Turkish Journal of Range and Forage Science (TJRFS), 2020, 1(2): 35 – 45

Research Article

Turkish Journal of Range and Forage Science

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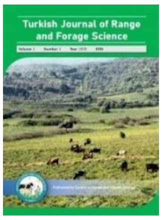

Silage Quality of Second Forage Pea at Different Plant Densities and Cereal Mixtures

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ARTICLE INFO

Received 01 October 2020
Accepted 10 November 2020

Keywords:

Forage pea
Mixture
Plant density
Silage quality

ABSTRACT

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 ($P \leq 0,01$) and cereal mixtures ($P \leq 0,01$) had a significant effect on the dry matter content (Table 2). All interactions were significant ($P \leq 0,01$) 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 ($P \leq 0,01$) 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.

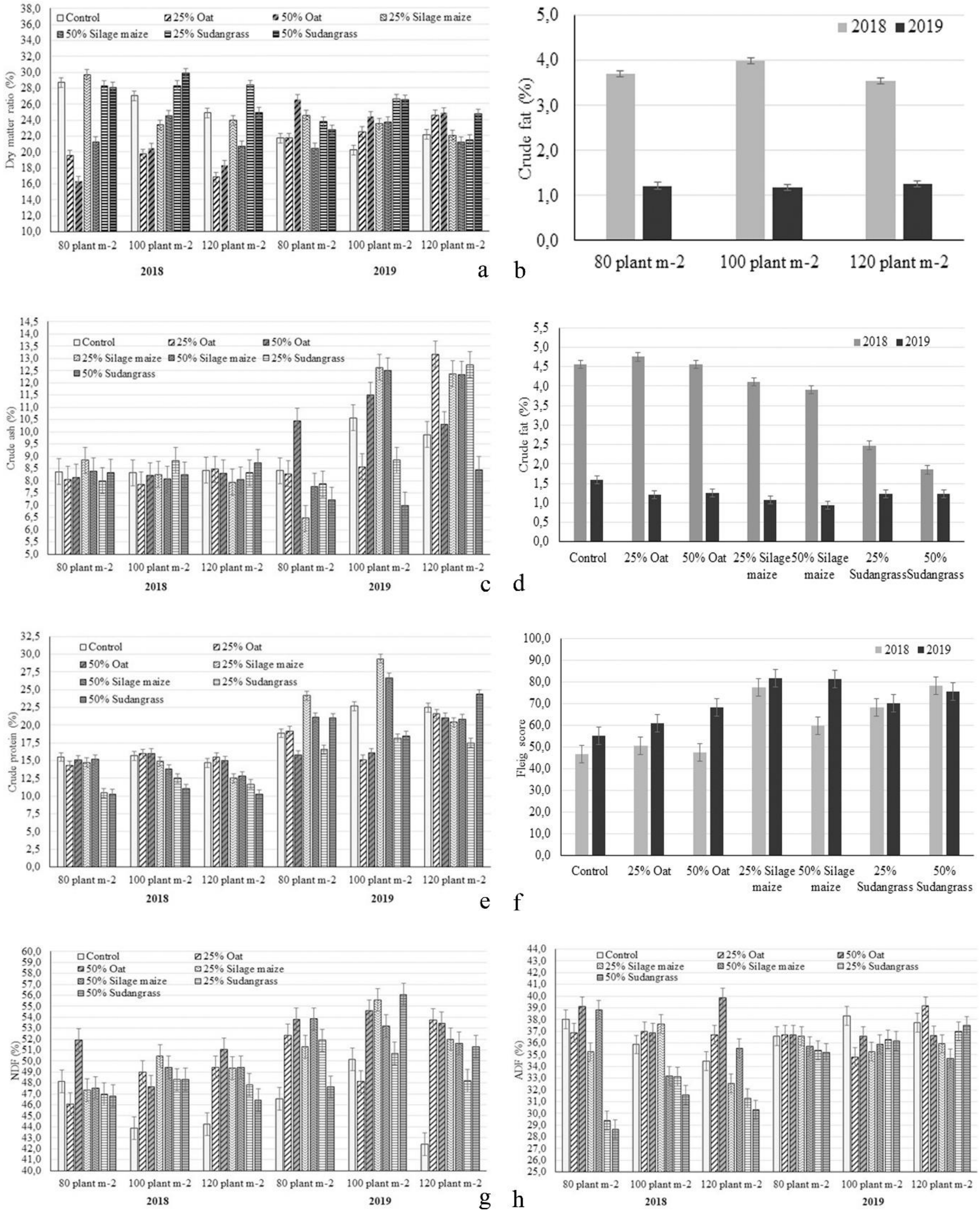

Figure 1. Significant interactions of **a)** DM (three-way), **b)** CF (year x pea density), **c)** CA (three-way), **d)** CF (year x mixture), **e)** CP (three-way), **f)** Fleig score (year x mixture), **g)** NDF (three-way), **h)** ADF (three-way)

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.

References

Acikgoz, E. 2001. Forage Crops. VIPAS publication number 58, 584p. Bursa. (In Turkish).

Adesogan, A.T., M.B. Salawu and E.R. Deaville, 2002. The effect on voluntary feed intake, in vivo digestibility and nitrogen balance in sheep of feeding grass silage or pea–wheat intercrops differing in pea to wheat ratio and maturity. Animal Feed Science and Technology, 96:(3-4), 161-173.

Albrecht, K.A. and K.A. Beauchemin, 2003. Alfalfa and other perennial legume silage. Silage science and technology, 42, 633-664.

Asik, B.B., A. Uzun and E. Acikgöz, 2020. Seeding rate and cultivar impacts on nutrient uptake of field pea under fertile soil condition. Chilean journal of agricultural research, 80:(1), 11-20.

