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THE EFFECT OF MIXTURE RATES AND CUTTING STAGES ON SOME YIELD AND QUALITY CHARACTERS OF PEA (*Pisum sativum* L.)+OAT (A*vena sativa* L.) MIXTURE

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ABSTRACT

This research was conducted to determine the effects of seed rates in mixtures of pea+oat and cutting stages on the hay yield and its quality. The experiment was performed over two years (2003-2005) at Uludag University, Faculty of Agriculture, Agricultural Research and Application Center, Bursa, using five different mixture rates of pea and oat crops (100% Pea+0% Oat, 75% Pea+25% Oat, 50% Pea+50% Oat, 25% Pea+75% Oat and 0% Pea+100% Oat) and three different cutting stages (the jointing stage of oat, the stage oat in scabbard and milk-dough stage of oat). According to the results, it may be suggested that the mixture of 25% pea+75% oat should be grown to obtain higher hay yield and the mixture of 50% pea+50% oat to obtain higher level of crude protein. In addition, the pea+oat mixture should be harvested at oat milk-dough stage.

Keywords: Cutting stages, mixture rates, oat, pea

INTRODUCTION

Mixedcropping of annual crops such as pea+oat or pea+barley is traditional system of agriculture. Peas are important feed grain legumes for animal production. They are widely grown for hay, pasture or silage production either alone or mixed with cereals (Mc Kenzie and Sponer, 1999). Reductions in forage and seed yield have been attributed to lodging. When peas are grown as a monoculture, they exhibit severe lodging after flowering (Heath and Hebblethwaite, 1985; Stelling, 1997). So, peas are often sown in mixtures with cereals that have an upright stature (Uzun and Acikgoz, 1998). Tall varieties of pea are cultivated with cereals, reducing lodging and increasing hay yield and quality (Robinson, 1960; Anderson, 1975; Droushiotis, 1989; Tan and Serin, 1996). In legume+cereal mixedcropping, the selection of plants, mixture rates and cutting stages are very important. Legume-cereal mixtures are important protein and carbonhydrate sources for livestock (Karadag and Buyukburc, 2003). Many studies were conducted to determine the crops to be used in a pea mixture, and variable results were obtained. Some studies indicated that mixedcropping pea with oat increased hay yield (Robinson, 1960; Mitchell, 1983). It was reported in other studies that pea with barley should be mixed (Chapko et al., 1991). Mixture rates of legume+cereal are important in mixedcropping for high yield and fodder value. The cereal ratio in the hay can be higher than the sowing ratio. Because, the plant density of cereals is high in the hay due to their characteristic of tillering and the hay yield; while crude protein ratio and yield decrease (Bayram and Celik, 1999; Kwabiah, 2004; Geijersstam and Martensson, 2006). Cutting stages are also quite significant in mixedcropping. As the growth stages of plant progress, weight of hay increases, but the fodder value decreases. The reason is that cereals are more quickly mature in the mixture. Therefore, the cutting stages for mixedcrops should be determined based on the growth stages of the cereal (Acikgoz and Cakmakci, 1986; Droushiotis, 1989; Johnston et al., 2001). Although numerous studies related to pea+cereal mixtures were performed in Turkey, there are no specific studies of the semi-leafless pea+oat mixtures in our region. Therefore, this study was conducted to increase the general knowledge on this topic and to determine the best mixture rate and the optimum cutting stage for pea+oat mixtures and to ascertain whether oat prevents lodging in pea plants.

MATERIALS AND METHODS

One pea variety (semi-leafless cv. Kirazli) and one oat genotype (local ecotype) were used in this study. The field trials were conducted during two growing seasons (2003-2004 and 2004-2005) at Uludag University, Faculty of Agriculture, Department of Field Crops, Bursa (40°11′ North, 29°04′ East).

Although the total precipitation average of Bursa had been 585.6 mm during the plant growth stages for long-term period, the total precipitation in 2003-2004 corresponding to November-May, which is the plant growth stage, was 518.2 mm. The total precipitation during the period of October-May in 2004-2005 was 539.4 mm. For 2003-2004 the mean temperature during plant growth stage (9.5 ^{0}C) was similar to the mean of long-term in the same period (10.1 ^{0}C). For 2004-2005, the

mean temperature in the period from October-May was 10.3 ^{0}C, which was similar to the mean of long-term in the same period (10.8 ^{0}C). For the period of this experiment, the relative humidity values during the plant growth period were slightly lower than the mean relative humidity value of long-term in the same period (Anonymous, 2005).

