agronomic properties and green herbage yield of the plants, the most appropriate harvest time is seen as a decrease in the values by delaying the harvest time. It was observed to be in the 50% flowering period. It is thought that similar studies should be done in different ecologies.

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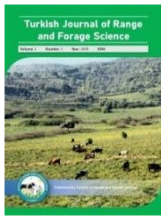

Effect of Quinoa-Corn Intercropping Production System on Yield and Quality of Mixture Silage

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The experiment was conducted on Adnan Menderes University, Agriculture Faculty of the farm under the Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) in 2019 and 2020. In addition to corn and quinoa parcels, 3 different mixtures (25% quinoa - 75% corn, 50% quinoa - 50% corn and 75% quinoa - 25% corn) were determined. The field experiment was carried out in a randomized block design with three blocks as replication. Periodic (approximately 20 daily) measurements (plant height, stem diameter, and chlorophyll amount) were made during the plant growth period. Green and dry grass yield values and some silage quality measurements (ADF, NDF, protein, fiber, and ash rate) were made at harvest date when the corn plant reached the dough maturity stage period (1/4 milk line). As a result of the study, it was determined that corn has serious adverse effects on quinoa during the plant growing and quinoa had also some negative effects on corn. None of the mixture treatments (25%, 50%, or 75% quinoa) containing quinoa plant showed as high green and dry grass yield values as 100% corn. However, all mixtures containing quinoa have shown that higher-quality grass (especially high protein rate) can be produced. Moreover, ADF and NDF values obtained from the mixtures also showed some positive changes. So, the results showed that quinoa can increase the quality of feed in some amount in the mixtures. It can necessary to do more studies on the subject in the future.

1. Introduction

According to statistics data of Turkey, the number of cattle has reached approximately 18 million heads and the number of sheep and goats has reached approximately 50 million heads (Anonymous, 2020). Although these figures seem to be sufficient for our country, the yield from animals (meat, milk, etc.) is insufficient.

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To increase productivity, fattening should be done with high-quality feed with high nutritional content. However, feed expenses constitute the biggest expense of livestock businesses. Feed expenses reach up to approximately 70% of total operating expenses in some branches of the livestock business (Arslan and Erdurmus, 2012). The high production costs of animal products (especially feed costs) are directly reflected in the sales prices of all animal products (milk, cheese, butter, etc.), especially meat.

Quality feed production, which is one of the most important costs of livestock enterprises in our country; every year about 11 million tons of agricultural land, grassland areas of about 10 million tons are produced as 21 million tons in total. Considering our animal assets and the amount of grass produced, it is understood that the amount of roughage deficit is approximately 51 million tons. Nowadays this open stalk, straw, and husk, etc. Although it is tried to be supplied from roughages with low feed value or intensive/mixed feed sources, it is not sufficient (Topcu and Ozkan, 2017). One of the most important problems to be solved in the development of our country's livestock is to meet the need for high quality, cheap and abundant roughage regularly. Roughages are indispensable feed sources in animal husbandry and it is a fact that there is a serious shortage of quality roughage in livestock farming in our country.

Quinoa plant, which is mostly used in human nutrition, is a dioctyl and one-year plant from the family of goose fats or spinach, and its main homeland is South America (Kaya & Karaer, 2017). Quinoa seeds are an extremely valuable foodstuff with high carbohydrate, quality protein, fat, fiber, vitamin, and mineral content (Keskin and Kaplan Evlice, 2015). It is thought that a plant with such a rich nutrient content can be an alternative feed plant that can increase the quality of roughage production. If this plant can be grown with corn, even if the green grass yield decreases slightly, the loss in yield can be compensated by the product quality. This project aims to determine the amount of grass to be obtained (green and dry weight) by planting quinoa plants at different rates together with the corn plant and to observe the nutritional value (protein rate, fiber rate, ash rate, ADF, and NDF) changes of the obtained grass. Also, with this project, the responses of different field crops under living conditions were measured (Plant height, stem thickness, chlorophyll). Thus, the quinoa (*Chenopodium quinoa* Willd.) plant, which has gained popularity in our country in recent years, can be considered as an alternative plant in animal nutrition due to its rapid growth and easy cultivation.

2. Material and Method

The experiment was conducted on Adnan Menders University Agriculture Faculty Farm under the Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) during the summer plant production season of 2019 and 2020.

The field experiment was conducted in a Randomized Complete Block Design double factor (treatment and year) with three blocks as replication. Five different treatments were determined within the scope of the experiment. In addition to the whole corn (100% corn) and quinoa (100% quinoa) parcels named as standard, the proportional mixtures (25%, 50%, and 75%) of these two plants have provided other three different treatments. "25% quinoa - 75% corn" treatment was made by growing one-row quinoa and three rows of corn in four rows of parcels. Similarly, mixtures of "50% quinoa-50% corn" and "75% quinoa-25% corn" were made by growing two rows quinoa - two rows corn and three rows quinoa - one-row corn, respectively. For each parcel (100% corn, 100% quinoa, 25% corn - 75% quinoa, 50% corn - 50% quinoa and 75% corn - 25% quinoa) were planned as 280 m^2 with 10 m row length and 3 repetitions.

The results of the analysis of soil taken from the experiment area (Table 1) were examined. It was determined that the land on which the experiment was established had a sandy loam structure, the amount of organic matter is low and the reaction is alkaline. Besides, the results were obtained that amount of potassium was low but, the amount of phosphorus was high.

The average temperature, precipitation, and average values for long year's dates in Aydın/Koçarlı during the 2019-2020 crop growing period were shown in Table 2. It was seen that the average temperatures of all months of 2019 (except June) were found to be lower than those measured in 2020. Furthermore, it was said that the summer period of 2019 (from April to September) was rainier than in 2020. So, it was generally interpreted in terms of average temperature and precipitation amounts that the summer season of 2019 (from April to September) was colder and humid.

Table 2. Weather conditions of two years of the experiment

Months	Temperature (°C)			Precipitation (mm)		
	2019	2020	Many years	2019	2020	Many years
April	15.8	16.5	15.7	59.2	43.8	45.5
May	22.4	23.6	20.9	8.3	40.3	33.5
June	25.6	24.1	25.9	97.7	8.7	14.0
July	26.6	27.7	28.4	0.2	1.4	3.5
August	27.2	28.9	27.2	0.0	0.7	2.2
September	22.1	25.7	23.2	11.8	0.0	14.4

Considering the plant growth and development periods, agricultural processes such as top fertilization, intermediate hoe, and irrigation were applied. Fertilization took place in two stages. First fertilization (safe 80 kg/ha N, P, and K applied as 15-15-15 compound fertilizer) was carried out in the determined field area before sowing. Then, sowings were carried out (03.05.2019 - 25.05.2020) when soil and weather conditions were suitable. Emergency dates of the corn plant were recorded as 10.05.2019-30.05.2020 and the quinoa plant as 14.05.2019-04.06.2020. The top fertilization process with urea performed during the study (safe 150 kg/ha N) was carried out on 03.06.2019-15.06.2020. At regular weekly intervals, the roads around the parcels were sent manually. The drip irrigation method was envisaged for irrigation. Thus, it was contributed to the reduction of weed damage.