Azim, A., A.G. Khan, M.A. Nadeem and D. Muhammad, 2000. Influence of maize and cowpea intercropping on fodder production and characteristics of silage. Asian-Australasian Journal of Animal Sciences, 13:(6), 781-784.

Balabanli, C., S. Albayrak, M. Turk and O. Yuksel, 2010. A research on determination of hay yields and silage qualities of some vetch+cereal mixtures. Turkish Journal of Field Crops, 15:(2), 204-209.

Basaran, U., E. Gulumser, H. Mut and M. Copur-Dogrusoz, 2018. Determination of silage yield and quality of grasspea+cereal intercrops. Turkish Journal of Agriculture – Food Science and Technology, 6:(9), 1237-1242.

Bejandi, T.K., R.S. Sharifii, M. Sedghi and A. Namvar, 2012. Effects of plant density, Rhizobium inoculation and microelements on nodulation, chlorophyll content and yield of chickpea (*Cicer arietinum* L.). Annals of Biological Research, 3:(2), 951-958.

Borreani, G., L. Cavallarin, S. Antoniazzi and E. Tabacco, 2006. Effect of the stage of growth, wilting and inoculation in field pea (*Pisum sativum* L.) silages. I. Herbage composition and silage fermentation. Journal of the Science of Food and Agriculture, 86:(9), 1377-1382.

Budakli-Carpici, E., 2016. Nutritive values of soybean silages ensiled with maize at different rates. Legume Research-An International Journal, 39:(5), 810-813.

Can, M., G. Kaymak, E. Gülümser, Z. Acar and İ. Ayab, 2019. Orman üçgülü yulaf karışımlarının silaj kalitesinin belirlenmesi. Anadolu Tarım Bilimleri Dergisi, 34:(3), 371-376.

Canbolat, Ö., K.C. Akbay and A. Kamalak, 2019. Yem bezelyesi silajlarında karbonhidrat kaynağı olarak melas kullanılma olanakları. Tarim ve Doga Dergisi, 22:(1), 122.

Collins, M. and J.O. Fritz, 2003. Forage Quality, In: Forages: An Introduction to Grassland Agriculture eds. Barnes, R.F., Nelson C.J., Collins, M., Moore K.J., 6th ed., Iowa State Press, Ames, pp. 363-390.