The experimental field was located in the coastal area of northwest Turkey, 70 m above sea level. The soil was clay-loam, slightly alkaline, salt-free, in neutral pH level, poor in organic matter, rich in phosphorus and potassium.

The experiment was designed with three replication according to a randomized complete block. The pea and oat were tested at five different mixture rates (100% Pea+0% Oat, 75% Pea+25% Oat, 50% Pea+50% Oat, 25% Pea+75% Oat and 0% Pea+100% Oat). The plots were harvested at 3 different growth stages of oat (the jointing stage of oat, the stage of oat in sheath and the milk-dough stage of oat). The plot size was 1.4 m x 5 m= 7 m^2. The seeds were planted with 100 pea seeds m^{-2} and 500 oat seeds m^{-2} seeding rate on 03.11.2003 in the first year and on 25.10.2004 in the second year. Before seeding, 30 kg ha^{-1} N was applied in both years. Since weeds were not problematic during the experiment, no control was utilized. Analysis of variance was performed on the data using the software programs MINITAB (Release 14) and MSTAT-C (Version 2.1 Michigan State University, 1991). The statistical significance of the treatments was determined at the 0.05 and 0.01 probability levels using the F-test (Steel et al., 1997).

RESULTS AND DISCUSSION

The pea ratio in the green herbage, forage yield, dry matter yield, crude protein ratio and crude protein yield were examined in this study. These data are given below as the average of the 2 experimental years.

Pea Ratio in the Green Herbage (%)

The analysis of variance revealed that mixture rates, cutting stages and mixture ratesxcutting stages interaction all significantly affected the pea ratio in the green herbage.

As seen in Table 1, the ratio of pea in the green herbage (55.11%) increased, because the pea ratio increased in mixture. As the oat ratio increased in mixture, the pea ratio in the green herbage (17.70%) decreased. The reason of this was higher competitive abilityof cereals than legumes (Ofori and Stern, 1987; Tan and Serin, 1996). Similar results have also been obtained in some mixedcropping studies conducted on vetch and oat mixtures (Altın and Ucan, 1996; Bayram and Celik, 1999).

The pea ratio in the green herbage was highest (43.78%) at the first cutting (the jointing stage of oat and the early blooming of pea). Due to the rich tillering of the oat plants, the pea ratio in the green herbage decreased with the cutting stages (Table 1). Our results were in close agreement with Buyukburc et al. (1989) and Hatipoglu et al. (1990). However, some studies have indicated that the legume ratio increased gradually with the growth stage in mixture (Acikgoz and Cakmakci, 1986; Tukel and Yilmaz, 1987; Tan and Serin, 1996). The highest pea ratio in the green herbage was obtained at the first cutting stage of the pea 75%+oat 25% mixture (61.75%) (Table 1).

Forage Yield (t ha^{-1})

In this trait, mixture rates, cutting stages and mixture rates x cutting stages interaction were significant.

The highest forage yield was obtained from 0% pea+100% oat (47.34 t ha^{-1}) and 25% pea+75% oat (47.17 t ha^{-1}) parcels. Excluding the pure sowings, the forage yield increased as the cereal ratio increased. Carr et al. (1998) reported that the ratio of cereals should be high to obtain a high yield in oat+pea mixtures or oats should be sown alone. Acar and Ozkaynak (2000) found that the forage yield attained from a mixture of pea with oat was higher than pea alone. The forage yield increased with the cutting stages and the highest yield was 53.13 t ha^{-1} at the third cutting stage (milk-dough stage of oat and when the pea grains were fully developed within the pod) (Table 1). According to Johnston et al. (2001), the forage yield of pea+cereal mixtures was 70-100% higher when harvested at the milk-dough stage of cereals than at the emergence of the flag leaf. The highest forage yields were obtained at the third cutting stages of the 0% pea+100% oat, 25% pea+75% oat and 50% pea+50% oat mixtures (Table 1).

Dry Matter Yield (t ha^{-1})

The effects of the mixture rates, cutting stages and mixture rates x cutting stages interaction were significant for the dry matter yield.

