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DETERMINATION OF FORAGE YIELD AND QUALITY OF PEA (*Pisum sativum* L.) MIXTURES WITH OAT AND BARLEY

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ABSTRACT

The aim of the study was to determine the forage yield and quality of pure stands or binary mixtures of pea (*Pisum sativum* L.) with oat *(Avena sativa* L.) and barley (*Hordeum vulgare* L.) mixtures. Two seeding ratios (55:45 and 65:35) were used to investigate forage yield and quality of pea-oat and pea-barley mixtures. Experiment was established in early spring of 2010 and 2011 in a randomized complete block design, with 3 replicates, in Isparta, Turkey. Dry matter (DM) yield, crude protein (CP) content, crude protein yield (CPY), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrient (TDN) and relative feed value (RFV) were determined for each monoculture or mixture. The oat and barley grown in monoculture had the highest DM yield (13520 and 12810 kg ha), followed by pea-oat and pea-barley (55:45) seeding ratio, with 11270 and 10540 kg ha. CP content was highest in monoculture pea followed by pea-cereal (65:35). The highest forage quality parameters were achieved when pea was grown as a monoculture or when at a high proportion in mixture. The results showed that mixture of pea with barley and oat at the 65:35 seeding ratio was obtained higher productive and quality forage.

Key words: Pea, cereal, mixture, forage quality, relative feed value.

INTRODUCTION

In forage crop production systems, grass-legume mixtures preferred due to their several advantages over monoculture. They have ability to fix atmospheric free nitrogen into the soil by symbiotic living with bacteria of *Rhizobium* species and sustaining of soil fertility (Albayrak et al. 2004). Annual legumes are low-yielding, particularly in areas with low rainfall and hinder harvest because it normally lays on the soil surface (Lithourgidis et al. 2006). On the other hand, small grain cereals provide high dry matter yields but they produce forage with low protein. Legumes are rich in terms of protein concentration, whereas cereals have higher carbohydrate contents, and cereals benefit from the nitrogen fixed by legumes when they are grown together. Several researches reported that annual legume-cereal mixtures resulted in high yields and high nutritional quality as compared with cereals alone (Karadağ and Büyükburç, 2003; Agegnehu et al. 2006; Yolcu et al. 2009; Balabanlı et al. 2010). Benefits of mixture include greater uptake of water and nutrient, enhanced weed suppression, and increased soil conservation (Vasilakoglou et al. 2005). In the legume mixtures with cereals, it is essential to be known the rates of the legume and cereal species on high forage yield and quality. The objective of the present study was to evaluate pea, oat and barley monocultures as well as mixtures of pea with each of the above cereals in two seeding ratios (55:45 and 65:35) for forage yield and quality under Isparta ecological conditions.

MATERIALS AND METHODS

The research was conducted during the 2010 and 2011 growing seasons in Isparta Province (37°45′N, 30°33′E, elevation 1035 m), located in the Mediterranean region of Turkey. The total precipitation, average temperature and humidity data for the experimental area are given in Table 1. The major soil characteristics of the research area, based on the method described by Rowell (1996), were as follows: The soil texture was clay loam, the organic matter was 1.4% by the Walkley-Black method, the lime was 7.2% by Schiebler calcimeter, the total salt was 0.38%, the exchangeable K was 119 mg kg^{-1} by 1N NH4OAc, the extractable P was 3.9 mg kg^{-1} by 0.5N NaHCO3 extraction, and the pH in a soil saturated extract was 7.5. Pea (Kirazlı cv) (*Pisum sativum* L.), oat (population) (*Avena sativa* L.) and barley (population) (*Hordeum vulgare* L.) were used as the experimental material.