Collins, M. and V.N. Owens, 2003. Preservation of Forage as Hay and Silage, In: Forages: An Introduction to Grassland Agriculture, eds. Barnes, R.F., Nelson, C.J., Collins, M. Moore, K.J., 6th ed., Iowa State Press, A Blackwell Publishing Company, Ames, Iowa, USA, pp 443-471.

Cook C.W. and J. Stubbendieck, 1986. Range research: basic problems and techniques. Society for Range Management, Colorado. 317p.

Craine, J.M. and R. Dybzinski, 2013. Mechanisms of plant competition for nutrients, water and light. Functional Ecology, 27:(4), 833-840.

Davies, D.R., R.J. Merry, A.P. Williams, E.L. Bakewell, D.K. Leemans and J.K.S. Tweed, 1998. Proteolysis during ensilage of forages varying in soluble sugar content. Journal of Dairy Science, 81:(2), 444-453.

Denek, N. and A. Can, 2006. Feeding value of wet tomato pomace ensiled with wheat straw and wheat grain for Awassi sheep. Small Ruminant Research, 65:(3), 260-265.

Dewhurst, R.J., R.T. Evans, N.D. Scollan, J.M. Moorby, R.J. Merry and R.J. Wilkins, 2003. Comparison of grass and legume silages for milk production. 2. In vivo and in sacco evaluations of rumen function. Journal of Dairy Science, 86:(8), 2612-2621.

Dogan, S. and O. Terzioglu, 2019. Van koşullarında yem bezelyesi (*Pisum arvense* l.) ve arpa (*Hordeum vulgare* l.) karışımların ot verimi ve silaj kalitesine etkisi. Bahri Dağdaş Bitkisel Araştırma Dergisi, 8:(1), 106-114.

Dok, M., M. Şahin, M. Sürmen, and İ. Sezer, 2016. Çeltik tarlalarında değişik baklagil yem bitkilerinin kışlık ara ürün olarak yetiştirme imkânlarının araştırılması. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 25:(Özel Sayı-1), 105-109.

Driehuis, F., J.M. Wilkinson, Y. Jiang, I. Ogunade and A.T. Adesogan, 2018. Silage review: animal and human health risks from silage. Journal of Dairy Science, 101:(5), 4093-4110.

Dumlu, Z., and T. Mustafa, 2009. Erzurum şartlarında yetişen bazı baklagil yem bitkileri ve karışımlarının silaj değerlerinin belirlenmesi. Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 40(2), 15-21.

Erkovan, Ş., O. İleri, H.İ. Erkovan, and A. Koç, 2020. Eskişehir ekolojisinde uygun ekim zamanı ve ekim sıklığının yem bezelyesinin yaş ot verimi ve bazı özelliklerine etkisi. ÇOMÜ Ziraat Fakültesi Dergisi, 8:(1), 225-232.

Eskandari, H., A. Ghanbari and A. Javanmard, 2009. Intercropping of cereals and legumes for forage production. Notulae Scientia Biologicae, 1:(1), 07-13.

Filya, I., R.E. Muck and F.E. Contreras-Govea, 2007. Inoculant effects on alfalfa silage: fermentation products and nutritive value. Journal of dairy science, 90:(11), 5108-5114.

Fraser, M.D., R. Fychan and R. Jones, 2001. The effect of harvest date and inoculation on the yield, fermentation characteristics and feeding value of forage pea and field bean silages. Grass and Forage Science, 56:(3), 218-230.

Fychan R., J. Roberts, M.D. Fraser and R. Jones, 2000 Yield and ensiling potential of pea/cereal bi-crops. Proceedings of the British Grassland Society 6th Research Conference, 11–13 September 2000, Craibstone, Bucksburn, Aberdeen, pp. 61–62.