Table 1. Soil analysis results

Soil texture (%)			pH	Organic Matter (%)	P (ppm)	K (ppm)
Sand	Mile	Clay				
72	16.7	11.3	8.0	1.91	21	176
Sandy loam			High	Low	High	Low

Measurements

Periodic measurements and harvest (for silage)

During the study, periodic (approximately 20 daily) measurements (plant height, stem diameter, and chlorophyll amount) were made. The first sampling dates were done on 07.06.2019 - 19.06.2020. This was followed by sampling in 20-day periods in two years and the last sampling dates were done on 05.08.2019 - 23.08.2020. Plant height, stem thickness, and chlorophyll rate measurements were measured with a wooden meter (ruler of 300 cm), an electronic caliper (Mitutoyo digital 500-181-30, 0.01 mm precision), and a chlorophyll meter (SPAD 502 Plus) (Uddling et. al., 2007).

Harvest was carried out (08.08.2019 - 27.08.2020) when the corn plant reached the dough maturity stage period (1/4 milk line). The harvesting process was carried out by manually cutting the middle part from the soil surface after leaving the edge effects of the two rows in the middle of each parcel (6 * 1.4 = 8.4 m^2). Yields (green weight) were calculated by converting the figures obtained (green and dry weight). The obtained material from parcels was sampled and dried in an oven (48 hours at 70 ^{o}C, Perry and Compton, 1977). Using the obtained results for calculation, dry yield (dry weight) was tried to be determined.

Quality measurements (ADF, NDF, protein, fiber, and ash rate)

Samples were ground after the material obtained from the parcels was weighed. NIRS-FT (Bruker MPA) instrument was used for silage quality analyzes (protein, ADF, NDF, ash, and fiber), in the TARBIYOMER laboratory of Adnan Menderes University. For measurements, a sample with a depth of 2.8 cm was placed in the chamber of the instrument, approximately 9 cm in diameter, and analyzes were performed (Gislum et. al., 2004).

Measurements obtained from experiment repetitions were analyzed (variance analysis) using the TARIST package program according to the random blocks trial design (Acikgoz et. al., 2004). A comparison of the averages was made using LSD (0.05).

4. Results and Discussions

Two main results were emphasized within the scope of the study. The first of these was to determine the effects of intercrop production rates on plants during the vegetation period. For this purpose, when the plants reach a certain growth level, plant height, chlorophyll, and stem thickness values were measured in certain periods (about 20 days). The results and LSD values (mixture*variety) calculated with variance analysis were given in Table 3. The second was to determine the changes in the final product (green and dry grass) obtained as a result of intercrop production. In addition to green and dry weight values, some quality characteristics (protein rate, fiber rate, ash rate, ADF, and NDF) of the grass were determined. The results and LSD values (mixture*year) calculated with variance analysis were given in Table 4.

Table 3 shows that the first measurements during the growing period of corn were made on 07.06.2019 and 25.06.2020. The maximum corn plant height values were given as 136.2 cm (75% quinoa - 25% corn) in the first year and 162.3 cm (50% quinoa - 50% corn) in the second year. Similarly, the maximum quinoa plant height values were appeared to 82.3 cm by 2019 (100% quinoa) and 93.6 cm (75% quinoa - 25% corn) by 2020. The maximum Chlorophyll values of corn and quinoa were determined 75% quinoa - 25% corn parcel as 55.8 and 52.2 in 2019 respectively. The values were determined as 56.5 (25% quinoa - 75% corn) in the corn plant and 56.6 (75% quinoa - 25% corn) in the quinoa in 2020. “75% quinoa - 25% corn” parcel gave the highest values of stem thickness in both plants in both years (except quinoa (16,3 mm) in 2020). The maximum stem thickness measured corn as 29.2 mm (2019) and 25.0 mm (2020) and quinoa as 13.9 mm (2019).

The next measurements of the experiment were made on 28.06.2019 and 15.07.2020. The maximum corn plant height values were given as 266.0 cm (75% quinoa - 25% corn) in the first year and 231.0 cm (100% corn) in the second year. Similarly, the maximum quinoa plant height values were appeared to 134.7 cm by 2019 (75% quinoa - 25% corn) and 178.8 cm (50% quinoa - 50% corn) by 2020. The maximum Chlorophyll values of both plants were reported as 63.2 for corn and 63.6 for quinoa in 2019 at 75% quinoa - 25% corn parcel. The values were determined as 57.9 (50% quinoa - 50% corn) in the corn plant and 60.7 (100% quinoa) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 28.8 mm (100% corn) for 2019 and 27.2 mm (75% quinoa - 25% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 13.8 mm (50% quinoa - 50% corn) in 2019 and 19.6 (100% quinoa) in 2020.

The third measurement of the experiment was made on 17.07.2019 and 03.08.2020. The maximum corn plant height values were determined as 284.0 cm in the first year and as 260.8 cm in the second year at 100% corn parcel. The maximum quinoa plant height values were appeared to 145.0 cm by 2019 (100% quinoa) and 182.8 cm (50% quinoa - 50% corn) by 2020. The maximum Chlorophyll values were reported as 60.6 (75% quinoa - 25% corn) for corn and 55.1 (100% quinoa) for quinoa in 2019. The values were determined as 64.8 (100% corn) in the corn plant and 60.3 (50% quinoa - 50% corn) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 30.7 mm (100% corn) for 2019 and 21.4 mm (75% quinoa - 25% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 16.5 mm (100% quinoa) in 2019 and 17.2 (25% quinoa - 75% corn) in 2020.

The last measurements of the experiment were made on 05.08.2019 and 19.08.2020. The maximum corn plant height values were given as 296.5 cm (100% corn) in the first year and 261.0 cm (100% corn) in the second year. The maximum quinoa plant height values were appeared to 159.0 cm by 2019 (100% quinoa) and 200.2 cm (75% quinoa - 25% corn) by 2020. The maximum Chlorophyll values were reported as 60.1 (75% quinoa - 25% corn and 100% corn parcels) for corn and 55.9 (100% quinoa) for quinoa in 2019. The values were determined as 60.5 (100% corn) in the corn plant and 58.2 (50% quinoa - 50% corn) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 29.6 mm (100% corn) for 2019 and 22.0 mm (50% quinoa - 50% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 15.9 mm (100% quinoa) in 2019 and 18.0 (25% quinoa - 75% corn) in 2020.