The experiment was established on 13 March 2010 and 17 March 2011. Each plot consisted of 10 rows, each 5 m in length. The row spacing was 20 cm and the seeds were mixed and sown together. The seeding rates were 12 kg/da for pea and 20 kg/da for oat and barley. Monoculture pea, oat, barley and binary mixtures of pea with oat and barley (55:45 and 65:35 seeding ratio) were sown. Cereal monoculture plots received a N application of 80 kg ha (26% ammonium nitrate). No P or K fertilizer was applied, because the soil test results indicated that sufficient amounts were present in the soil. The mixtures were fertilized 3 kg/da N. The plots were harvested on 21 June 2010 and 24 June 2011. The harvest time was based on the pea 50% flowering stage. The plots were harvested to a 5-cm stubble height using a plot harvest machine. The

Table 1. Monthly precipitation, mean temperature and humidity in the experimental area

Months	Precipitation (mm)			Temperature (°C)			Humidity (%)		
	Long-years	2010	2011	Long-years	2010	2011	Long-years	2010	2011
March	52.9	33.2	50.4	8.72	6.32	5.9	64.9	59.64	70.62
April	58.8	47.0	42.8	11.86	10.34	10.6	61.9	60.97	68.54
May	46.0	32.4	42.5	17.05	14.44	15.5	58.1	55.14	64.84
Jun	27.8	53.7	61.8	19.23	19.78	20.1	52.1	61.84	56.55
Total	185.5	166.3	197.5	-	-	-	-	-	-
Mean	-	-	-	14.22	12.72	13.03	59.25	59.39	65.14

botanical compositions were determined for 2 randomly selected 1 m^{-2} quadrates in each plot. Samples were collected following the harvest, hand-separated, dried at 70°C for 48 h and weighed. The dried samples were reassembled and ground to pass through a 1-mm screen. The crude protein content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Kacar and İnal, 2008). The ADF (acid detergent fiber) and NDF (neutral detergent fiber) concentrations were measured according to Ankom Technology (Albayrak et al. 2009). The total digestible nutrients (TDN) and the relative feed value (RFV) were estimated according to the following equations adapted from Aydın et al. (2010):

TDN= (-1.291 x ADF) + 101.35

RFV = (120)/NDF) x ((88.9 - (0.779 x ADF)) x (0.775)).

Land equivalent ratio (LER) was defined as the relative area of monoculture plant required to have the same yield obtained from its mixture. LER was calculated by using the formula given below (Albayrak et al. 2004):

LER= (yield of legume in mixture / yield of legume alone) + (yield of cereal in mixture/yield of cereal alone).

The experiment was conducted in a randomized complete block design, with 3 replications. The statistical analysis of the yield and quality data was performed using the General Linear Model procedure of SAS (SAS Inst., 1998). The means were compared using the Least Significant Difference (LSD) test at the 0.05 probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

The results of the analysis of variance showed that the effects of the year and treatments on the dry matter (DM) yield were significant (Table 2).

Table 2. Results of analysis of variance and F values of the traits determined

Sources of variation	df	DMY	CP	CPY	ADF	NDF	TDN	RFV
Year (Y)	1	126.8**	5.0*	76.5*	1.99ns	2.01ns	1.98ns	4.25ns
Blok(Year)	4	7.7ns	3.49*	3.40ns	4.71*	2.67ns	4.69*	8.62*
Treatment	6	259.4**	71.3**	80.4**	83.1**	361.5**	82.9**	589**
Y x Treatment	6	4.0ns	1.21ns	10.2ns	0.01ns	0.06ns	0.01ns	0.06ns
Error	24							

df, degrees of freedom; ns, not significant. *P < 0.05, **P < 0.01.

The greatest forage DM yield was obtained from pure oat and barley stands (13520 and 12810 kg ha, respectively) (Table 3). The mixtures of pea with oat and barley in 55:45 seeding ratio had higher DM yield than those of 65:35 seeding ratio. Monoculture pea gave the least DM yield (6650 kg ha). Pea-oat and pea-barley mixtures (55:45 and 65:35 seeding ratios) produced 69%, 48%, 92% and 40% more forage DM yield than pea monoculture alone, but about 19 and 36% less than monoculture oat and 21 and 37 less than monoculture barley. In present study, forage DM yield of all mixtures were lower than yields of the each cereal in monoculture (Table 3). Some researcher reported that pea-cereal forage mixtures did not out yield cereal forage sole crops (Chapko et al. 1991; Giocomimi et al. 2003; Aasen et al. 2004). On the other hand many studies have reported that yields of legume-cereal mixtures were intermediate or even lower than yields of monocultures due to the competition between species (Caballero et al. 1995; Valanquez-Beltran et al. 2002; Carr et al. 2004).