Gelir, G., 2019. Determination of silage quality characteristics of feed peas (*Pisum sativum* supsp arvense L.), triticale and mixtures grown in Diyarbakir (Master Thesis). Dicle University, Science Institute, Diyarbakir, 63p.

Geren, H., R. Avcioglu, H. Soya and B. Kir, 2008. Intercropping of corn with cowpea and bean: Biomass yield and silage quality. African Journal of Biotechnology, 7:(22), 4100-4104.

Gilliland, T.J. and J. Johnston, 1992. Barley/pea mixtures as cover crops for grass re-seeds. Grass and Forage Science, 47:(1), 1-7.

Grant, K., J. Kreyling, L.F. Dienstbach, C. Beierkuhnlein and A. Jentsch, 2014. Water stress due to increased intra-annual precipitation variability reduced forage yield but raised forage quality of a temperate grassland. Agriculture, Ecosystems & Environment, 186, 11-22.

Hoffman, P.C., 2005. Ash content of forages. Focus on Forage, 7:(1), 1-2.

Jaster, E.H., 1995. Legume and grass silage preservation. Post-Harvest Physiology and Preservation of Forages, 22, 91-115.

Jinghui, L., Z. Zhaohai, J. Lixin, H. Yuegao, W. Ying and L. Hai, 2006. Intercropping of different silage maize cultivars and alfalfa. Zuo Wu Xue Bao, 32:(1), 125-130.

Kavut, Y.T. and H. Geren, 2017. Farklı hasat zamanlarının ve karışım oranlarının İtalyan çimi (*Lolium multiflorum* L.)+ baklagil yembitkisi karışımlarının verim ve bazı silaj kalite özelliklerine etkisi. Ege Üniversitesi Ziraat Fakültesi Dergisi, 54:(2), 115-124.

Kilic, A. 1986. Silo Feed. Bilgehan Publications. Izmir, 327p.

Konuk, A., and A. Tamkoç, 2018. Yem bezelyesinde kışlık ve yazlık ekimin bazı tarımsal özellikler üzerine etkisi. Bahri Dağdaş Bitkisel Araştırma Dergisi, 7:(1), 39-50.

Laidlaw, A.S. and N. Teuber, 2001. Temperate forage grass-legume mixtures: advances and perspectives. In International Grassland Congress (Vol. 19, pp. 85-92).

Latre, J., K. Dewitte, E. Wambacq, B.D. Roo and G. Haesaert, 2008. Ensiling of intercrops with legumes. In 13th International Conference of Forage Conservation, Nitra, Slovakia, 3-5 September (pp. 104-105). Slovak Agricultural Research Centre, Research Institute of Animal Production, Nitra.

Lauriault, L.M. and R.E. Kirksey, 2004. Yield and nutritive value of irrigated winter cereal forage grass–legume intercrops in the Southern High Plains, USA. Agronomy Journal, 96:(2), 352-358.

McDonald, P., A.R. Henderson and S.J.E., 1991. The Biochemistry of Silage (2nd ed.), Chalcombe publications, Marlow, UK.

Mustafa, A.F., D.A. Christensen and J.J. McKinnon, 2000. Effects of pea, barley, and alfalfa silage on ruminal nutrient degradability and performance of dairy cows. Journal of Dairy Science, 83:(12), 2859-2865.

Mustafa, A.F. and P. Seguin, 2003. Characteristics and in situ degradability of whole crop faba bean, pea, and soybean silages. Canadian Journal of Animal Science, 83:(4), 793-799.

Mustafa, A.F., P. Seguin, D.R. Ouellet and I. Adelye, 2002. Effects of cultivars on ensiling characteristics, chemical composition, and ruminal degradability of pea silage. Journal of dairy science, 85:(12), 3411-3419.

Mustafa, A.F. and P. Seguin, 2004. Chemical composition and in vitro digestibility of whole-crop pea and pea–cereal mixture silages grown in South-western Quebec. Journal of Agronomy and Crop Science, 190:(6), 416-421.