Table 3. Plant height, stem diameter, and chlorophyll amount values obtained from plants at the sampling dates throughout the study

Years			2019			2020		
Dates	Mixture	Variety	Plant height (cm)	Chlorophyll	Stem diameter (mm)	Plant height (cm)	Chlorophyll	Stem diameter (mm)
07.06.2019 – 25.06.2020	100% Quinoa		82.3	51.0	13.7	91.7	56.4	16.3
	100% Corn		134.4	53.1	29.1	162.2	51.1	21.9
	75% Quinoa - 25% Corn	Quinoa	81.5	52.2	13.9	93.6	56.6	15.3
		Corn	136.2	55.8	29.2	156.7	55.9	25.0
	50% Quinoa - 50% Corn	Quinoa	80.8	48.6	13.5	85.2	52.5	13.9
		Corn	126.3	55.4	27.3	162.3	56.0	22.6
	25% Quinoa - 75% Corn	Quinoa	58.8	45.1	10.2	90.1	53.1	14.7
		Corn	133.4	48.7	25.8	161.0	56.5	20.3
28.06.2019 – 15.07.2020	100% Quinoa		132.8	59.1	13.3	153.6	60.7	19.6
	100% Corn		258.0	61.5	28.8	231.3	57.3	24.6
	75% Quinoa - 25% Corn	Quinoa	134.7	63.6	12.4	145.2	57.4	18.0
		Corn	266.0	63.2	25.8	202.8	56.8	27.2
	50% Quinoa - 50% Corn	Quinoa	130.3	55.3	13.8	178.8	58.1	16.7
		Corn	237.3	56.9	26.2	202.3	57.9	26.4
	25% Quinoa - 75% Corn	Quinoa	122.5	52.6	11.6	132.0	58.9	16.2
		Corn	260.5	58.4	26.3	211.7	57.6	27.1
17.07.2019 – 03.08.2020	100% Quinoa		145.0	55.1	16.5	182.4	50.4	16.6
	100 % Corn		284.0	60.1	30.7	260.8	64.8	18.3
	75% Quinoa - 25% Corn	Quinoa	140.5	51.7	15.3	174.6	56.6	17.0
		Corn	265.3	60.6	24.1	226.9	57.7	21.4
	50% Quinoa - 50% Corn	Quinoa	132.5	55.0	14.8	182.8	60.3	16.0
		Corn	255.5	54.8	27.0	226.7	47.2	20.5
	25% Quinoa - 75% Corn	Quinoa	133.8	53.6	12.5	143.1	53.2	17.2
		Corn	276.0	54.7	25.7	222.7	59.6	19.1
05.08.2019 – 19.08.2020	100% Quinoa		159.0	55.9	15.9	188.3	57.4	17.1
	100% Corn		296.5	60.1	29.6	261.0	60.5	18.6
	75% Quinoa - 25% Corn	Quinoa	145.0	51.5	14.1	200.2	53.4	17.4
		Corn	270.3	60.1	25.2	225.0	57.6	18.3
	50% Quinoa - 50% Corn	Quinoa	141.8	53.6	15.5	193.6	58.2	16.4
		Corn	261.3	53.6	26.6	242.7	50.8	22.0
	25% Quinoa - 75% Corn	Quinoa	144.0	52.9	11.9	163.4	55.0	18.0
		Corn	289.0	56.4	26.0	258.2	58.7	20.4
LSD mixture*variety (0.05)			47.0	1.48	0.61			

Table 4. Green and dry grass and quality parameters

Years	2019							2020						
Mixtures	Green grass (kg ha^{-1})	Dry grass (kg ha^{-1})	ADF	NDF	Protein (%)	Fiber (%)	Ash (%)	Green grass (kg ha^{-1})	Dry grass (kg ha^{-1})	ADF	NDF	Protein (%)	Fiber (%)	Ash (%)
100% Quinoa	38868	16490	34.4	43.3	18.2	4.1	1.6	65271	19880	31.9	37.8	16.0	3.2	2.9
100% Corn	91253	41287	37.1	55.0	8.3	4.3	1.2	84953	28388	26.6	32.8	9.0	1.6	1.6
75% Quinoa - 25% Corn	68735	30404	33.5	48.8	13.9	3.8	1.6	59946	22724	31.7	40.1	13.6	5.4	2.6
50% Quinoa - 50% Corn	67843	31877	36.6	49.3	12.5	4.3	1.2	35895	20922	32.1	37.1	14.0	1.3	2.2
25% Quinoa - 75% Corn	89638	43069	35.6	49.2	11.3	4.0	1.3	44598	24567	34.9	40.2	12.8	1.8	1.8
LSD mixture*year (0.05)	6232	2983	3.2	4.4	2.7	0.3	0.2							

It can be concluded that the plants do not suppress each other intensely at the beginning of the vegetation period (first measurement time) from the overall Table 3. But corn had a negative effect on quinoa plant height and stem thickness in later periods (second, third, and fourth samples). Moreover, according to the chlorophyll averages measured periodically throughout the study, quinoa chlorophyll values measured in almost all treatments (except for some 25% corn and 50% corn treatments) where corn entered the mixtures were lower than 100% quinoa (especially in all 75% corn treatments). The low concentration of chlorophyll directly limits the photosynthetic potential and primary production (Curran et al., 1990). Additionally, calculating the chlorophyll content can be an alternative way of measuring the nutritional status of the plant (Filella et al., 1995). As pigmentation is directly related to plant stress physiology, while the concentration of carotenoids increases under stress, the concentration of chlorophyll decreases (Peñuelas and Filella 1998). Corn plants put stress on quinoa plants and the result was predictable prior to the study, but it was an interesting another result of the study that quinoa has also a negative effect on corn plant height and stem thickness. Although it was thought that corn can crush quinoa with a plant height approaching 3 meters, it has been observed that the corn was partially affected (shortening, stalk thinning, and fluctuations in chlorophyll values) in almost all mixing treatments (starting from 25%) added quinoa.

Green and dry grass yield values calculated by harvesting and drying of green grass of parcels at the end of the study were given in Table 4. Also, some quality parameters such as ADF, NDF, Protein (%), fiber (%), and ash (%) were given. It was observed that the mixture treatments affected green and dry grass yields and quality parameters when the values obtained from the study were examined in general (Table 4). The difference between mixtures was found to be significant in all measured parameters. The highest green grass yield was determined as 91253 kg/ha (100% corn) in 2019. It was followed up with 25% quinoa - 75% corn treatment, which yielded 89638 kg/ha. Treatments (100% corn and 25% quinoa - 75% corn) were also given the highest dry grass values (41287 kg ha^{-1} and 43069 kg ha^{-1} respectively). The highest average green grass yield was given as 84953 kg ha^{-1}in 2020.

