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Growing Forage Pea (*Pisum arvense* L.) for Hay: Different Sowing Dates and Plant Densities in Central Anatolia

Kaba Yem Amaçlı Yem Bezelyesi (*Pisum arvense* L.) Yetiştiriciliği: İç Anadolu'da Farklı Ekim Zamanları ve Bitki Sıklıkları

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ABSTRACT

The study was carried out to determine the effects of different sowing times (October and November) and plant densities (80, 100, and 120 seeds m^{-2}) on hay yield and quality of some forage pea cultivars (Özkaynak and Taşkent) in 2018 and 2019 years of Eskisehir ecological conditions. The experiment was established in Randomized Complete Block Design with three replications. Hay yield, crude protein, neutral detergent fiber, acid detergent fiber, and acid detergent lignin contents were investigated. Hay yield, acid detergent fiber, and acid detergent lignin contents were higher in 2018 (5139.2 kg ha^{-1}, 31.76%, and 8.02%, respectively) but crude protein (13.89–14.44%) and neutral detergent fiber (37.52–37.77%) contents did not change significantly between the years. Cultivars and plant densities did not cause any significant variation on the examined characteristics but late autumn sowing caused a 1.51% increase in crude protein content, which was significant. Neither late autumn sowing nor different plant densities caused any negative effects on hay yield and quality of forage peas. Therefore, forage peas could be sown in both October and November using any of the Özkaynak or Taşkent cultivars at 80 seeds m^{-2} plant density in Central Anatolia conditions.

Keywords: Forage pea, hay quality, hay yield, plant density, sowing date

ÖZ

Bu çalışma, bazı yem bezelyesi çeşitlerinde (Özkaynak ve Taşkent) farklı ekim zamanları (Ekim, Kasım) ve bitki sıklıklarının (80, 100, 120 tohum m^{-2}) kuru ot verimi ve kalitesine etkilerini belirlemek amacıyla 2018 ve 2019 yıllarında Eskişehir ekolojik koşullarında yürütülmüştür. Deneme Tesadüf Blokları Deneme Desenine göre üç tekrarlamalı olarak kurulmuştur. Çalışmada kuru ot verimi, ham protein (HP), nötr deterjan lif (NDF), asit deterjan lif (ADF) ve asit deterjan lignin (ADL) oranları incelenmiştir. Kuru ot verimi, ADF ve ADL oranları (sırasıyla 5139,2 kg ha^{-1}, %31,76 ve %8,02) 2018'de daha yüksek olurken, HP (%13,89–%14,44) ve NDF (%37,52–%37,77) oranları yıllar arasında önemli bir değişiklik göstermemiştir. Çeşitler ve ekim sıklığı arasında incelenen özellikler yönünden önemli bir farklılığın olmadığı, ancak geç sonbahar ekiminin HP içeriğinde %1,51'lik bir artışa neden olduğu belirlenmiştir. Güzlük ekim ve farklı bitki sıklıklarının yem bezelyesinin kuru ot verimi ve kalitesi üzerinde herhangi bir olumsuz etkisi olmamıştır. Bu nedenle, İç Anadolu koşullarında Özkaynak veya Taşkent yem bezelyesi çeşitlerinin Ekim-Kasım aylarında ve 80 tohum m^{-2} kullanılarak ekilmesi önerilmektedir.

Anahtar Kelimeler: Yem bezelyesi, yem kalitesi, kaba yem verimi, bitki sıklığı, ekim zamanı

Introduction

Forage pea (*Pisum sativum* ssp. *arvense* L.) is an important cool-season leguminous forage species grown for grain or hay production in temperate climate zone. In addition to the main cropping in cool areas, the plant could be grown as an intermediate crop (Kaplan & Gökkuş, 2018) or second crop (Ileri et al., 2018) in temperate climate zone like Central Anatolia in Turkey. Intermediate cropping gives an advantage for producers without decreasing the sowing area of warm-season crops such as corn, soybean, etc. On the other hand, forage plants do not compete with cash crops during the main growing season or, especially perennials, do not suit crop design (Ağırbaş et al., 2017). Whereas, intermediate or second crop forage production provides an important advantage for producers without any decrement in cash crop sowing area in cropping design. Forage pea could be cultivated as an intermediate crop before warm-season main crops or as a second crop after cool-season cereals in the Central Anatolia region or any other region having similar ecology. Local producers are sowing silage corn followed by winter forage pea as an intermediate crop (Kalkan & Avcı, 2020).