Table 3. Dry matter (DMY) yield, crude protein content (CP) and crude protein yield (CPY) of pea, oat and barley grown in monoculture and in mixtures (average of 2 years).

Treatments	Seed ratios	DMY (kg ha)	CP (%)	CPY (kg ha)
Pea	100	6650 d	16.08 a	1071.4 c
Oat	100	13520 a	10.87 d	1469.0 ab
Pea : oat	55:45	11270 b	13.95 c	1574.1 a
Pea : oat	65:35	9890 c	15.33 ab	1515.6 a
Barley	100	12810 a	10.46 d	1339.1 b
Pea : barley	55:45	10540 bc	14.99 b	1579.2 a
Pea : barley	65:35	9340 c	15.06 b	1409.5 ab
CV (%)		10.42	4.99	10.14

Means followed by the same columns are not significantly different at p<0.05.

The pea component in dry matter were significantly different (p<0.01) (Table 5). The highest pea component in dry matter was determined from the mixture containing 65% pea and 35% cereal, whereas the mixture containing 55% pea and 45% cereal had the least pea component in dry matter (Table 4). Albayrak et al. (2004) reported that as increasing the proportion of cereal in mixed (legume-

Table 4. Acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN) and relative feed value (RFV) of pea, oat and barley grown in monoculture and in mixtures (average of 2 years)

Treatments	Seed ratios	ADF (%)	NDF (%)	TDN (%)	RFV (%)
Pea	100	25.81 e	38.27 f	68.03 a	167.27 a
Oat	100	34.61 a	59.12 a	56.67 e	97.45 g
Pea : oat	55:45	30.66 c	50.53 c	61.78 c	119.69 e
Pea : oat	65:35	28.53 d	47.15 f	64.52 b	131.64 b
Barley	100	31.84 b	57.37 b	60.24 d	103.93 f
Pea : barley	55:45	30.24 c	49.51 cd	62.31 c	122.75 d
Pea : barley	65:35	28.90 d	48.65 d	64.04 b	127.02 c
CV (%)		2.47	1.78	1.54	1.83

Means followed by the same columns are not significantly different at $p<0.05$.

cereal) forages increases the yield of dry matter per unit area. This finding is consistent with the present results.

The treatments and year were significant for the CP content and CP yield (Table 2). All pea-cereal mixtures had higher CP content than those of monoculture of oat and barley (Table 3). Monoculture pea had the highest CP content (16.08%), followed by the mixtures of pea-oat (65:35) (15.33%) and pea-barley (65:35) (15.06%). In contrast, oat and barley monoculture had the lowest CP (10.87 and 10.46%, respectively). In all mixtures, the crude protein content increased as pea seeding rate increased (Table 3). These results in agreement with those reported by Caballero et al. 1995 and Giocomini et al. 2003.

Table 5. Results of analysis of variance and F values of the traits determined and pea rate in mixture with land equivalent ratio (LER) (average of 2 years).

Sources of variation	df	Pea rate in mixture	LER	Treatments	Seed ratios	Pea rate in mixture (%)	LER
Year (Y)	1	1.06ns	8.55*	Pea : oat	55:45	42.05 b	1.21
Blok(Year)	4	2.57ns	1.94ns	Pea : oat	65:35	50.58 a	1.12
Treatment	3	19.88**	2.31ns	Pea : barley	55:45	42.65 b	1.15
Y x Treatment	3	0.24ns	0.36ns	Pea : barley	65:35	49.97 a	1.07
Error	12			CV (%)	5.45	8.17	

df, degrees of freedom; ns, not significant. *P < 0.05, **P < 0.01. Means followed by the same columns are not significantly different at $p<0.05$.