The highest value of dry grass value was recorded as 28388 kg ha^{-1} in 2020. Similar to the first year (2019), 100% corn treatment showed the highest green and dry grass yield. But, 25% quinoa - 75% corn treatment was not performing like the first year of the experiment. The maximum ADF average in the first year of the study was measured 100% corn treatment. Similarly, the maximum NDF values were obtained from 100% corn parcels in the same year (2019). But, in the second year of the study, different results were obtained from the first year. The maximum ADF and NDF averages were obtained from 25% quinoa - 75% corn treatment in 2020. The highest protein content values (18.2% for 2019 and 16.0% for 2020) were obtained from quinoa (100% quinoa) in both years of the study. Similarly, the treatment gave the highest ash content values (1.6% for 2019 and 2.9% for 2020) in both years. However, fiber rate values show some differences. The maximum fiber rate value (4.3%) was measured from 2 different treatments (100% corn and 50% quinoa - 50% corn) in the first year of the experiment, while the maximum fiber rate value (5.4%) in the second year was measured from 75% quinoa - 25% corn treatment.

In parallel with many previous studies, 100% corn showed the highest values of green and dry grass (Koca et al., 2010; Koca and Erekul, 2016). Baghdadi et al. (2016a) reported that the crop combination rate significantly affected the total dry matter yield of corn-soybean feed in their study. Among the corn and soybean monocropping and corn-soybean intercropping, reported that the total dry matter yield of corn (1477 kg ha^{-1}) was the highest value. Similarly, Stoltz et al. (2013) in their studies, sole corn had a higher dry matter yield (by 44-57%) than intercropped corn. Other studies have shown similar results corn included in the intercropping systems significantly increased dry matter yield (Kizilsimsek et al., 2020; Javanmard et al., 2009; Geren et al., 2008; Azim et al., 2000). This study yielded similar results to those of the other studies. However, the lowest protein content value was also measured from the same treatment. In almost all treatments where quinoa was added to the mixture, decreases in green and dry grass yield were observed. Similar results have been observed in the literature in the mixture treatments with corn. Tansi (1987) determined that the crude protein rate of corn in co-cultivation is higher than in lean cultivation, which is consistent with our results. Ibrahim et al. (2006) have conducted in their study, corn and cowpea seeds mixed in various combinations affected protein production, where the increasing rate of cowpea in the seed mixture increased the crude protein concentration. While sole cowpea produced more protein (18.10%), corn monocropping produced lower (8.5%). The 75:25 crop combination of corn and cowpea produced more protein (10.45%) than a sole corn crop. Result of another study, protein content was significantly affected by crop combination rate and declined with a decrease in the proportion of soybean from 16.24% to 9.91% Baghdadi et al. (2016b). Accordingly, our study similar results included. The most dramatic result from the study that the protein rates were noticeably increased in almost all quinoa mixture treatments every two years. In addition, quinoa improved the ADF and NDF values (especially in the first year of the study) measured in almost all of the different mixtures. There have been many studies advocating the necessity of high protein rate and balanced of ADF and NDF values in roughage production. ADF is mostly a feed value used to determine the digestibility status of roughage by the animal, while NDF is a feed value used to determine the availability of roughage by animals (Sayar et al., 2018). Some researchers emphasized that ADF and NDF values should be as low as possible for good forage quality (Lacefield, 1988; Schroeder, 1994; Sayar et al., 2018). According to the studies conducted with NDF and ADF concentration, the lowest values were found in monocropping corn silage, followed by the silages of the intercropping systems (Souza et al., 2019). There was revealed that all quinoa varieties examined had a quality fiber content in terms of NDF (36.48-39.86%) and ADF (19.46-23.45%) rate (Temel and Tan, 2020). Quinoa may be recommended to improve the quality of feed. It may even be argued that it can be tolerated yield losses with good farming practice conditions.

5. Conclusion

The results of the corn-quinoa mixture experiment conducted under Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) in the summer plant production season in 2019 and 2020 were given below as follows.

- In addition to the significant negative effects of a corn plant on quinoa (plant height, chlorophyll rate, and stem thickness) especially in the later growth and development periods (second, third and fourth measurements), some negative effects of quinoa on corn (plant height and stem thickness) were determined.

- None of the mixture treatments (25%, 50%, or 75% quinoa) containing quinoa plant or any of the 100% quinoa parcels showed as high yield values as green and dry grass yields from 100% corn. However, all mixtures containing quinoa (25%, 50%, or 75% quinoa) and 100% quinoa parcels have shown that higher-quality grass can be produced. In both years, a significant increase was observed in the protein rate of all mixtures parcels containing quinoa. ADF and NDF values also showed some positive changes.

Although many results have been obtained from an intercrop study in two years, measuring more grass quality parameters (dry matter content changes between periodic measurements, digestible energy, metabolizable energy, oil rate, and mineral nutrient contents) will give more accurate and available results about farming practices. Furthermore, the effects of plant mixtures on soil structure can be determined with soil samples taken from the experiment area. Also, conducting the study in different locations to see the ecological impacts can be seen as a good idea during the next years.

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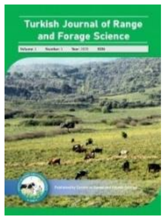

Effect of Nitrogen Fertilization on Growth and Forage Yield of Sorghum [*Sorghum bicolor* (L.) Moench.] under Takhar Agro-Ecological Conditions

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A field experiment was carried out at Bagh-e-Zakhera research station, Takhar province of Afghanistan during 2020 to assess the effects of nitrogen (N) fertilization on growth and forage yield of sorghum under Takhar agro-ecological conditions. The experiment was laid out in randomized complete block design, using 4 replications. There were four levels of nitrogen N1 (control), N2 (50 kg N ha^{-1}), N3 (75 kg N ha^{-1}), and N4 (100 kg N ha^{-1}). The result of this research indicated that N fertilization significantly increased all growth parameters and forage yield of sorghum over control. Among the different levels of N fertilizer, application of N4 significantly enhanced the growth parameters such as plant height (245.26 cm), number of leaves (10.15 $plant^{-1}$), leaf area (3536.80 cm^2 $hill^{-1}$), dry matter accumulation (240.10 g $plant^{-1}$) at 90 days after sowing. Forage yield was significantly enhanced with increase in level of N fertilization and application of N4 resulted in the production of highest forage yield (6217.55 kg ha^{-1}). Whereas, no significant differences were detected with N4 and N3 treatments for stover yield. The crop growth rate of sorghum was significantly influenced by N fertilization, and the highest value for crop growth rate (69.09 g $plant^{-1}$ day^{-1}) was obtained with N4 treatment. From the results of this study, it was concluded that the growth and forage yield of sorghum can be enhanced with the application of 100kg of N ha^{-1} under agro-ecological conditions of Takhar province of Afghanistan.