With regard to the mixture rates, dry matter yield increased with the increasing rate of oat in mixtures, and the highest dry matter yield (15.54 t ha^{-1}) was obtained from the 100% oat plots (Table 1). Several studies showed that the dry matter yield increased with the increasing rate of oat in mixtures of oat with annual legumes (Walton, 1975; Osman and Nersoyan, 1985; Droushiotis, 1989). Furthermore, Mitchell (1983) indicated that the oat physically supported the pea plants in such mixtures and provided most of the dry matter production. As expected, there was an increase in the dry matter yield due to the increasing dry matter production of the plants with the delay of cutting stages. The highest dry matter yield (15.36 t ha^{-1}) was found at the third cutting stage (Table 1). Our findings agree with those previous reports (Acikgoz and Cakmakci, 1986; Tan and Serin, 1996; Turk et al., 2007). When the interaction of the mixture rates x cutting stages were considered, the highest dry matter yield (19.12 t ha^{-1}) was obtained from 100% oat and at last cutting stages (Table 1).

Crude Protein Ratio (%)

An analysis of variance found statistically significant differences among mixture rates, and cutting stages for crude protein ratio. The mixture rates x cutting stages interaction was also significant.

Table 1. Some yield and quality characteristics of different mixture rates, cutting stages and mixture ratesxcutting stages interaction in pea+oat mixture

Cutting Stage	Mixture Rates					
	100P+0O**	**75P+25O**	**50P+50O**	**25P+75O**	**0P+100O**	**Means**
			PEA RATIO IN THE GREEN HERBAGE (%)			
1. STAGE	100.00 a*	61.75 b	36.59 e	20.58 h	0.00 k	43.78 A
2. STAGE	100.00 a	54.03 c	31.40 f	18.15 ı	0.00 k	40.72 B
3. STAGE	100.00 a	49.53 d	29.19 g	14.36 j	0.00 k	38.62 C
Means	100.00 A	55.11 B	32.39 C	17.70 D	0.00 E	
LSD (0.05): Mixture Rate= 0.653; Cutting Stages= 0.653; Mixture RatesxCutting Stages= 1.132						
			FORAGE YIELD (t ha^{-1})			
1. STAGE	33.32 g	34.08 g	37.67 f	37.91 ef	38.42 ef	36.28 C
2. STAGE	38.47 ef	38.90 e	42.46 d	47.45 c	47.09 c	42.88 B
3. STAGE	47.93 c	49.10 b	55.94 a	56.16 a	56.52 a	53.13 A
Means	39.91 D	40.69 C	45.36 B	47.17 A	47.34 A	
LSD (0.05): Mixture Rates= 65.630; Cutting Stages= 50.830; Mixture RatesxCutting Stages= 113.700						
			DRY MATTER YIELD (t ha^{-1})			
1. STAGE	6.81 l	7.83 k	9.93 hı	10.27 h	12.23 f	9.42 C
2. STAGE	8.46 j	9.49 ı	11.80 fg	13.69 d	15.28 c	11.74 B
3. STAGE	11.43 g	13.14 e	16.37 b	16.77 b	19.12 a	15.36 A
Means	8.90 E	10.15 D	12.70 C	13.58 B	15.54 A	
LSD (0.05): Mixture Rates= 26.970; Cutting Stages= 20.890; Mixture RatesxCutting Stages= 46.720						
			CRUDE PROTEIN RATIO (%)			
1. STAGE	19.69 a	17.69 b	16.22 c	13.85 d	9.10 h	15.31 A
2. STAGE	17.35 b	15.86 c	14.06 d	11.36 f	6.89 ı	13.10 B
3. STAGE	13.62 d	12.96 e	11.66 f	10.33 g	5.02 j	10.72 C
Means	16.89 A	15.50 B	13.98 C	11.85 D	7.00 E	
LSD (0.05): Mixture Rates= 0.275; Cutting Stages= 0.213; Mixture RatesxCutting Stages= 0.477						
			CRUDE PROTEIN YIELD (t ha^{-1})			
1. STAGE	1.34 ı	1.38 hı	1.61 cd	1.42 gh	1.11 j	1.37 C
2. STAGE	1.47 fg	1.50 ef	1.66 bc	1.55 de	1.05 j	1.45 B
3. STAGE	1.56 de	1.70 b	1.91 a	1.73 b	0.96 k	1.57 A
Means	1.46 C	1.53 B	1.73 A	1.57 B	1.04 D	
LSD (0.05): Mixture Rates=4.574; Cutting Stages= 3.543; Mixture RatesxCutting Stages= 7.923						

*: Means followed by the same letter are not significantly different at P< 0.05, using the LSD test.
**: P: Pea; O: Oat