Nkosi, B.D., A.T. Kanengoni and R. Thomas. 2011. Effects of ensiling total mixed potato hash ration with or without bacterial ınoculation on silage fermentation and nutritive value for growing pigs. J. Anim. Vet. Adv. 10: 1667-1672.

Pursiainen, P. nad M. Tuori, 2008. Effect of ensiling field bean, field pea and common vetch in different proportions with whole-crop wheat using formic acid or an inoculant on fermentation characteristics. Grass and Forage Science, 63:(1), 60-78.

Rondahl, T., J. Bertilsson and K. Martinsson, 2011. Effects of maturity stage, wilting and acid treatment on crude protein fractions and chemical composition of whole crop pea silages (*Pisum sativum* L.). Animal feed science and technology, 163:(1), 11-19.

Rowden, R., D. Gardiner, P.C. Whiteman and E.S. Wallis, 1981. Effects of planting density on growth, light interception and yield of a photoperiod insensitive pigeon pea (*Cajanus cajan*). Field Crops Research, 4, 201-213.

SAS Institute Inc., 2011. Base SAS® 9.3 Procedures Guide [computer program]. 536p.

Salawu, M.B., A.T. Adesogan, C.N. Weston and S.P. Williams, 2001. Dry matter yield and nutritive value of pea/wheat bi-crops differing in maturity at harvest, pea to wheat ratio and pea variety. Animal feed science and technology, 94:(1-2), 77-87.

Salawu, M.B., A.T. Adesogan, M.D. Fraser, R. Fychan and R. Jones, 2002. Assessment of the nutritive value of whole crop peas and intercropped pea–wheat bi-crop forages harvested at different maturity stages for ruminants. Animal Feed Science and Technology, 96:(1-2), 43-53.

Seydosoğlu, S., 2019. Farklı oranlarda karıştırılan yem bezelyesi (*Pisum sativum* L.) ve arpa (*Hordeum vulgare* L.) hâsıllarının silaj ve yem kalitesine etkisi. Ege Üniversitesi Ziraat Fakültesi Dergisi, 56:(3), 297-302.

Shao, H., D. Shi, W. Shi, X. Ban, Y. Chen, W. Ren, F. Chen and G. Mi, 2020. The impact of high plant density on dry matter remobilization and stalk lodging in maize genotypes with a different stay-green degree. Archives of Agronomy and Soil Science, 66, 1-15.

Tekeli, A.S. and E. Ates, 2003. Yield and its components in field pea (*Pisum arvense* L.) lines. Journal of Central European Agriculture. 4: 313-317.

Thorvaldsson, G., G.F. Tremblay and H. Tapani-Kunelius, 2007. The effects of growth temperature on digestibility and fibre concentration of seven temperate grass species. Acta Agriculturae Scandinavica Section B-Soil and Plant Science, 57:(4), 322-328.

Turgut, I., A. Duman, U. Bilgili and E. Acikgoz, 2005. Alternate row spacing and plant density effects on forage and dry matter yield of corn hybrids (*Zea mays* L.). Journal of Agronomy and Crop Science, 191:(2), 146-151.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Symposium: carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. Journal of Dairy Science, 74:(10), 3583-3597.

Wang, N. and J.K. Daun, 2004. Effect of variety and crude protein content on nutrients and certain antinutrients in field peas (*Pisum sativum*). Journal of the Science of Food and Agriculture, 84:(9), 1021-1029.

Weinberg, Z.G., G. Ashbell, A. Azrieli and I. Brukental, 1993. Ensiling peas, ryegrass and wheat with additives of lactic acid bacteria (LAB) and cell wall degrading enzymes. Grass and Forage Science, 48:(1), 70-78.

Wilkinson, J.M., 1999. Silage and animal health. Natural toxins, 7(6): 221-232.

Yilmaz, A., S. Altinok and Z. Kocabas, 2009. An investigation on quality parameters of the silages made by corn and soybean grown in different seeding rates. Journal of Animal and Veterinary Advances, 8:(9), 1856-1859.