MINERAL, CRUDE ASH, AND CRUDE FAT CONTENTS OF SECOND CROP FORAGE PEA AND CEREALS MIXED CROPPING

Onur İLERİ[1], Şule ERKOVAN[1]

[1] Eskişehir Osmangazi University, Faculty of Agriculture, Department of Field Crops, Eskişehir, Turkey

Corresponding author e-mail: oileri@ogu.edu.tr

ABSTRACT

This research was carried out to determine some minerals, crude ash, and crude fat contents of second crop forage pea + cereals mixtures, which were sown after wheat harvest in Central Anatolia ecological conditions. The field experiments were conducted in the 2018-2019 years. Mixed cropping was carried out using forage pea at different densities (80, 100, 120 plants m^{-2}), and 25-50 % of the suggested densities of oat, silage maize, and Sudangrass. Results revealed that phosphorus (P) and magnesium (Mg) contents are increasing, but the crude fat content is in a decreasing trend depending on precipitation. Plant densities of forage pea did not cause any significant variation but cereal species caused significant differences in the examined characteristics. Phosphorus content was higher in pea + silage maize mixtures. Especially 25 % oat and pea mixtures had higher Calcium (Ca) content (10163,0 mg kg^{-1}) but increasing densities of cereals decreased Ca content in mixtures. The highest Mg content was 3692,1 mg kg^{-1} and it was recorded at 50 % silage maize + pea mixed cropping. Crude fat contents of forage pea and warm-season cereals (silage maize, Sudangrass) mixtures remained between 1,6 – 1,8 % but it was higher than 2 % at oat mixtures. The increasing ratio of the warm season cereals caused higher crude ash content in the mixtures and the highest value was determined as 11,68 % in 50 % silage maize and forage pea mixture. Forage pea and 50 % silage maize mixed cropping should be suggested for the high-quality second crop forage production in the region by considering the examined characteristics.

Keywords: Forage pea, Mixed cropping, Mineral content, Crude ash, Crude fat

INTRODUCTION

Forage legumes have been widely cultivated due to their high crude protein content. Forage pea (*Pisum sativum* ssp. *arvense*) is an annual forage legume, which contains nearly 20 % crude protein in its hay (Acikgoz, 2001), is highly digestible (Uzun et al., 2005), and has high lysine content (Manga et al., 2003). The cultivation area of the plant is increasing in Turkey due to these high-quality characteristics (TUIK, 2020). Although forage pea has high yielding and high-quality forage production capacity, it is mostly grown as mixed cropping due to common lodging problems (Tan et al., 2013).

Forage pea is generally sown in autumn in our country as a mixture with the erectly growing winter cereals like oat, barley, and triticale (Gocmen and Ozaslan-Parlak, 2017; Gulumser et al 2017). Moreover, it was observed in recent years that forage pea could be

cultivated as a mixture cropping using warm-season cereals as silage maize and Sudangrass in irrigated areas of Central Anatolia at the second crop season after wheat harvest (Ileri et al., 2020). Maize and Sudangrass could alleviate the heat stress on forage pea because of their shadow effects and forage pea facilitate the growth of these cereals via nitrogen fixation (Geren and Alan, 2012; Hu et al., 2016). Therefore, high-quality and high yielded forage could be produced using these mixtures in the second crop season (Gulumser et al., 2017).

Crude protein content and digestibility are considered as the major forage quality characteristics but mineral, crude ash, and crude fat contents could also be quite effective directly or indirectly on animal production and welfare. For example; grass tetany risk increases under Mg deficiency (McDonald et al., 1995), deficient P content in consumed forage could cause pica or low production (McDowell, 1992), and excessive P may affect animal welfare negatively by causing renal calculus (Emerick, 1988). Greene (2000) indicated Ca deficiency does not have a direct negative effect but it is well-known that Ca/P and Ca/Mg ratios in forage could directly affect animal production (NRC, 1996). Besides crude fat content in consumed forage might be related to the fat content in animal productions as milk (Anil et al., 1998) and crude ash content is important because it indicates the total mineral content of forage (Eskandari et al., 2009).