As seen in Table 1, the highest crude protein ratio (16.89%) was observed in the 100% pea plots, and the lowest crude protein ratio was obtained from the 100% oat (7.00%). Droushiotis (1989) indicated that legumes are more palatable to animals and possess a higher crude protein content than cereals. Among the mixtures, the highest crude protein ratio (15.50%) was found in the 75% pea mixture (Table 1). Since pea had a high nitrogen content, crude protein ratio increased as the percentage of pea in mixture increased (Tan and Serin, 1996). Mitchell (1983) reported that the hay quality of oat increased when oat intercropped with pea. It is well known that the crude protein ratio decreases as plant growth stage progresses. In this study, the crude protein ratios decreased with the delay of the cutting stages, and the lowest crude protein ratio (10.72%) was obtained at the third cutting stage, whereas, crude protein ratio was the highest (15.31%) at the first cutting stage (Table 1). Many researchers reported similar results (Acikgoz and Cakmakci, 1986; Roberts et al., 1989; Tan and Serin, 1996; Turk et al., 2007). The crude protein ratio of the 100% pea plot at the first cutting stage was 19.69% (Table 1).

Crude Protein Yield (t ha^{-1})

Main effects and the mixture rates x cutting stages interaction were statistically significant for crude protein yield characteristic.

The highest crude protein yield was obtained from 50% pea+50% oat mixtures (1.73 t ha^{-1}). Whereas, the lowest crude protein yield was found in the 100% oat

plots (1.04 t ha^{-1}). The 100% pea plots produced the lower crude protein yield (1.46 t ha^{-1}) than pure oat plots (Table 1). Bayram and Celik (1999) found similar results in vetch+oat mixtures. The highest crude protein yield (1.57 t) was at the third cutting stage (Table 1). As the growth stage of plants progresses, the crude protein ratio in the plant decreases, but the dry matter yield increases. Hence, the crude protein yield increased depending on the growth stage, which is similar to the results of others (Acikgoz and Cakmakci, 1986; Garnsworthy and Stokes, 1993; Tan and Serin, 1996). When interactions of the mixture rates x cutting stages concidered, the highest crude protein yield (1.91 t ha^{-1}) was determined at the third cutting stages of the 50% pea+50% oat mixtures (Table 1). In their study using a 50% vetch+50% oat mixture, Acikgoz and Cakmakci (1986) reported that the highest crude protein yield was obtained when oat harvested at the milk-dough stage.

CONCLUSIONS

In this study, we found that pea and oat can be successfully cultivated in a mixture and that oat plays an important role in obtaining a high yield. According to the results, cultivation of a 25% pea+75% oat mixture for higher hay yield and 50% pea+50% oat mixture for higher crude protein content are recommended and these mixtures should be harvested at the milk-dough stage of oat. In addition, as one of the objectives of mixedcropping is to prevent lodging of the pea, we found that the oat plants successfully served this purpose.

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LITERATURE CITED

Acar, R., I. Ozkaynak, 2000. Cultivation of some forage crops and cereal mixtures at irrigation condiditons. Journal of Selcuk University Agriculture Faculty. 14(21): 1-9.

Acikgoz, E., S. Cakmakci, 1986. Researches on forage yield and quality of common vetch and cereals mixtures in Bursa conditions. Journal of Uludag University Agriculture Faculty. 5: 67-73.

Altin, M., M. Ucan, 1996. Mixing structure and hay yield at different nitrogen doses of varied vetch+oat mixtures in Kumkale arid conditions. Turkey 3. Meadow Range and Forage Crops Congress (17-19 June 1996, Erzurum), 334-340.

Anderson, C., 1975. A comparison of vicia species for summer grazing and subsequent oat crop production in Western Australia. Australian Journal of Experimental Agriculture and Animal Husbandry. 15(74): 400-405.

Anonymous, 2005. Climate datas in Bursa. Bursa Meteorology Regional Directorate. (Unpublished records), Bursa.

Bayram, G., N. Celik, 1999. Effects on forage yield and quality of mixture rates and nitrogen fertilisation at oat (*Avena sativa* L.) and common vetch (*Vicia sativa* L.) mixedcropping. Turkey 3. Field Crops Congress, Volume III. Meadow Range, Forage Crops, Grain Legumes Crops, (15-18 November 1999, Adana), 53-58.