Forage peas produce high-quality hay, which is rich in minerals and contains about 15–20% crude protein (CP) (Açıkgöz, 2001; Kocer & Albayrak, 2012) and has high digestibility which is about 70–80% (Uzun et al., 2005a). In addition to hay and grain production, forage pea is also produced for green manure, silage, and grazing (Ateş & Tekeli, 2017). On the other hand, it is both suitable for mixed cultivation with cereals and used in crop rotation (McKenzie & Spaner, 1999; Uzun et al., 2005b). It is an important legume species in crop rotation, as it can be cultivated in winter conditions of the Central Anatolia region without irrigation. However, the sowing time of winter forage peas is an issue to be considered in this region, where winters are cold. In this ecology, seeds should be sown in autumn to provide germination and ensure the plants go through winter as a seedling. In autumn planting, plants with four to five leaves and the form of rosettes entering the winter are least affected by the cold (Alan & Geren, 2012; Annicchiarico & Iannucii, 2007). Thus, plants could start growing early in the following spring and higher production could be achieved compared to spring sowing. Winter sowings could reach the harvesting stage earlier than spring sowing and do not cause delaying plantation of warm-season crops besides higher yield. Therefore, determining the appropriate sowing date of forage peas in autumn is important in the region.

As the plant density increases in forage crops, yield, and quality values increase up to a point (Açıkgöz, 2001). Besides, appropriate plant density is also important against winter damage, especially for autumn sowing (Knott & Belcher, 1998). Since the seed size in forage peas is quite variable among cultivars, it is more common to determine the number of seeds to be sown per unit area rather than by weight. Some researchers suggested that the sowing density should be between 60 and 100 per square meters for forage peas (Konuk & Tamkoç, 2018; Tan et al., 2012; Uzun et al., 2012).

In this study, the effects of different sowing times [normal autumn (October) and late autumn (November)] and plant density (80, 100, and 120 seeds m^{-2}) on hay yield and quality in two registered forage pea cultivars (Özkaynak and Taşkent), which are widely used in Central Anatolia region, were examined.

Methods

The two-year field study was carried out in Eskisehir Osmangazi University, Faculty of Agriculture Research Areas in the 2017–2018 and 2018–2019 growing seasons. In the study, the effects of two sowing times; timely (middle of October) and late sowing (middle of November), and three plant densities (80, 100, and 120 seeds m^{-2}) on hay yield and quality of two forage pea cultivars (Ozkaynak and Taskent) were investigated. The experiment was established in Randomized Complete Block Design with three replications. Combinations of factors were randomly allocated within the blocks. The sowing was carried out using 30 cm row spacing on 5 rows and each was 5 m long (7.5 m^2). While sowing, 30 kg ha^{-1} N and 70 kg ha^{-1} P_2O_5 were applied using diammonium phosphate (DAP) fertilizer. October and November sown plants reached four to six and two to four leaf stages, respectively, until winter. The experiment was arranged as an intermediate crop and conducted under rainfed conditions.

The yearly average temperatures of Eskisehir in the experimental years were 12.2 and 13.6°C, respectively, and were similar to the long-term average (12.9°C). Total precipitation was higher than the long-term average (352.4 mm) and the relative humidity

Table 1.
*Meteorological Data Belong to the Experiment Field in Study Years and Long-Term Average**