Forage pea and cereals mixed cropping researches generally focus on forage yield, crude protein content, and digestibility. There is little information about the mineral, crude ash, and crude fat contents of these mixtures. Carr et al. (2004) determined the Ca content of pea-barley and pea-oat mixtures in a range of 6420 – 7000 mg kg^{-1} and P content between 1970 – 2800 mg kg^{-1}. In another research, Neugschwandtner and Kaul (2016) examined the stubble of pea-oat mixture and determined the Mg content between 913 – 3943 mg kg^{-1}. Other researchers indicated the crude ash and crude fat contents of forage pea – cereal mixtures respectively in the range of 3,19 – 13,58 % and 1,43 – 1,98 % (Gronle et al., 2015; Gocmen and Ozaslan-Parlak, 2017; Tsialts et al., 2018).

In our experiment we investigated the Ca, Mg, P, crude fat, and crude ash contents in the forage of forage pea and cereals (oat, silage maize, Sudangrass) mixture cropping, which were cultivated in the second crop season after wheat harvest in Central Anatolia conditions.

MATERIAL AND METHOD

The two-year field research was carried out in the experimental field of the Faculty of Agriculture, Eskisehir Osmangazi University in 2018 and 2019 years. Some minerals (Ca, Mg, P), crude ash, and crude fat contents were examined in the mixtures prepared by using different plant densities of forage pea and cereals.

Table 1. Meteorological data belong to experiment location*

Months	Precipitation (mm)			Temperature (ºC)			Humidity (%)		
	2018	2019	LYA	2018	2019	LY	2018	2019	LY
Jan	31,5	60,2	38,7	2,2	4,3	0,3	95,5	91,0	98,2
Feb	40,5	50,1	32,5	6,6	3,4	4,7	90,7	79,6	92,6
March	74,8	13,4	33,4	10,1	6,3	9,3	81,5	64,5	81,6
Apr	16,5	26,7	35,0	15,4	9,5	13,1	60,7	69,3	67,8
May	84,8	42,2	44,8	17,6	16,5	16,5	83,0	65,1	86,1
June	**72,5**	**45,7**	**30,6**	**20,6**	**20,9**	**20,4**	**80,7**	**67,9**	**83,3**
July	**38,3**	**33,5**	**14,0**	**23,0**	**21,3**	**23,3**	**71,4**	**62,3**	**75,8**
Aug	**25,0**	**2,4**	**7,8**	**23,5**	**22,3**	**22,9**	**62,2**	**61,0**	**74,1**
Sep	**4,3**	**5,0**	**14,4**	**19,1**	**18,1**	**20,0**	**62,9**	**62,1**	**68,1**
Oct	41,0	18,3	27,0	14	14,2	12,9	75,5	70,1	79,6
Nov	29,6	33,9	29,2	8,4	7,9	7,5	79,2	76,2	80,3
Dec	63,6	74,1	45,1	2,7	2,9	3,6	96,0	89,9	93,6
Tot. Ave.	***522,***	***405,***	***352,4***	***13,6***	***12,3***	***12,8***	***78,3***	***71,6***	***81,8***

*Turkish State Meteorological Service

LYA**:** Long years average

The typical continental climate conditions of Central Anatolia prevail in the experimental location, which indicates hot and dry summers, snowy winters. The mean annual precipitation of the Eskisehir is between 400-500 mm and total precipitation and average temperature were higher in the first experimental year (Table 1). Soil samples were taken from the experimental field in a depth of 0-20 cm and analyzed at the laboratory of the Soil Science and Plant Nutrition Department. According to the report, the soil was clay-loamy, slightly alkaline, slightly limy, poor in available phosphorus and organic matter, rich in potassium, and have no salinity problem.

Forage pea (*Pisum sativum* ssp. *arvense* L. cv. Tore) was sown using three different densities (80, 100, 120 plants m^{-2}) and separately in a mixture with oat (cv. Checota), silage maize (cv. Kilowatt), and Sudangrass (cv. Gozde-80). Cereal ratios were used by considering the 25 and 50 % of the suggestions, which were 180 kg ha^{-1} for oat (Basaran et al., 2018), 100000 plants ha^{-1} for silage maize (Turgut et al., 2005), and 20 kg ha^{-1} for Sudangrass (Acikgoz, 2001).