1. Introduction

Sorghum forage is the basic feed for livestock and especially valuable for feeding in all regions of the world. Sorghum fodder, with a little protein supplement, maintains cattle in good condition throughout the winter with little or no gain supplement.

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Sorghum contains a reasonable amount of protein (7.5 10.8%), ash (1.2–1.8%), oil (3.4–3.5%), fiber (2.3–2.7%), and carbohydrate (71.4– 80.7%) with a dry matter ranging from 89.2% to 95.3% (AbdelRahaman et al., 2005). Sorghum stover contains 6.0-6.4% crude protein and 32-36% crude fiber (Sunil Kumar et al., 2012). It is widely grown in the semiarid regions of the world as animal feed, human food, or bioenergy feedstock. Its tolerance to drought and superior adaptation to marginal environments make it an attractive crop in rainfed production systems. Sorghum has adaptive traits for stressful environments and wide genetic variability for traits including tolerance to low nutrient supplies and efficiency in utilizing water and nutrients (Mahama et al., 2014). The great advantage of sorghum is that it can become dormant under adverse conditions and resume growth after a relatively severe drought (Bimbraw, 2013).

Sorghum is also consumed as staple food grain and is used for a variety of products like alcohol, edible oil, sugar, and waxes, etc. It is quite a soft, palatable, and fast-growing annual fodder crop adapted to areas up to 1500 m altitude. However, it remains green and palatable over a longer period than maize and pearl millet fodders (Bimbraw, 2013). High-quality forage is obtained from sorghum under good fertilizer management and a package of practices (Mukherjee and Maiti, 2008). The maximum nutrients in the fodder are available when the crop is cut at 50% flowering to the milk stage. The quality of fodder crop also partly depends on the amount of fertilizer applied to the crop. The Hydrogen cyanide (a poisonous compound to animals) contents in the dried or ensiled sorghum reduce sharply and silage or hay presents no danger to animals (Gupta and Singh, 2018).

Nitrogen (N) fertilizer is known to boost the aboveground biomass yield (Anderson et al., 2013). It plays a critical role in cell division during plant growth (Stals and Inzé, 2001) and the deficit of soil nitrogen leads to lower sorghum biomass due to reductions in leaf area, chlorophyll index, and photosynthetic rate (Mahama et al., 2014). Production of forage sorghum with applying a little amount of N fertilizer is manageable, but this crop displays a great deal of reaction in response to applied nitrogen (Ram and Sing, 2001). In irrigated areas, N fertilizer is very important and is the main factor affecting the dry matter yield of sorghum cultivars; N fertilizers are easily soluble and leachable in most of the soils and increase the forage yield of sorghum varieties (Rahman et al., 2001). Forage sorghum displayed a positive reaction to increasing nitrogen to about 200 kg ha^{-1} but the further application had no effect on yield increase (Gupta and Sing, 1988). Although, sorghum utilizes nitrogen more efficiently than corn and is more resistant to drought and higher temperatures (Young and Long, 2000) inadequacy of N fertilizer reduces the congregation of dry matter and leads to growth reduction (Zhao et al., 2005). Previous research has demonstrated that the application of N increased biomass and productivity of sorghum (Kaizzi et al., 2012). The nitrogen doses 50-200 kg ha-1 contributed to an increase in the crude protein together with an increase in dry matter and/or protein concentration and crude protein increased 59.5-312.9% (Melo et al., 2017).

Takhar province is located in the north-eastern region of Afghanistan. More than half of the province (57%) is mountainous or semi-mountainous terrain, while more than one third (37%) is flat. Double cropping systems of wheat, rice, and cotton in rotation with fodder (alfalfa, maize), legumes (bean), and vegetable crops (potato, tomato) are common in this province. Years of the crisis have led to the loss of markets and households are forced into subsistence farming. The most common livestock in this province is cattle (Sharifi and Bell, 2011).

Research activities have been focused on important cereals in Afghanistan, but less attention was given to the forage crops, particularly sorghum. However, legume forages such as lucerne and clovers were grown in different parts of Afghanistan for centuries. Therefore, the present experiment was carried out to ascertain the effects of nitrogen fertilization rates on growth and forage yield of sorghum under agro-ecological conditions of Takhar province of Afghanistan.

2. Materials and Methods

This research was conducted at Bagh-e-Zakhera Research Station, department of agriculture, Takhar province of Afghanistan during the growing season 2020, to examine the effects of different levels of N fertilization on sorghum growth and forage yield under Takhar agro-ecological conditions. In Takhar, the temperature typically varies from 2°C to 37°C and is rarely below -4°C or above 40°C. The rainy period of the year lasts for 5.2 months (December 3 to May 10), with a sliding 31-day rainfall of at least 13 millimeters. The most rain falls during the 31 days centered around March 20, with an average total accumulation of 34 millimeters. The physical and chemical characteristic of soil is given in table 1.

Table 1. Chemical and physical characteristics of soil.

Physical characteristics			**Chemical properties**				
Texture class	**Clay (%)**	**Sand (%)**	**pH**	**EC (dS/m)**	**Potassium (ppm)**	**Phosphorus (ppm)**	**Nitrogen (%)**
Silty loam	19	24	7.92	0.250	84.66	15.96	0.089

The experiment was carried out in a randomized complete block design with four replications. The experiment was comprised of 4 rates of Nitrogen: N1 (no N application), N2 (50 kg N ha^{-1}), N3 (75 kg N ha^{-1}), and N4 (100 kg N ha^{-1}). The source of N was urea fertilizer. Phosphorus (60 kg P_2O_5 ha^{-1}) was applied to each plot at the time of land preparation.

The area of the experiment was divided into 16 plots (4 x 3.6 m) each. The row spacing was 45cm, and 15 cm distance was kept between the plants. The seeding rate was 10 kg h^{-1}, and seeds of a local variety of sorghum were sown to a depth of 5 cm by hand in the first week of May 2020. Weed control was carried out using a recommended dose of Pendimethalin herbicide. All other agronomic practices were kept uniform for all the treatments. The sampling was done at 45, 60, and 90 days after sowing (DAS). Five plants were taken from each replication randomly to measure plant height, number of leaves per plant, leaf area, and dry matter accumulation.