The main advantages of legume-cereal mixtures have been increased CP yield, relative to cereal sole crops (Strydhorst et al. 2008). All mixtures and monoculture cereals had the highest CP yield (Table 3). Although monoculture oat and barley had lower CP content than pea-cereal mixtures, they gave the high CP yield because of their higher DM yields (Table 3). Many researcher reported that legumes increased yields of CP of mixtures because they had high CP content (Assefa and Ledin, 2001; Kuusela et al. 2004).

Differences in the NDF and ADF concentrations occurred among treatments (Table 2). In this experiment a contrast trend to that of CP content was observed for ADF and NDF; they increased as the pea seeding ratio decreased in mixtures (Table 4). Monoculture pea had the lowest values of ADF (25.81%) and NDF (38.27), whereas the highest ADF and NDF values were observed in the monoculture of oat (34.61 and 59.12%) and monoculture barley (31.84 and 57.37%, respectively). Aesen et al (2004) reported that increasing the legume proportion resulted in decreased ADF and NDF concentrations for the legume-grass mixtures. Carr et al. (2004) found that pea, barley, oat, pea-barley and pea-oat mixtures of ADF values 38.2%, 38.5%, 34.4% and 36.5%, respectively. Strydhorst et al. (2008) reported that barley and pea-barley mixtures of NDF values were 55.2% and 41.8%, respectively. Van Soest (1996) indicated that under similar growth conditions, legumes have low NDF values whereas cereals have high values which are in agreement with the present study.

The TDN and RFV were only affected by treatment (Table 2). Monoculture pea had higher TDN than monoculture cereals and all mixtures (Table 4). TDN values increased as the pea seeding rate increased in mixtures. Pea-oat and pea-barley mixtures (65:35 seeding ratios) had 13.8% and 6.3% more TDN values than monoculture oat and barley monoculture. The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage. As ADF increases there is a decline in TDN which means that animals are not able to utilize the nutrients that are present in the forage (Lithourgidis et al. 2006). In present study, the lowest values for TDN in monoculture oat and barley are attributed to the high amount of ADF (Table 3).

The forages with an RFV value over 151, 150-125, 124-103, 102-87, 86-75, and less than 75 are categorized as prime, premium, good, fair, poor and rejected, respectively. Van Soest (1996) reported that the RFV is not a direct measure of the nutritional content of forage, but that it is important for estimating the value of the forage. Based on the average of the 2 years, the pea-cereal mixtures (65:35) and 55:35 mixtures had relative feed values ranging from 127.02-131.64 and 119.63-122.75, respectively, and thus, may be categorized as premium and good qualities.

Land equivalent ratio (LER) values were presented in Table 5. LER values of pea-cereal (55:45 seeding ratio) were higher than those of pea-cereal (65:35 seeding ratio). The mixtures out yielded the pure sowings (LER>1). Therefore, this means that a mixture uses environmental resources better than pure sowing and competition between mixture components is not high (Albayrak et al. 204; Karadağ and Büyükburç, 2003).

CONCLUSION

According to our study, forage yield was higher in cereals monocultures compared to the pea-cereal mixtures whereas pea-cereal mixtures had higher CP content, TDN

and RFV values than monoculture of oat and barley. The mixture of pea with oat and barley at the 65:35 seeding ratio had higher forage quality than that of 55:45 seeding ratio. Therefore, pea-oat and pea-barley mixtures at 65:35 seeding ratio can be recommended for high forage quality.

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LITERATURE CITED

Aasen, A., Baron, V.S., Clayton, G.W., Dick, A.C., and D.H. McCartney. 2004. Swath grazing potential of spring cereals, field pea and mixtures with other species. Canadian Journal of Plant Science. 84(4): 1051-1058.

Agegnehu, G., Ghizaw, A. and W. Sinebo. 2006. Yield performance and land-use efficiency of barley and faba bean mixed cropping in Ethiopian highlands. Eur. J. Agron. **25**:202-207.

Albayrak, S., M. Türk and O. Yüksel. 2009. Effects of phosphorus fertilization and harvesting stages on forage yield and quality of woolypod vetch. Turkish Journal of Field Crops. 14(1): 30-40.