The experiment was arranged in a completely randomized block design using three replications. Sowing was carried out after the wheat harvest on 12 July 2018 and on 22 July 2019. Every plot consisted of 5 rows each 5 m long and had 30 cm row spacing (5m x 1,5m = 7,5 m^2). Mixtures were sown using experimental markers and irrigation was applied using sprinklers.

Harvest time was determined considering the pod-filling stage of forage pea (Fraser et al., 2001) and it was on 15 September in 2018 and 4 October in 2019. All plants were harvested using hand sickle from the middle 1m^2 of the plots. Harvested samples were oven-dried at 60°C until reached constant weight and grounded using the experiment mill to pass through a 2 mm sieve. Analyses were carried out using near-infra-red spectroscopy (NIRS), which was calibrated for determining Ca, Mg, P, crude ash, and crude fat contents (Gronle et al., 2015).

All data were subjected to analysis of variance using SAS 9.3 statistical software and the means were separated using Tukey Multiple Comparison Test (SAS Institute, 2011).

RESULTS

Phosphorus content significantly varied between the years and among the mixtures but pea density did not cause any significant variation. The third-order interaction was also significant (Table 2). In 2019, P content was quite higher than in 2018. The highest and the lowest P contents were recorded at 50 % silage maize mixture (2178,2 mg kg^{-1}) and 50 % oat mixture (1714,3 mg kg^{-1}) respectively. However, the mixtures did not cause any significant differences considering monocrop forage pea in terms of P content (Table 2).

Calcium content showed similar variations with P, and it was statistically significant between the years and among mixtures, but not the pea densities (Table 2). Ca content increased in the second year and it was lower than monocrop pea at 50 % silage maize or Sudangrass mixtures. Other mixtures did not cause any significant variation concerning monocrop forage pea but a significant year × mixture interaction occurred because of the significant variation trends of the mixtures in both years.

The Mg content significantly varied among the mixtures and only the year × mixture interaction was significant but the other factors did not cause any significant variation in Mg content (Table 2). Mg content varied between 2471,6 – 3692,1 mg kg^{-1} among the mixtures and the highest value was observed in the mixture of 50 % silage maize.

Crude fat content was 2,11 % in 2018 but significantly decreased to 1,67 % in the second experimental year. Different pea densities did not cause any significant variation but the mixtures prepared using silage maize or Sudangrass decreased the crude fat content concerning monocrop forage pea (Table 2). Pea – oat mixtures had statistically similar crude fat content with monocrop forage pea and they were higher than 2 % in both oat densities (Table 2). The year × mixture interaction was also significant.

Crude ash content did not show a significant variation between the years and among the pea densities but the difference among the mixtures and three-order interaction were significant ($P \leq 0,01$). All mixtures of silage maize and Sudangrass were statistically in the same group but they were significantly higher than monocrop forage pea in terms of crude ash content. Crude ash contents of the oat mixtures did change significantly from monocrop forage pea (Table 2).

Table 2. P, Ca, Mg, crude fat, and crude ash contents

	P (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})	Crude fat (%)	Crude ash (%)
Year (Y)					
2018	1057,3 b	6233,4 b	3199,7	2,11 a	10,67
2019	2755,5 a	11440,2 a	3185,2	1,68 b	10,45
Pea density (P)					
80 plants m^{-2}	1937,2	8911,4	3281,7	1,88	11,19
100 plants m^{-2}	1940,9	9095,8	3198,6	1,91	10,00
120 plants m^{-2}	1840,9	8503,2	3097,1	1,90	10,49
Mixture (M)					
Monocrop pea	1861,7 abc	10292,8 a	3330,6 ab	2,29 a	9,81 cd
25% Oat	1783,3 bc	10163,0 a	3040,5 ab	2,15 ab	10,17 bcd
50% Oat	1714,3 c	9647,3 ab	2741,6 b	2,09 ab	9,46 d
25% Silage maize	2106,1 ab	8320,9 abc	3341,7 ab	1,84 bc	11,02 ab
50% Silage maize	2178,2 a	7333,4 c	3692,1 a	1,67 c	11,68 a
25% Sudangrass	1813,0 bc	8279,4 abc	2991,1 b	1,65 c	10,68 abc
50% Sudangrass	1888,2 abc	7820,8 bc	3209,9 ab	1,60 c	11,09 ab
Mean	*1906,3*	*8836,8*	*3192,4*	*1,89*	*10,56*
		ANOVA			
Y	*	**	ns	**	ns
P	ns	ns	ns	ns	ns
M	**	**	*	**	**
Y × P	ns	ns	ns	ns	**
Y × M	ns	*	**	**	**
P × M	**	ns	ns	ns	**
Y × P × M	*	ns	ns	ns	**