The height of the plant (cm) was measured from the soil surface to the top of the plant. The number of leaves per plant was counted manually in the field. The area of leaf was measured manually using a ruler and the obtained value was calculated as leaf area (cm^2) $hill^{-1}$. Dry matter accumulation was measured as increase in accumulation of total dry matter (g $plant^{-1}$) over the time.

Forage yield was measured as total fresh weight of plant (kg ha^{-1}) at 90 DAS. To measure the stover yield, samples were collected at 90 DAS and panicles were remove from plants and the leaves and stalks were dried under the sunlight of hot summer for one week and weighed to obtain the stover yield (kg ha^{-1}). Crop growth rate (CGR) was calculated as the plant's dry weight increase per unit of time (Nogueira et al., 1994).

$$CGR = (W2 - W1) / (T2 - T1)$$

Where: W1 and W2 = total dry weight of plant at first and second sampling; T1 and T2= time of first and second sampling.

Statistical analyses were performed using the SPSS statistics package (student version 22). Analysis of variance (ANOVA) was carried out to evaluate the effects of the main factor (Nitrogen levels) on growth and forage yield of sorghum. Less Significant Difference (LSD) was used to estimate the least significant range between means at the probability level of 0.05.

3. Results and Discussion

The response of sorghum plants to different levels of N was significant ($P < 0.05$). Application of N fertilizer significantly affected growth and forage yield of sorghum, and a higher dose of nitrogen enhanced all growth characteristics. Analysis of variance for plant height at 45, 60, and 90 DAS revealed that the effect of N fertilization was significant ($p < 0.05$), and the highest plant height was observed with the application of 100 kg of N ha^{-1} (N4). The significant differences were recorded with the application of various doses of N fertilizer in samples collected at 45, 60, and 90 DAS (Table 2). The increase in plant height by application of higher rates of nitrogen might be due to the increase in the number of nodes and internodal distance (Afzal et al. (2012). Uchino et al. (2013) also reported that plant height enhanced with increased N fertilizer level reported.

The effect of different levels of N fertilization on the number of leaves per plant is presented in Table 2. Significant differences among the various levels of N application were observed during the growing season. The number of leaves per plant gradually increased with an increase in the rate of N fertilizer, and a higher number of leaves was recorded with N4 treatment. The age of the plant also influenced the number of leaves, and more leaves were recorded at 90 DAS. The same trend was reported by Abuswar and Mohammed (1997) who revealed that nitrogen fertilization significantly affects the number of green leaves of fodder sorghum. In another research, Afzal et al. (2012) found that the number of leaves per plant increased steadily with a progressive increase in growth and an increasing dose of N fertilizer.

Table 2. Effects of N fertilization of sorghum plant height and number of leaves (plant^{-1}). [a]

Treatments	Plant height (cm)			Number of leaves per plant		
	45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS
N_1	43.30d	156.70c	182.74d	5.96b	6.42b	7.19c
N_2	52.55c	180.10b	208.15c	6.18b	7.81a	8.22b
N_3	59.07b	186.07b	229.41b	6.85b	8.03a	8.77b
N_4	66.55a	201.33a	245.26a	8.00a	8.66a	10.15a
LSD ($p \leq 0.05$)	4.01	7.36	4.01	0.98	0.90	0.60

[a] *Means followed by the same letters are not significantly different from each other at 5% probability level. LSD (0.05): least significant difference at 5% probability level*. DAS: days after sowing

Analysis of variance showed that N fertilization significantly increased the leaf area of sorghum (Table 3). The increase in the dose of N fertilizer enhanced the leaf area, and a significantly higher leaf area was recorded with N4 treatment. The progress in crop growth also highly affected leaf area as higher leaf area was observed on 90 DAS (Table 3). The application of nitrogen fertilizer was shown to enhance the growth of sorghum as observed in the plant leaf area and leave area index (Olugbemi and Ababyomi, 2016). Application of N fertilizer increased the green leaf area of sorghum but decreased the time of flowering by 5 days (Mahama et al., 2014).

Application of N fertilizer significantly enhanced dry matter accumulation (g plant^{-1}) in sorghum. Plant dry matter gradually increased with an increase in N rate and age of the plant, as the highest dry matter accumulation was recorded with the application of 100 kg N ha^{-1} (N4) at 90 DAS, while the lowest dray matter accumulation was noted with N1 or control (Table 3). Ashiono et al., (2005) revealed that N deficiency can result in reduced dry matter of dual-purpose sorghum. Bebawi (1987) reported that with increasing nitrogen levels in forage sorghum the number of tillers and the leaf area of plants increases and this ultimately leads to a rise in dry matter accumulation. Melo et al., (2017) also found that a higher level of N fertilization contributed to an increase in dry matter.

Mean comparison of nitrogen levels revealed that increasing nitrogen application resulted in an increase in the forage yield. A progressive increase in the forage yield was observed with increase in the rate of N application. The highest forage yield was recorded with the application of 100 kg N ha^{-1} (N4), while, the N1 treatment resulted in the lowest forage yield (Table 4). Nitrogen is a crucial component of plant nutrition, and its deficiency limits the productivity of crops more than any other element. Previous researches have shown that the application of N increased the forage yield of sorghum (Kaizzi et al., 2012; Reza et. al., 2013). Likewise, Mahama et al., (2014) found that grain and forage yield of sorghum increased linearly with increasing N rates from 0 to 90 kg N ha^{-1}.

Statistical analysis of data showed that N fertilization significantly increased the stover yield of sorghum according to control. Stover yield of N4 and N3 treatments was statically similar, however, it was significant compared to N2 and N1 (control). The lowest stover yield was observed with N1 treatment (Table 4). The application of nitrogen fertilizer improves the growth and forage yield of sorghum compared with the control (Olugbemi and Ababyomi, 2016) which in turn increases the stover yield of sorghum.

Table 3. Effects of N fertilization on leaf area and dry matter accumulation (g plant^{-1}). [a]

Treatments	Leaf area (cm^2) hill^{-1}			Dry matter accumulation (g plant^{-1})		
	45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS
N_1	225.42b	552.17d	1109.16c	11.21b	27.69c	64.63d
N_2	342.ab	708.31c	1628.28c	12.14b	38.46b	131.94c
N_3	703.25ab	895.08b	2445.41b	13.50a	40.98b	195.94b
N_4	822.37a	1058.94a	3536.80a	13.83a	47.93a	240.10a
LSD ($p \leq 0.05$)	500	64.37	606	1.17	5.1	42.24

[a] *Means followed by the same letters are not significantly different from each other at 5% probability level. LSD (0.05): least significant difference at 5% probability level*. DAS: days after sowing

Crop growth rate (CGR) was significantly affected by N fertilization, and a higher level of N fertilizer enhanced CGR. The maximum value of CGR was recorded with application of 100 kg N ha^{-1} (N4). The lowest crop growth rate was observed with N1 treatment where no N fertilizer was applied (Table 4). Application of N fertilizer enhances cell division during plant growth (Stals and Inze, 2001), it increases the aboveground biomass yield (Anderson et al., 2013), which consequently boosts crop growth rate. These findings are in line with Olugbemi and Ababyomi (2016) who reported that the highest CGR values were obtained with the application of a higher rate of N.