	Total Rainfall (mm)				Mean Temperature (°C)				Mean Relative Humidity (%)			
Month	**2017**	**2018**	**2019**	**LTA**	**2017**	**2018**	**2019**	**LTA**	**2017**	**2018**	**2019**	**LTA**
January	28.3	31.5	60.2	38.7	–1.7	2.2	4.3	0.3	99.3	95.5	91.0	98.2
February	8.8	40.5	50.1	32.5	2.8	6.6	3.4	4.7	92.2	90.7	79.6	92.6
March	26.9	74.8	13.4	33.4	8.5	10.1	6.3	9.3	80.4	81.5	64.5	81.6
April	60.2	16.5	26.7	35.0	10.8	15.4	9.5	13.1	73.5	60.7	69.3	67.8
May	101.0	84.8	42.2	44.8	15.4	17.6	16.5	16.5	83.4	83.0	65.1	86.1
June	49.3	72.5	45.7	30.6	20.1	20.6	20.9	20.4	85.3	80.7	67.9	83.3
July	9.5	38.3	33.5	14.0	23.7	23	21.3	23.3	73.8	71.4	62.3	75.8
August	29.9	25.0	2.4	7.8	22.4	23.5	22.3	22.9	60.2	62.2	61.0	74.1
September	6.8	4.3	5.0	14.4	20.9	19.1	18.1	20.0	58.3	62.9	62.1	68.1
October	52.7	41.0	18.3	27.0	11.9	14	14.2	12.9	78.3	75.5	70.1	79.6
November	33.4	29.6	33.9	29.2	6.7	8.4	7.9	7.5	86.9	79.2	76.2	80.3
December	34.0	63.6	74.1	45.1	4.5	2.7	2.9	3.6	92.5	96.0	89.9	93.6
Mean	440.8	522.4	405.5	352.4	12.2	13.6	12.3	12.9	80.3	78.3	71.6	81.8

Note: *T.C. Ministry of Agriculture and Forestry General Directorate of Meteorology
LTA = Long-term average.

value was lower than the long-term average (81.8%). During the growing period of plants (October–June), rainfall was higher in the first year (Table 1). The temperature was lower in February, March, April, and May of the second year.

The soil of the study area has a clay-loam texture class and is in the class of slightly alkaline (7.68), moderately calcareous (14.61%), nonsaline, low in phosphorus (61.6 kg ha^{-1}) and organic matter (1.62%), and sufficient in potassium (1688 kg ha^{-1}). The field has good drainage and there is no groundwater problem.

Sowings were done by hand on October 20 and November 16 in the first year and October 26 and November 16 in the second year for timely and late sowing dates. Weed control was done by hand hoeing in the early spring of both years. Harvest was carried out using a hand sickle and considering the full blooming stage of forage pea (Uzun et al., 2005a). In every plot, a randomly selected 1 m^2 area was harvested and oven-dried at 60°C until it reached a constant weight to determine hay yield. Dried samples were grounded in the experimental mill to pass through a 2 mm sieve and the CP ratio was determined by the Kjeldahl method. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) contents were determined according to the principles specified by Van Soest et al. (1991).

Data were subjected to ANOVA based on a general linear model for repeated measurement using SAS 9.3 statistical software (SAS Institute, 2011) and means were separated using Tukey Multiple Comparison Test.

Results

Hay yield, CP, NDF, ADF, and ADL contents were investigated in the study conducted to determine the sowing time and plant density using two forage pea cultivars in Eskisehir conditions. The mean values and variance analysis of examined characteristics were summarized in Table 2.

While the effect of years on hay yield was significant ($p < .01$), cultivars and sowing time did not cause a significant effect (Table 2). An average hay yield was 4434.3 kg ha^{-1} and it was higher in the second year (5139.2 kg ha^{-1}) than in the first year (3729.5 kg ha^{-1}). All interactions related to hay yield were insignificant.

The average CP content was 14.16% and it did not change significantly depending on years and cultivars but the effect of sowing time was significant ($p < .01$). Late-sown plants had higher CP content (14.92%) compared to timely sown plants (13.41%). In the first year, neither sowing density nor sowing time did not significantly affect CP content, whereas CP content was significantly higher in late sowings, and it was more pronounced at the plots sown using 100 seeds m^{-2} in the second year. On the other hand, the hay harvested from the plots that were sown using 80 and 100 seeds m^{-2} densities had statistically higher CP content in timely sowings. Similar fluctuations were also observed among the factors' effects related to CP content; hence triple interaction was significant (Figure 1).

An average NDF content was 37.64% and it did not change significantly among the treatments, hence, neither treatments' effect nor their interactions were statistically significant (Table 2).

In the experiment, overall ADF content was 27.98% and the years' effect was significant ($p < .01$) but the effects of sowing density and sowing time were not significant (Table 2). The first-year samples had lower ADF content (24.21%) than that of the second year (31.77%). There was no significant interaction effect on ADF content in the experiment.