ns: the difference is not significant, *: P≤0,05, **: P≤0,01

DISCUSSION

Recommended P content is about 2000 mg kg^{-1} in the forage for proper animal nutrition (NRC, 1996). In the first year of the study, P content was below the recommendation but it was higher and 2755,5 mg kg^{-1} in the second year. This might be due to the delayed maturation caused by higher precipitation in the second year (Table 1) because P content decreases as the maturation of the plant increases (Bormann et al., 2004; Haan et al., 2007). Gulumser et al (2017) were also determined a higher P content in the forage in the years received higher precipitation. P content of the mixed croppings was not statistically different from monocrop forage pea but it was observed the P content increased up to recommended levels (2000 mg kg^{-1}) by mixed cropping of forage pea with warm-season cereals (Table 2). Various cereal ratios were stated not to cause significant differences in the P content of the pea cereal mixtures (Gulumser et al., 2017; Kaymak et al., 2021).

The mean Ca content was determined as 8836,6 mg kg^{-1} and it was higher than the recommendation (3000 mg kg^{-1}) made by Kidambi et al (1989). Besides, other researchers indicated the Ca content of pea and cereals mixtures between 6042 – 9270 mg kg^{-1} (Carr et al., 2004; Gulumser et al., 2017). It was observed that Ca content was also higher as similar to P content in the year which received more precipitation. Similar findings were also reported by Gulumser et al (2017) and Onal-Asci et al (2018). Monocropped forage pea had higher Ca content than all mixtures mathematically, but only 50 % silage maize and Sudangrass mixtures had lower values statistically than monocrop forage pea. This is mainly originated from the higher Ca content of the legumes concerning cereals, especially warm-season cereals (Carr et al., 2004; Kacar and Katkat, 2007).

Some researchers reported the Mg content of the forage pea and cereal mixtures between 730 – 3340 mg kg^{-1} (Gulumser et al., 2017; Kaymak et al., 2021). Mean Mg content was 3192,4 mg kg^{-1} in our research and it was consistent with the findings in the literature. There were not any significant differences between years and plant densities possibly due to the similar maturation levels at harvest because it is known that Mg content is related to the maturation level of the plant (Onal-Asci et al., 2018). Increasing cereal density could increase the Mg content in legume-cereal mixed cropping (Egritas and Onal Asci, 2015). In our research, increasing warm-season cereals density caused a slight increase in the Mg content of the mixture but this variation was not statistically significant (Table 2).

High-quality forage resources could contain about 1,2 – 5,8 % crude fat (Thiex et al., 2003). Moreover, the crude fat content might be affected significantly by climatic variations, especially precipitation, and altitude (Pozdisek et al., 2011; Tsialtas et al., 2018). Therefore, higher crude fat content in the second year might be related to higher precipitation in the second year (Table 1). Some researchers reported the variation among the pea-cereal mixtures was not significant (Carr et al., 2004; Pozdisek et al., 2011). In the research, pea-oat mixtures did not cause any significant difference in crude protein content considering monocrop forage pea but especially warm-season cereals caused a significant decrement. These results might be indicating that forage pea could display various responses due to cool- or warm-season cereals used in the mixed cropping in terms of crude fat content.

Crude ash content roughly indicates the total mineral content of the forage (Eskandari et al., 2009). This content changes between 7,9 – 8,3 % in the hay of forage pea (Kavut et al., 2016). Similar maturity levels during the harvest might be the main reason for non-significant variation between years and among the pea densities because crude ash content of forage pea could change significantly due to maturation level (Seydosoglu and Bengisu, 2019). Researchers reported that there were not any significant differences in crude ash content of pea-cereal mixtures (Gocmen and Ozaslan-Parlak, 2017; Seydosoglu and Bengisu, 2019) but we determined significant differences among the mixtures (Table 2). The difference mainly originated from the presence of warm-season cereals in the mixture, which were not examined in the other researches, because warm-season cereals have higher crude ash content concerning cool-season cereals (Carr et al., 2004; Kacar and Katkat, 2007).