Table 4. Effects of N fertilization on forage yield, stover yield and crop growth rate of sorghum. [a]

Treatments	Forage yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Crop growth rate (g $plant^{-1}$ day^{-1})
N_1	1742.22d	594.44c	19.36d
N_2	3480.00c	1433.33b	38.67c
N_3	5659.11b	2201.33a	62.18b
N_4	6217.55a	2467.55a	69.09a
LSD ($p \leq 0.05$)	519.88	470.44	6.87

[a] *Means followed by the same letters are not significantly different from each other at 5% probability level. LSD (0.05): least significant difference at 5% probability level*

.

4. Conclusion

Forage and fodder crop production is a very important component of farming systems, as it provides adequate feed for the livestock. The outcome of this study shows that N fertilization can significantly enhance the growth and forage yield of sorghum. Application of 100 kg N ha^{-1} significantly increased plant height, the number of leaves per plant, leaf area, dry matter accumulation, forage yield, stover yield, and crop growth rate during growing period under Takhar province agro-ecological conditions. The study however also revealed that application of 75 kg N ha^{-1} would also result in the production of reasonable stover yield of sorghum.

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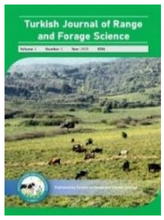

Effects of Mowing Height and Biogas Digestate as a Soil Amendment on Green Quality of Strong Creeping Red Fescue (*Festuca rubra* var. *rubra*)

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A B S T R A C T

One of the most important points to be considered during establishment in lawn areas is the soil structure. Also, at this stage, the way to obtain a homogeneous, frequent and high-quality appearance is the correct and timely maintenance procedures. It is very important to adjust the mowing time and height in these maintenance operations. For this reason, in the study carried out, 3 different mowing heights were formed in the grass field facility established in the control soil and biogas digestate added. In the experiment, 2 varieties of the strong creeping red fescue (*Festuca rubra* var. *rubra*) were used as turfgrass. According to the data obtained from the experiment, it was determined that the germination speed was higher and the higher canopy percentage was earlier in the soil with biogas digestate. However, different results were obtained in terms of coverage percentage in the following periods. In terms of leaf color index, it was observed that the mowing made at a height of 75 mm had the highest value and seasonally had a higher color value in the spring season. As a result, different organic soil amendment materials can be used while establishing the lawn and depending on the type of use, the height of mowing with 50-75 mm will create a quality green for general use.

1. Introduction

Turfgrasses are easy to grow, adapt to extreme conditions, and also visually pleasing. These plants, which are known to have a lot of benefits, need to be suitable for maintenance to have an ideal appearance and to survive for many years (Emmons, 2007). In the mowing process, which is one of the most important maintenance operations, the time and height of the mowing play an important role in determining the quality of the lawn (Turgeon,1991). Mowing height varies depending on the intended use and the type (Lee et.al.). For example, this mowing height is recommended as 3-50 mm for strong creeping red fescue, but this situation may vary depending on the ecology and time (Aldous and Chivers, 2002). Strong creeping red fescue (*Festuca rubra* var. *rubra*) is a kind of grass that is resistant to drought, very high density and its color varies between light green-green. It forms a strong and durable grass layer due to the presence of rhizomes. It is also known for its resistance to shade and close shape.

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Although it is not very selective in terms of soil properties, the quality of the grass increases with the additions applied to the soil (Aldous and Chivers, 2002; Emmons, 2007), and its high resistance to diseases, which reduces the need for fungicide applications (Aamlid et al., 2012).

Biogas digestates are substances rich in minerals that are produced as a result of anaerobic fermentation of organic wastes. In addition to increasing the yield in plants, it increases the microbial activity in the soil and improves the soil properties. It also plays a role as a soil amendment because it has the same properties compared to livestock manure, which is used extensively in grass areas, as well as it contains fewer pests. (Chen et al. 2012; Makádi et al. 2012; Sürmen ve Kara, 2019). For this reason, the effects on the germination speed as a result of the use of these digestates were also examined in the study.

Turfgrasses, in particular, have an important place in this respect, where practices aimed at increasing human welfare are increasing day by day. Turfgrass establishments, especially in sports facilities and large parks, not only appeal to the visual but also have positive effects on human health. The most important factor in the longevity and quality of these facilities is maintenance work. For this reason, in this study, the effects of the mowing height and biogas digestate as soil amendment was examined.

2. Materials and Methods

The research was conducted in the district of Koçarlı in Aydın province at an altitude of 60 m in 2019-2020. The experimental area of soil was loamy and alkaline with low organic matter. Lime content of soil is 3.82%, total saline content of 0.02%, phosphorus (P) content of 35 ppm and available potassium of 320 ppm. In addition to the control plots, plots with biogas digestate (0.1 ton ha^{-1}) were created before planting in the first week of November Nitrogen, phosphorus and potassium fertilizers were applied at a rate of 75 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} K_2O respectively, before seeding and leveling the soil with a cultivator and harrow. In the experiment, the green quality of two different varieties of strong creeping red fescue (*Festuca rubra* var. *rubra*) (Maxima, Relevant) in three different mowing heights (25,50 and 75 mm) was determined in three replications. Germination speed percentages were determined 6 and 16 days after planting to see if there is a difference in the germination of the soil to which biogas digestate was added. To determine the difference between the seasons in the coverage rate of the canopy, a mobile application called Canopeo was preferred (Patrignani and Ochsner, 2015). AL-KO HIGHLINE 46.5 P-A gasoline lawnmower was used to perform the mowing operations. The sprinkler irrigation system has been preferred for irrigation operations, and irrigation has been carried out depending on the plant water demand. The program named Field Scout Green Index was used to determine the amount of green leaf color index (Pille et al., 2011). The data obtained were analyzed using the LSD multiple comparison method in the SAS statistical package program (SAS, 1998).

3. Results and Discussion

According to the results obtained from the study, it was determined that there was faster germination in the parcels where biogas digestate was applied in terms of germination speed. In the first measurement taken 6 days after planting, 5% germination was obtained in both strong creeping red fescue varieties, while 10% germination was observed in the plots where biogas digestate was applied. When the parcels were examined 16 days after planting, it was found that there was almost complete germination in the parcels where biogas digestate was applied (Table 1.).