Table 2.
Averages and Variance Analysis Results of Some Pea Cultivars Planted at Different Dates and Density

Treatments	Hay Yield (kg ha^{-1})	Crude Protein (%)	NDF (%)	ADF (%)	ADL (%)
Year (Y)					
2018	3729.5 B	13.89	37.52	24.21 B	4.20 B
2019	5139.2 A	14.44	37.77	31.76 A	8.02 A
Cultivar (C)					
Ozkaynak	4337.3	13.74	36.65	27.53	6.32
Taskent	4531.4	14.59	38.64	28.44	5.90
Sowing time (S)					
October	4548.7	13.41 B	38.09	28.49	6.20
November	4320.1	14.92 A	37.21	27.47	6.01
Plant density (P)					
80 seeds/m^{-2}	4667.1	13.96	36.79	27.49	6.36
100 seeds/m^{-2}	4825.1	14.49	37.27	27.57	5.78
120 seeds/m^{-2}	3810.9	14.05	38.89	28.89	6.18
Mean	4434.3	14.16	37.64	27.98	6.11
Y	**	ns	ns	**	**
C	ns	ns	ns	ns	ns
S	ns	**	ns	ns	ns
P	ns	ns	ns	ns	ns
Y × C	ns	ns	ns	ns	ns
Y × S	ns	**	ns	ns	ns
Y × P	ns	ns	ns	ns	ns
C × S	ns	ns	ns	ns	ns
C × P	ns	ns	ns	ns	ns
S × P	ns	ns	ns	ns	*
Y × C × S	ns	ns	ns	ns	ns
Y × C × P	ns	ns	ns	ns	ns
Y × S × P	ns	*	ns	ns	ns
C × S × P	ns	ns	ns	ns	ns
Y × C × S × P	ns	ns	ns	ns	ns

Note: Averages marked with different letters differ at 1% significance level
*F-test significant at $p \leq .05$.
**F-test significant at $p \leq .01$.
ADF = acid detergent fiber; ADL = acid detergent lignin; NDF = neutral detergent fiber; ns = not significant.

In the experimental samples, ADL content showed significant differences ($p < .01$) over the years, while the other factors did not have a significant effect. The average ADL content was 6.11% and it was determined as 4.20% and 8.02% in the first and second years, respectively. While the highest ADL content was obtained from 80 seeds m^{-2} plant density in timely sowing, it was the highest at 120 seeds/m^{-2} plant density in late sowing. These differences caused significant sowing time × plant density interaction (Figure 2).

Discussion

Hay yield was higher in the second year compared to the first year. In the second year, precipitation and temperature were

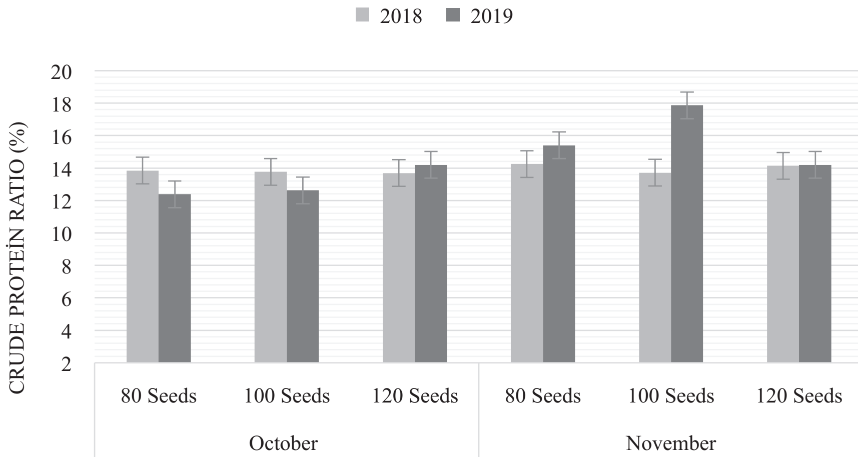

Figure 1.
Interaction Effect of Year × Sowing Time × Plant Density on Crude Protein Content in Forage Pea Sown at Different Sowing Times and Plant Densities in Autumn.