CONCLUSIONS

Phosphorus, calcium, magnesium, crude fat, and crude ash contents of the second crop forage pea-cereal mixed cropping could be affected significantly from yearly climatic variations and could produce forage in higher quality in the years which were cooler and receive higher precipitation. Pea density of 80 plants m^{-2} could be used for such mixtures because increasing densities did not have any significant effect on the examined characteristics. Results showed that high-quality forage could be produced after wheat harvest in the Central Anatolia Region by mixed cropping of forage pea – silage maize or Sudangrass. In such mixtures, forage pea with a density of 80 plants m^{-2} could be sown with 50 % silage maize (50000 plants ha^{-1}) after wheat harvest in the region.

ACKNOWLEDGEMENT

Many thanks to Prof Ali KOC and Prof Halil Ibrahim ERKOVAN for their contributions to the research and we also thank Emre KARA for the support during the laboratory analyses.

REFERENCES

Acikgoz, E. 2001. Forage Crops. VIPAS Publication Number: 58, Bursa, 584p. (In Turkish).

Anil, L., Park, J., Phipps, R.H., Miller, F.A. 1998. Temperate intercropping of cereals for forage: a review of the potential for growth and utilization with particular reference to the UK. Grass and Forage Science, 53(4): 301-317.

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

Bormann, K., Powers, W.J., Russell, J.R. 2004. Effects of forage maturity on phosphorus digestion in beef cows. Iowa State University Animal Industry Report, 1(1).

Carr, P.M., Horsley, R.D., Poland, W.W. 2004. Barley, oat, and cereal–pea mixtures as dryland forages in the northern Great Plains. Agronomy Journal, 96(3): 677-684.

Egritas, O. and Onal-Asci, O. 2015. Determination of some mineral matter contents in common vetch cereals mixtures. Academic Journal of Agriculture, 4(1): 13 18.

Emerick, R.J. 1988. Urinary calculi. p. 523–531. In D.C. Church (ed.) The ruminant animal: Digestive physiology and nutrition. Prentice-Hall, Englewood Cliffs, NJ.

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

Fraser, M.D., Fychan, R., Jones, R. 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.

Geren, H. and Alan, O. 2012. Effects of different sowing dates on the herbage yield and some other yield characteristics of two pea (*Pisum sativum* L.) cultivars, Anadolu Journal of Aegean Agricultural Research Institute, 22(2): 37 – 47. (In Turkish).

Gocmen, N. and Ozaslan-Parlak, A. 2017. Determination of seeding rates of pea intercrops with oat, barley and triticale. COMU Journal of Agriculture Faculty, 5(1): 119-124. (In Turkish).

Greene, L.W. 2000. Designing mineral supplementation of forage programs for beef cattle. Journal of Animal Science, 77(1): 125.

Gronle, A., Heß, J., Bohm, H. 2015. Effect of intercropping normal-leafed or semi-leafless winter peas and triticale after shallow and deep ploughing on agronomic performance, grain quality and succeeding winter wheat yield. Field Crops Research, 180: 80-89.

Gulumser, E., Mut, H., Dogrusoz, M.C., Basaran, U. 2017. The effect of sowing rates on quality traits of legumes + cereals mixtures. Selcuk Journal of Agriculture and Food Sciences, 31(3): 43-51. (In Turkish).

Haan, M.M., Russell, J.R., Kovar, J.L., Powers, W.J., Benning, J.L. (2007). Effects of forage management on pasture productivity and phosphorus content. Rangeland Ecology and Management, 60(3): 311-318.

Hu, F., Gan, Y., Chai, Q., Feng, F., Zhao, C., Yu, A., Mu, Y., Zhang, Y. 2016. Boosting system productivity through the improved coordination of interspecific competition in maize/pea strip intercropping. Field Crops Research, 198: 50-60.

Ileri, O., Erkovan, S., Erkovan, H.I., Koc, A. 2020. Fresh forage yield and some characteristics of forage pea-crop mix sowed using different rates in second crop season of Central Anatolia. International Journal of Agriculture and Wildlife Science, 6(3): 538-545. (In Turkish).