Albayrak, S., M. Güler, and M.Ö. Töngel, 2004. Effects of seed rates on forage production and hay quality of vetch-triticale mixtures. Asian Journal of Plant Science. 3 (6): 752-756.

Assefa, G and I. Ledin. 2001. Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. Anim. Feed Sci. Technol. 92, 95–111.

Aydın, N., Mut, Z., Mut, H and İ. Ayan. 2010. Effect of autumn and spring sowing dates on hay yield and quality of oat (*Avena sativa* L.) genotypes. Journal of Animal and Veterinary Advances. 9(10): 1539-1545.

Balabanlı, C., Albayrak,S., Türk, M., and O. Yüksel. 2010. A research on determination of hay yields and silage qualities of some vetch+cereal mixtures. Turkish Journal of Field Crops. 15(2):204-208.

Caballero, A.R., E.L. Goicoechea-Oicoechea and P.J. Hernaiz-Ernaiz. 1995. Forage yields and quality of common vetch and oat sown at varying seeding ratios and seeding rates of vetch. Field Crops Research. 41: 135-140.

Chapko, L.B., Brinkman, M.A., and K.A. Albrecht. 1991. Oat, oat–pea, barley, and barley–pea for forage yield, forage quality, and alfalfa management. Journal of Production Agriculture. 4:486-491.

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

Giacomini, S.J., Vendruseolo, E.R.O., Cubilla, M., Nicoloso, R.S., and M.R. Fries. 2003. Dry matter, C/N ratio and nitrogen, phosphorus and potassium accumulation in mixed soil cover crops in Southern Brazil. Rev. Bras. Ciencia Solo 27, 325–334.

Karadağ, Y and U. Büyükburç. 2003. Effects of seed rates on forage production, seed yield and hay quality of annual legume-barley mixtures. Turk J Agric Forersty. 27: 169-174

Kacar. B and A. İnal. 2008. Bitki Analizleri. Nobel Yayınları.No:1241, Ankara, 892,s.

Kuusela, E.,Khalili,H., and P. Nykanen-Kurki. 2004. Fertilisation, seed mixtures and supplementary feeding for annual legume–grass–cereal pastures in organic milk production systems. Livest. Prod. Sci. 85, 113–127.

Lithourgidis, A.S., Vasilakoglou, I.B., Dhima, K.V., Dordas, C.A., and M.D. Yiakoulaki. 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. Field Crops Research. 99: 106-113.

Rowell, D.R. 1996. Soil Science: Methods and Applications. Longman, Harlow.

SAS Institute 1998. INC SAS/STAT users' guide release 7.0, Cary, NC, USA.

Steel, R.G.D., J.A Torrie and D.A. Dickey, 1997. Principles and Procedures of Statistics. A. Biometrical Approach 3rd Edi. Mc Graw Hill Book.INC.N.Y.

Strydhorst, S.M., J.R. King., K.J. Lopetinsky and K.N. Harker. 2008. Forage potential of intercropping barley with faba bean, lupin, or field pea. Agronomy Journal. 100: 96:182-190.

Van Soest, P.J. 1996. Allometry and ecology of feeding behavior and digestive capacity in herbivores: A Review. Zoo Biology 15:455 - 479.

Vasilakoglou, I.B., A.S. Lithourgidis and K.V. Dhima. 2005. Assessing common vetch:cereal intercrops for suppression of wild oat. In: Proceedings of the 13th International Symposium, Session S5, European Weed Research Society, Bari, Italy.

Velazquez-Beltran, L.G., Felipe-Perez, Y.E., and C.M. Arriaga-Jordan. 2002. Common vetch (*Vicia sativa* L.) for improving the nutrition of working equids in campesino systems on hill slopes in central Mexico. Trop. Anim. Health Prod. 34, 169–179.

Yolcu, H., M. Muazzez and V. Aksakal. 2009. Morphologic, yield and quality parameters of some annual forages as sole crops and intercropping mixtures in dry conditions for livestock. Journal of Food, Agriculture & Environment Vol.7 (3-4): 594-599.