lower in the period from early spring to the end of May. The main reason for the increase in the second year may be the low temperature, which may increase hay yield by lengthened growing season because forage pea is a typical cool-season legume and the optimum temperature for good growth performance of pea is between 13 and 18°C (Rubatzky & Yamaguchi, 1997). Özkaynak and Taşkent cultivars were well adapted to the region (Dereli, 2015), so there was no difference between them in terms of hay yield. Both cultivars showed the same performance in winter sowing. In the experiment, timely or late-sown plants enter winter in the rosette growing stage and they showed their growth performance in the spring, hence, there were no significant differences concerning hay yield between sowing times. Indeed, the suggestion of Mukherjee et al. (2013) on this topic support also this interpretation. Tan et al. (2014) reported that the number of seeds planted per unit area determines the hay production and Uzun & Açıkgöz (1998) declared that hay yield increases with increasing plant density up to optimum plant density, thereafter there is not any significant increase observed (Uzun et al., 2017). Researchers (Kadıoğlu et al., 2020; Konuk & Tamkoç, 2018; Uzun & Açıkgöz, 1998) suggested 60–100 seeds per m^{-2} depending on the ecological condition for forage pea plantation. In this experiment, there were no significant yield differences among sowing density for hay yield. In this condition, it can be stated that the sowing rate of 80 seeds m^{-2} is appropriate in the region.

The cultivars, which are well adapted to the region (Dereli, 2015), were developed by the same researcher and are morphologically similar (Halil & Uzun, 2019); therefore, it is expected that the cultivars may have some similarities concerning some properties like CP content. Indeed, both cultivars had similar CP content in this experiment. Crude protein content showed a significant difference between timely and late sowings. The late-sown plants reached spring at a shorter height than timely sowing; therefore, late-sown plants completed their development faster than timely sown ones. Consequently, they had less photosynthesis time compared to timely sown plants. For this reason, their CP contents were higher because they accumulated less carbohydrates in protoplasm and cell walls due to faster growth. Krawutschke et al. (2013), and Karayel and Bozoğlu (2015) also reported similar ideas. Sowing at different plant densities did not have a significant effect on CP content. Tan et al. (2014) also found similar results. In addition, Alatürk et al. (2021) stated that increasing plant density caused competition between plants, which also causes late maturation and increases the protein content. In this study, CP

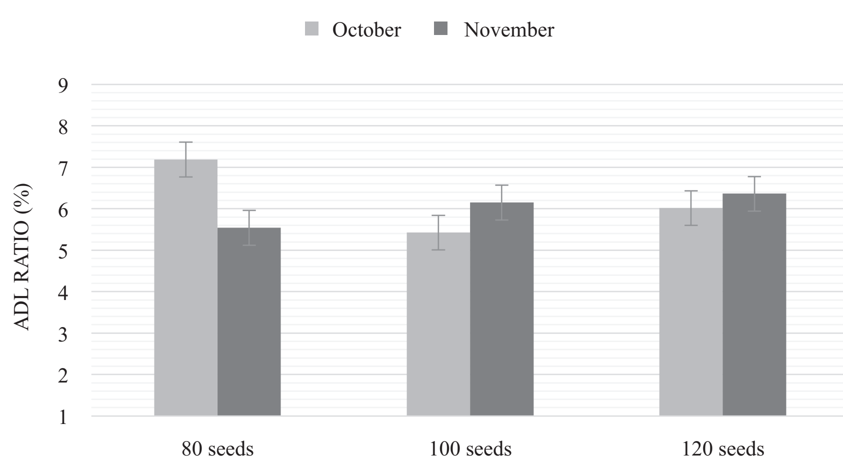

Figure 2.
Interaction Effect of Sowing Time × Plant Density on Acid Detergent Lignin (ADL) Content in Forage Peas Sown at Different Sowing Times and Plant Densities in Autumn.

ratio was not affected significantly by plant density because it did not cause serious competition. Forage CP content is a very important quality factor. The higher the CP value of forage, the higher the quality (Lithourgidis et al. 2006). Ruminants should consume forage, which has at least 7% CP content for survival rate (Meen, 2001). In this case, it can be emphasized that the CP content obtained in the study is sufficient for ruminant nutrition.