Kacar, B. and Katkat, A.V. 2007. Bitki Besleme. (3. Baski). Nobel Yayin No: 849, Nobel Yayin Dagitim, Ankara, pp 145-191. (In Turkish)

Kavut, Y.T., Celen, A.E., Cibik, S.E., Urtekin, M.A. 2016. A research on the yield and some yield characteristics of some field pea (*Pisum arvense* L.) varieties grown in different row spacings in Ege Region Conditions. Journal of Field Crops Central Research Institute, 25(Special Issue-2): 225-229. (In Turkish).

Kaymak, G., Gulumser, E., Can, M., Acar, Z., Ayan, I. 2021. Determination the silage quality of leafy and semi-leafy forage pea and annual ryegrass mixtures. Journal of the Institute of Science and Technology, 11(2): 1595-1602.

Kidambi, S.P., Matches, A.G., Gricgs, T.C. 1989. Variability for Ca, Mg, K, Cu, Zn, and K/(Ca +Mg) ratio among 3 wheatgrasses and sainfoin on the southern high plains. Journal of Range Management, 42: 316-322.

Manga, I., Acar, Z., Ayan, I. 2003. Baklagil Yem Bitkileri (Genisletilmis 3. Baski), Ondokuz Mayis Universitesi Ziraat Fakultesi Yayinlari Ders Kitabi, Yayin No: 7, Samsun, p.451.

McDonald, P.E., Edwards, R.D., Morgan, C.A. 1995. Animal Nutrition (5^{th} edition). Wiley, J and sons. USA. pp. 122-128.

Mcdowell, L.R. 1992. Minerals in Animals and Human Nutrition. Academic Press, New York.

Neugschwandtner, R.W. and Kaul, H.P. 2016. Concentrations and uptake of macronutrients by oat and pea in intercrops in response to N fertilization and sowing ratio. Archives of Agronomy and Soil Science, 62(9): 1236-1249.

NRC (National Research Council). 1996. Nutrient Requirements of Beef Cattle (7th edition). National Academy Press, Washington, DC. 232 p

Onal-Asci, O., Acar, Z., Arici-Kasko, Y. 2018. Mineral contents of forage pea-triticale intercropping systems harvested at different growth stages. Legume Research-An International Journal, 41(3): 422-427.

Pozdisek, J., Henriksen, B., Ponizil, A., Løes, A.K. 2011. Utilizing legume-cereal intercropping for increasing self-sufficiency on organic farms in feed for monogastric animals. Agronomy Research, 9(102): 343-356.

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

Seydosoglu, S. and Bengisu, G. 2019. Effects of different mixture ratios and harvest periods on grass quality of triticale (*Triticosecale wittmack*)–forage pea (*Pisum sativum* L.) intercrop. Applied Ecology and Environmental Research, 17(6): 13263-13271.

Tan, M., Koc, A., Dumlu-Gul, Z., Elkoca, E., Gul, I. 2013. Determination of dry matter yield and yield components of local forage pea (*Pisum sativum* ssp. *arvense* L.) ecotypes, Journal of Agricultural Sciences, 19(4): 289-296.

Thiex, N.J., Anderson, S., Gildemeister, B. 2003. Crude fat, hexanes extraction, in feed, cereal grain, and forage (Randall/soxtec/submersion method): collaborative study. Journal of AOAC International, 86(5): 899-908.

Tsialtas, I.T., Baxevanos, D., Vlachostergios, D.N., Dordas, C., Lithourgidis, A. 2018. Cultivar complementarity for symbiotic nitrogen fixation and water use efficiency in pea-oat intercrops and its effect on forage yield and quality. Field Crops Research, 226: 28-37.

Turgut, I., Duman, A., Bilgili, U. and Acikgoz, E. 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.

TÜİK. 2020. Bitkisel Uretim Istatistikleri. https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1, Erişim tarihi 18.04.2021, 19:21.

Uzun, A., Bilgili, U., Sincik M., Filya, I., Acikgoz, E. 2005. Yield and quality of forage type pea lines of contrasting leaf types, European Journal of Agronomy, 22(1): 85- 94.