Buyukburc, U., M. Munzur, R. Akman, 1989. Researches on case in Samsun Province crop rotation of annual legumes forage crops+cereal mixtures. Field Crops Central Research Institute. General Publication No: 1989/7, Ankara.

Carr, P.M., G.B. Martin, J.S. Caton, W.W. Poland, 1998. Forage and nitrogen yield of barley-pea and oat-pea intercrops. Agronomy Journal. 90(1): 79-84.

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

Droushiotis, D.N., 1989. Mixtures of annual legumes and small-grained cereals for forage production under low rainfall. Journal of Agricultural Science. 113: 249- 253.

Garnsworthy, P.C., D.T. Stokes, 1993. The nutritive value of wheat and oat silages ensiled on three cutting dates. Journal of Agricultural Science. 121: 233-240.

Geijersstam, L., A. Martensson, 2006. Nitrogen fixation and residual effects of field pea intercropped with oats. Acta Agriculturae Scandinavica Section B-Soil and Plant Science. 56: 186-196.

Hatipoglu, R., A.E. Anlarsal, T. Tukel, H. Baytekin, 1990. Effect of cutting stages on forage yield and botanical composition of vetch+barley mixture in Cukurova Region arid conditions. Journal of Cukurova University Agriculture Faculty. 5(3), 173-182.

Heath, M.C., P.D. Hebblethwaite, 1985. Agronomic problems associated with the pea crop. In: Heblethwaite, P.D., Heath, M.C., Dawkins, T.C.K. (eds.), The Pea Crop. Butterworths, London, pp. 19-26.

Johnston, J., J. Mckinlay, B. Wheeler, 2001. Forage production from spring cereals and cereal-pea mixtures. Agdex no. 120. Ontario Ministry of Agriculture. Food and Rural Affairs Toronto, Canada.

Karadag, Y., U. Buyukburc, 2003. Effects of seed rates on forage production, seed yield and hay quality of annual legume-barley mixtures. Turkish Journal of Agriculture and Forestry. 27: 169-174.

Kwabiah, A.B., 2004. Biological efficiency and economic benfits of pea-barley and pea-oat intercrops.Journal of Sustainable Agriculture.25(1): 117-128.

McKenzie, D.B., D. Sponer, 1999. White Lupin: An alternative to pea in oat-legume forage mixtures grown in new foundland. Can. J. Plant Sci. 79: 43-47.

Mitchell, W.W., 1983. Forage yield and quality of cereals at Pt. MacKenzie. Bulletin 61.

Ofori, F., W.R. Stern, 1987. Cereal-Legume ıntercropping systems. Advences in Agronomy. 41: 41-90.

Osman, A.E., N. Nersoyan, 1985. Annual legumes for integrating rainfed crop and livestock production. Proceedings XV. International Grassland Congress. (Japan), 1: 123-125.

Robinson, R.G., 1960. Oat-pea or oat-vetch mixtures for forage or seed. Agronomy Journal. 52(8): 546-549.

Roberts, C. A., K.J. Moore, K.D. Johnson, 1989. Forage quality and yield of wheat-vetch at different stages maturity and vetch seeding rates. Agronomy Journal. 81(1): 57-60.

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.

Stelling, D., 1997. Dry peas (*Pisum sativum* L.) grown in mixtures with faba beans (*Vicia faba* L.) a rewarding cultivation alternative. J.Agronomy and Crop Sci. 179: 65-74.

Tan, M., Y. Serin, 1996. A research on determination of optimum mixture rate and cutting stage for different vetch+cereal mixtures. Journal of Ataturk University Agriculture Faculty. 27(4): 475-489.

Tukel, T., E. Yilmaz, 1987.A research on determination of optimum mixture rate in common vetch (*V. sativa*)+barley

(*H. vulgare*) mixtures in Cukurova arid conditions. Turkish Journal of Agriculture and Forestry. 11(1): 171-178.

Türk, M., S. Albayrak, O. Yüksel, 2007. Effects of phosphorus fertilisation and harvesting stages on forage yield and quality of narbon vetch. New Zealand Journal of Agricultural Research. 50: 457-462.

Uzun, A., E. Acikgoz, 1998. Effect of sowing season and seeding rate on the morphological traits and yields in pea cultivars of differing leaf types. Journal Agronomy and Crop Science. 181: 215-222.

Walton, P.D., 1975. Annual forages seeding rates and mixtures for Central Alberta. Canadian Journal of Plant Science. 55: 987-993.