In the research, the difference between cultivars in terms of NDF content was insignificant. This situation probably originated from similarities between the cultivars for growth characteristics. Our NDF content results were similar to the results reported by other researchers (Başbağ et al., 2015; Kadıoğlu, 2011; Tan et al., 2014). Different sowing times did not have a significant effect on the NDF ratio. Neither sowing time nor sowing density, even years, did not cause any significant differences in NDF content. These factors probably did not cause any serious differences in growth characteristics, which cause changes in the NDF content of the plant. Hence, the plants that grow under these conditions had similar NDF content values. Some researchers also reported similar results for plant density (Borreani et al., 2007; Tan et al., 2014), sowing time (Pursley et al., 2020), and years (Javanmard et al., 2009). The NDF ratio is an important factor in determining forage quality. Dry matter intake increases with the decrease in the NDF content (Albayrak & Türk, 2013; Joachim & Jung, 1997). The results of NDF values obtained in the study were in superior quality class according to forage standards (NRC, 2001).

Acid detergent lignin is a main constituent of ADF, thus the effect of applications on ADL was similar to ADF content. In the study, ADF and ADL contents showed a similar changing trend with the hay yield according to years. Climatic conditions were more favorable for peas grown in the second year; hence, plants produced more dry matter and consequently stored more cell wall constituents such as cellulose and lignin, which are the main constituent of ADF. Therefore, ADF and ADL contents were higher in the second year. The other researchers (Uzun et al., 2017) also reported similar results. The cultivar, sowing time, and plant density applications did not have a significant effect on ADF content. The ADF content of Özkaynak (27.53%) and Taşkent (28.44%) cultivars are consistent with previous studies (Türk et al., 2007; Uzun et al., 2017). Sowing time did not affect ADF and ADL contents because plants sown in autumn might be accumulated similar cell wall material. Acid detergent fiber content of the hay is a good indicator of its digestibility as the ADF content increases the digestibility decrease (Açıkgöz et al., 2013). In this study, the overall ADF ratio was 27.98% and it was in the first class according to forage standards (NRC, 2001).

Conclusion and Recommendations

In the Eskisehir, animal raisers use harvest residues such as straw, sugar beet, and beet leaves for roughage deficit. Forage peas could be sown in winter as an intermediate crop and harvested in late spring before corn sowing and then, silage or grain corn could be sown. In this case, there is no restriction of main crop cultivation in the irrigated condition in the region. For this aim, forage peas could be sown in autumn from October to the middle of November using any of the cultivars of Ozkaynak or Taskent at 80 seeds m^{-2} plant density in the region. This practice contributes to alleviating good-quality hay shortages in the region.

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References

Açıkgöz, E. (2001). *Forage crops* (p. 584). VIPAS publication.

Açıkgöz, E., Sincik, M., Wietgrefe, G., Sürmen, M., Çeçen, S., Yavuz, T., Erdurmuş, C., & Göksoy, A. T. (2013). Dry matter accumulation and forage quality characteristics of different soybean genotypes. *Turkish Journal of Agriculture and Forestry*, *37*, 22–32.

Ağırbaş, N. C., Sapmaz, K., & Koç, A. (2017). Eskişehir ilinde yem bitkileri ekiliş alanı ve üretim miktarı üzerine tarımsal desteklemelerin etkisi [The effects of agricultural supports on forage crops of cultivation area and amount of production in Eskisehir province]. *Atatürk University Journal of the Agricultural Faculty*, *48*(1), 65–72.

Alan, O., & Geren, H. (2012). Bezelye'de (*Pisum sativum* L.) farklı ekim zamanlarının tane verimi ve diğer bazı tarımsal özellikler üzerine etkisi [Effects of different sowing dates on the seed yield and some other agronomical characteristics of pea (*Pisum sativum* L.)] *Journal of Agriculture Faculty of Ege University*, *49*:127–134.

Alatürk, F., Çınar, C., & Gökkuş, A. (2021). Farklı sıra aralıklarının bazı yem bezelyesi çeşitlerinin verim ve kalitesi üzerine etkileri [Effects of different row spacings on yield and quality of some field pea cultivars]. *Turkish Journal of Agricultural and Natural Sciences*, *8*(1), 53–57.

Albayrak, S., & Türk, M. (2013). Changes in the forage yield and quality of legume-grass mixtures throughout a vegetation period. *Turkish Journal of Agriculture and Forestry*, *37*, 139–147.

Annicchiarico, P., & Iannucci, A. (2007). Winter survival of pea, faba bean and white lupin cultivars in contrasting Italian locations and sowing times, and implications for selection. *Journal of Agricultural Science*, *145*(6), 611–622. [CrossRef].