Table 1. Germination speed averages of *Festuca rubra* var. *rubra* varieties

	08.11.2019		**18.11.2019**	
	Control	**Digestate**	**Control**	**Digestate**
Maxima	5%	10%	75%	95%
Relevant	5%	10%	70%	90%
Mean	5%	10%	72.5%	92.5%

When the averages of the green color value obtained with the Field Scout Green Index application were examined, it was determined that the green color value obtained seasonally in the spring months was higher. While it is seen that the highest green color value in terms of mowing height is obtained from the height of 75 mm, it is thought that this is due to the large canopy of the high mown turfgrass (Table 2.). The highest values were obtained in the same height and period in both strong creeping red fescue varieties. Calvache et. al. (2017) investigated the effects of the mowing height of the mixtures of different species with red fescue (*Festuca rubra*) in their study. They stated that although the mowing heights they have tried are at lower levels, the increase in the height of the mowing affects the lawn visual better. Robins and Bushman (2020) examined the effects of mowing height in different turfgrass mixtures in their study. Likewise, in this study, it is stated that higher mowing will provide a higher turf quality.

Table 2. Green color index (VR) averages according to seasons of *Festuca rubra* var. *rubra* varieties

***F.rubra rubra* (Maxima)**	**Soil**	**Mowing Height**			**Mean**
		25 mm	**50 mm**	**75 mm**	
Winter	**Control**	4.6	5.3	5.5	5.13
	Digestate	6.1	6.4	6.6	6.36
	Mean	5.35	5.85	6.05	5.75 B
Spring	**Control**	7.3	8.5	8.7	8.16
	Digestate	7.1	8.6	8.7	8.13
	Mean	7.20	8.55	8.70	8.15 A
Summer	**Control**	4.8	5.5	5.5	5.26
	Digestate	5.5	5.6	5.8	5.63
	Mean	5.15	5.55	5.65	5.45 C
Total Mean		5.90 C	6.65 B	6.80 A	
***F.rubra rubra* (Relevant)**	**Soil**	**Mowing Height**			**Mean**
		25 mm	**50 mm**	**75 mm**	
Winter	**Control**	5.7	6.7	6	6.13
	Digestate	5.9	6.9	7.4	6.73
	Mean	5.80	6.80	6.70	6.43 B
Spring	**Control**	7.8	8.2	8.4	8.13
	Digestate	7.7	8.1	8.5	8.10
	Mean	7.75	8.15	8.45	8.11 A
Summer	**Control**	5.5	5.9	6.2	5.86
	Digestate	5.2	5.8	6.1	5.70
	Mean	5.35	5.85	6.15	5.78 C
Total Mean		6.30 C	6.93 B	7.10 A	

If we compare the soils with biogas digestate compared to the control soils, it is seen that similar values are obtained in the Maxima variety except the value taken in the winter period. However, as a result of the statistical analysis, all double and triple interactions were found to be important (Table 2.). Lack of sufficient research for the utilization of biogas digestates in lawns creates difficulties in terms of comparing the results obtained. Andruschkewitsch et al. (2013) examined the effect of biogas digestate applied on delicate red fescue species on forage yield. Although it is stated in the study that the biogas digestate applied to the strong creeping red fescue does not make a difference, it may differ since the study is a pot study and a study for grasslands. Głowacka et al. (2020) stated that biogas wastes may have positive effects on Poaceae family. Kılıç and Türk (2017) conducted fertilization studies on tall fescue turf and stated that increasing the amount of fertilization will increase the value of leaf color index. This situation suggests that biogas waste rich in NPK content may also have positive effects.

Considering the coverage data according to the seasons, differences among the varieties were determined. In Maxima variety, the best coverage was obtained in spring, while in the Relevant variety, this value was obtained in winter, which is the planting time. At the same time, the highest value in terms of mowing heights was obtained from 75 mm height in Maxima variety, while this value was obtained from 50 mm height in Relevant variety. According to statistical analysis, there was a difference between all applications and interactions (Table 3.). It is also known that the height of the mowing has an important effect on weed control. It is reported that 4-5 cm mowing height can be ideal for Fine Fescue’s (Turgeon, 1991). DeBels et al. (2012) stated in their study that the close mowing to the tall fescue causes distortions in the green visual. This result is similar to the result we have obtained and it is seen that the close mowing harms the fescues.

Table 3. Canopy coverage averages (%) according to seasons of *Festuca rubra* var. *rubra*

***F.rubra rubra* (Maxima)**	**Soil**	**Mowing Height**			**Mean**
		25 mm	**50 mm**	**75 mm**	
Winter	**Control**	67.85	91.66	92.82	84.11
	Digestate	81.76	92.74	93.6	89.32
	Mean	74.80	92.20	93.15	86.71 B
Spring	**Control**	83.5	93.6	94.5	90.53
	Digestate	84	93.5	94.2	90.56
	Mean	83.75	93.55	94.35	90.55 A
Summer	**Control**	67.33	77.81	78.11	74.41
	Digestate	66.15	77.27	78.4	73.94
	Mean	66.74	77.54	78.25	74.17 C
Total Mean		75.09 C	87.76 B	88.58 A	
***F.rubra rubra* (Relevant)**	**Soil**	**Mowing Height**			**Mean**
		25 mm	**50 mm**	**75 mm**	
Winter	**Control**	87.77	96.46	96.31	93.51
	Digestate	85.1	96.28	96.21	92.53
	Mean	86.43	96.37	96.26	93.02 A
Spring	**Control**	82.3	97.5	97.3	92.36
	Digestate	84.2	96.8	97.1	92.70
	Mean	83.25	97.15	97.20	92.53 B
Summer	**Control**	67.56	76.46	76.31	73.44
	Digestate	68.1	76.72	76.32	73.71
	Mean	67.83	76.59	76.31	73.57 C
Total Mean		79.17 C	90.03 A	89.92 B	

4. Conclusion

Grass areas occupied an important place almost everywhere where humanity has settled in the last century. It is the most important rule of sustainability to fulfill the maintenance conditions in these areas that create quality visuals, especially in sports facilities, parks and gardens. In this respect, the effects of the mowing height and biogas digestate application on the green quality of the strong creeping red fescue grass were investigated. As a result of the research, it was determined that both varieties in the research have similar properties in terms of green color index, while some differences were observed in terms of coverage. In terms of mowing height, the highest values were obtained from 75 mm mowing height and it was observed that the green color index and coverage increased as the mowing height increased. Considering the usage purpose of the grass area, it was concluded that the mowing height of 50-75 mm would be ideal for this species. The work done is a study for the year of the facility. The examination of these and similar studies for many years will support the accuracy of the study.

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