Ateş, E., & Tekeli, A. S. (2017). Farklı taban gübresi uygulamalarının yem bezelyesi (*Pisum arvense* L.)'nin ot verimi ve kalitesine etkisi [The effect of different based fertilizer applications on herbage yield and quality of fodder pea (*Pisum arvense* L.)]. *KSU Journal of Agriculture and Nature*, *20*, 13–16.

Başbağ, M., Aydın, A., Çaçan, E., & Sayar, M. S. (2015). The quality values of some legume plants in southeastern Anatolia Region. 11st Congress of Field Crops, 7–10 September (pp. 95–99). Canakkale, Turkey.

Borreani, G., Peiretti, P. G., & Tabacco, E. (2007). Effect of harvest time on yield and pre-harvest quality of semi-leafless grain peas (*Pisum sativum* L.) as whole-crop forage. *Field Crops Research*, *100*(1), 1–9. [CrossRef]

Dereli, D. N. (2015). *Cultivation possibility of some annual legumes as a second crop under Eskisehir ecological conditions (p. 58)* [Master's Thesis, Eskişehir Osmangazi University, Institute of Science, Department of Field Crops].

Halil, D. S., & Uzun, A. (2019). Determination of combining ability and hybrid performance of some pea (*Pisum sativum* L.) lines obtained by crossing with Line x Tester analysis method. *Fresenius Environmental Bulletin*, *28*(10), 7119–7123.

İleri, O., Budaklı, E. C., Erbeyi, B., Avcı, S., & Koç, A. (2018). Effect of sowing methods on silage yield and quality of some corn cultivars grown in second crop season under irrigated condition of Central Anatolia, Turkey. *Turkish Journal of Field Crops*, *23*(1), 72–79.

Javanmard, A., Nasab, A. M., Javanshir, A., Moghaddam, M., & Janmohammadi, H. (2009). Forage yield and quality in intercropping of maize with different legumes as double-cropped. *Journal of Food, Agriculture and Environment*, *7*(1), 163–166.

Joachim, H., & Jung, G. (1997). Analysis of forage fiber and cell walls in ruminant nutrition. *Journal of Nutrition*, *127*, 810–813.

Kadıoğlu, S. (2011). *The effects of phosphate fertilization and bacteria inoculation on agricultural and morphological characteristics of some different (forage) pea cultivars* [Doctoral Dissertation] (p. 172). Ataturk University, Graduate School of Natural and Applied Sciences, Department of Field Crops.

Kadıoğlu, S., Tan, M., Kadıoğlu, B., & Taşgın, G. (2020). Determination of yield and some characteristics of forage pea genotypes (*Pisum sativum* ssp. arvense L.) under Erzurum conditions. *Atatürk University Journal of Agricultural Faculty*, *51*(2), 151–158.

Kalkan, F., & Avcı, S. (2020). Effect of applying nitrogen on yield of silage maize grown after forage legumes. *KSU Journal of Agriculture and Nature*, *23*, 336–342.

Kaplan, O., & Gökkuş, A. (2018). Kışlık ara ürün olarak yetiştirilen yem bitkilerinin biberin (*Capsicum annuum* var. *annuum*) verim ve verim unsurlarına eEtkileri [The effects of fodder crops grown as a winter intermediate crop on yield and yield components of pepper (*Capsicum annuum* var. *annuum*)]. *COMU Journal of Agriculture Faculty*, *6*(2), 1–6.

Karayel, R., & Bozoğlu, H. (2015). Tryptophane and raw protein contents of local pea (*Pisum sativum* L.) lines for different sowing dates. *Journal of Agricultural Sciences*, *21*, 337–345.

Knott, C. M., & Belcher, S. J. (1998). Optimum sowing dates and plant populations for winter peas (*Pisum sativum*). *Journal of Agricultural Science, Cambridge*, *131*, 449–454.

Koçer, A., & Albayrak, S. (2012). Determination of forage yield and quality of pea (*Pisum sativum* L.) mixtures with oat and barley. *Turkish Journal of Field Crops*, *17*(1), 96–99.

Konuk, A., & Tamkoç, A. (2018). Yem bezelyesinde kışlık ve yazlık ekimin bazı tarımsal özellikler üzerine etkisi [Effect on some agricultural features of winter and summer planting in forage peas]. *Journal of Bahri Dagdas Crop Research*, *7*(1), 39–50.

Krawutschke, M., Kleen, J., Weiher, N., Loges, R., Taube, F., & Gierus, M. (2013). Changes in crude protein fractions of forage legumes during the spring growth and summer regrowth period. *Journal of Agricultural Science*, *151*(1), 72.

Lithourgidis, A. S., Vasilakoglou, I. B., Dhima, K. V., Dordas, C. A., & Yiakoulaki, M. D. (2006). Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. *Field Crops Research*, *99*(2–3), 106–113. [CrossRef]

McKenzie, D. B., & Spaner, D. (1999). White lupin: An alternative to pea in oat-legume forage mixtures grown in Newfoundland. *Canadian Journal of Plant Science*, *79*, 43–47.

Meen, A. (2001). Forage quality on the Arizona strip. *Rangelands*, *23*, 7–12.

Mukherjee, D., Sharma, B. R., & Mani, J. K. (2013). Influence of different sowing dates and cultivars on growth, yield and disease incidence in garden pea (*Pisum sativum*) under mid hill situation. *Indian Journal of Agricultural Sciences*, *83*(9), 918–923.

NRC (2001). *Nutrient requirements of dairy cattle* (7th edn). National Academy Press.

Pursley, A. A., Biligetu, B., Warkentin, T., Lardner, H. A., & Penner, G. B. (2020). Effect of stage of maturity at harvest for forage pea (Pisum sativum L.) on eating behavior, ruminal fermentation, and digestibility when fed as hay to yearling beef heifers. *Translational Animal Science*, *4*(1), 149–158. [CrossRef]

Rubatzky, V. E., & Yamaguchi, M. (1997). *World vegetables: Principles, production, and nutritive values* (2nd edn). International Thomson Publishing.

SAS Institute (2011). *Base SAS 9.3 Procedures Guide (computer program)*.

Tan, M., Kırcı, K. K., & Gül, Z. D. (2014). Effects of row spacing and seeding rate on hay and seed yield of Eastern Anatolian forage pea (*Pisum sativum* ssp. *arvense* L.) ecotype. *Turkish Journal of Field Crops*, *19*(1), 96–100.

Tan, M., Koç, A., & Dumlu Gül, Z. (2012). Morphological characteristics and seed yield of east Anatolian local forage pea (*Pisum sativum* ssp. *arvense* L.) ecotypes. *Turkish Journal of Field Crops*, *17*(1), 24–30.

Türk, M., Albayrak, S., & Yüksel, O. (2007). Effects of phosphorus fertilization and harvesting stages on forage yield and quality of narbon vetch. *New Zealand Journal of Agricultural Research*, *50*, 457–462.

Uzun, A., & Açıkgöz, E. (1998). Effect of sowing season and seeding rate on the morphological traits and yields in pea cultivars of differing leaf types. *Journal of Agronomy and Crop Science*, *181*, 215–222.

Uzun, A., Aşık, B. B., & Açıkgöz, E. (2017). Effects of different seeding rates on forage yield and quality components of pea cultivars under Bursa conditions. *Turkish Journal of Field Crops*, *22*(1), 126–133.

Uzun, A., Bilgili, U., Sincik, M., Filya, I., & Açıkgöz, E. (2005a). Yield and quality of forage type pea lines of contrasting leaf types. *European Journal of Agronomy*, *22*(1), 85–94. [CrossRef]

Uzun, A., Gün, H., & Açıkgöz, E. (2012). Farklı gelişme dönemlerinde biçilen bazı yem bezelyesi (*Pisum sativum* L.) çeşitlerinin ot, tohum ve ham protein verimlerinin belirlenmesi [Yield and quality characteristics of some pea (*Pisum sativum* L.) Varieties Harvested at Different Growing stages]. *Journal of Agricultural Faculty of Uludag University*, *26*(1), 27–38.

Uzun, A., Karasu, A., Turgut, İ., Çakmak, F., & Turan, Z. M. (2005b). Bursa koşullarında ekim nöbeti sistemlerinin mısırın verim ve verim öğeleri üzerine etkisi [The effect of crop rotation systems on the yield and yield components in corn under Bursa conditions]. *Journal of Agricultural Faculty of Bursa Uludag University*, *19*(2), 61–68.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods of dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74*(10), 3583–3597. [CrossRef]