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Effects of Seed Rates on Forage Production and Hay Quality of Vetch–triticale Mixtures

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Abstract: The forage yield and quality of common vetch, hairy vetch, hungarian vetch and triticale grown alone and as mixtures of legume + triticale were investigated in Black Sea costal area in Samsun, Turkey in the 2002-2003 and 2003-2004 growing seasons. The experiment design was Randomized Block Design with three replications. The highest green forage (32.94 t ha^{-1}), dry matter (6.23 t ha^{-1}) and crude protein yields (1.06 t ha^{-1}) were obtained from the mixture including 70% hairy vetch + 30% triticale. It was determined that 80% hairy vetch + 20% triticale mixture had the highest vetch rate in dry matter. The mean land equivalent ratio values of dry matter yield was 1.45. In conclusion, the 70% hairy vetch + 30% triticale mixture in arid seasons, 70% common vetch + 30% triticale in rainfall seasons can be recommended in the similar ecologies because of theirs high forage and crude protein yields.

Key words: Common vetch, hairy vetch, hungarian vetch, triticale, mixtures

INTRODUCTION

In the Black Sea region except Samsun, fields are quite rough and, therefore, difficult to cultivate for agricultural purposes. Main crops such as corn, sunflower, tobacco, soybean, and sugar beet are grown in the region in summers. In the region, since fields are planted with either vegetables or left empty from October to May, there is a great opportunity to grow some forage such as vetch during this period[1]. The vetch in annual leguminous forage is one of the most widespread genuses cultivated[2]. It has ability to fix atmospheric free nitrogen into the soil by symbiotic living with bacteria of *Rhizobium* species and sustaining of soil fertility[3]. Because of having weak and thin stem, the vetches spread. So harvest gets difficult and due to lossing leaves, its forage and quality decrease[4,5]. Vetch should be sown mixture with cereals in order to overcome spreading[6,7]. When vetches having high protein content grow mixture with the cereal having high starch content, it composes quality and easy digestible forage[8,9]. But, in the vetch mixtures with cereals, it is essential to be known the rates of the vetch and cereal species on high forage yield and forage quality. Because high cereal rate in botanic composition of legume + cereal mixture cause low protein content which is one of the most important factors to determine the forage quality[6].

The objective of this study was to determine the suitable mixture rate of vetches and triticale grown under Black Sea costal area in Turkey conditions.

MATERIALS AND METHODS

This study was conducted in the experimental area of Black sea Agricultural Research Institute, Samsun, Turkey (41°21′ N, 36°15′ E, altitude 4 m) in 2002-2003 and 2003-2004. Climatic data for the research area are given Table 1. Soil was clay-loam, pH 7.1; organic matter 2.05 g kg^{-1}; available P, 21 g kg^{-1}; available K, 93 g kg^{-1}. Common vetch (*Vicia sativa* L.) Cv. "Kubilay-82", hairy vetch (*Vicia villosa* Roth.) Cv."Menemen-79", hungarian vetch (*Vicia pannonica* Crantz.) "population" and triticale (*Triticosecale*) Cv. "Tatlicak-97" were used as plant materials.

The field trials started on 3 November of first year and 1 December of second year and were carried out in a randomized complete block design with three replications. Pure common vetch, hairy vetch, hungarian vetch and triticale, 80% vetch + 20% triticale, 70% vetch + 30% triticale, 60% vetch + 40% triticale and 50% vetch + 50% triticale mixtures were sown. Each plot was 6 m^2. Seeding rates of pure common vetch, hairy vetch, hungarian vetch and triticale were 120, 80, 100 and 200 kg ha^{-1}, respectively. When the legumes had 50% flower, the plots were harvested for forage yield. Subsamples were dried at 70°C for 48 h to determine dry matter yield. After vetch and triticale samples had dried, they were weighed one by one. So, it was determined vetch rate in dry matter of mixture. Crude protein analyses were determined on ground subsamples of legume and triticale hays. According to the micro-Kjeldahl procedure described by

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Nelson and Sommers[10], the nitrogen concentration of the hay was determined, and crude protein concentration was calculated (N x 6.25).

Land Equivalent Ratio (LER) was defined as the relative area of a monocrop plant required to have the same yield obtained from its mixture. LER was calculated by using the formula given below[11,12];

$$LER = \frac{\text{yield of legume in mixture}}{\text{yield of legume alone}} + \frac{\text{yield of grass in mixture}}{\text{yield of grass alone}}$$

Analysis of variance was performed on forage yield and its components data using the SAS[13] program. Means were compared using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Green forage yield: Highly significant differences were found in green forage yield: 11.60 to 34.33 t ha^{-1} in the first year and from 11.15 to 34.16 t ha^{-1} in the second year (Table 2). Average green forage yield varied from 11.37 t ha for pure triticale to 32.94 t ha for 70% hairy vetch + 30% triticale (Table 2). In the first year, the highest green forage yield (34.33 t ha^{-1}) was obtained from the mixture containing 70% hairy vetch and 30% triticale. In the second year, the highest green forage yield (34.16 t ha^{-1}) was obtained from the mixture containing 70% common vetch and 30% triticale (Table 2). The total precipitation in 2003 was lower than in 2004. Soya *et al.*[14] reported that the highest forage yield had been obtained from hairy vetch+cereal mixtures and common vetch+cereal mixtures in arid and rainfall seasons, respectively. The forage yields obtained from mixtures were almost higher than pure sowing yields. The similar results have been reported by other researchers[15-18].

Dry matter yield: The dry matter yields of the pure sowings and mixtures were significantly different ($p<0.01$) in both years. There were no differences between the years (Table 2). In the first year, the highest dry matter yield (6.48 t ha^{-1}) was obtained from the mixture containing 70% hairy vetch and 30% triticale, and the lowest dry matter yield (2.98 t ha^{-1}) was obtained from the pure triticale sowing (Table 2). In the second year, the highest dry matter yield (6.50 t ha^{-1}) was obtained from the mixture containing 70% common vetch and 30% triticale, and the lowest dry matter yield (2.98 t ha^{-1}) was obtained from the pure triticale sowing (Table 2). According to two year average, the lowest dry matter yield (2.88 t ha^{-1}) was obtained from pure triticale, and the highest (6.23 t ha^{-1}) was obtained from the mixture containing 70% hairy vetch and 30% triticale (Table 2). While these results confirm the findings of Anlarsal and Yağbasanlar[6], Hatipoğlu *et al.*[19] data are different from findings of some other researchers[14,15,20-22]. These differences might be caused by ecological factors such as precipitation and temperature during the vegetative growth in the experiment. In 2004, the mean dry matter yields of mixtures were higher than yields obtained in 2003 (Table 2). This might be due to higher precipitation in 2004. Mixture yields were higher than pure sowing yields. Similar results have been reported in other studies[17].

Vetch rate in dry matter: The vetch rate in dry matter were significantly different ($p<0.01$) in both years. There were no differences between the years (Table 2). In the first year, while the highest vetch rate in dry matter was determined from the mixture containing 80% hairy vetch and 20% triticale (78.79%), in the second year, the mixture containing 80% common vetch and 20% triticale the highest (75.68%). The mixture containing 50% common vetch and 50% triticale had the least vetch rate in dry matter in both years (45.79 and 49.14%, respectively). Pisulewska *et al.*[23] reported that increasing the proportion of legume in mixed (legume-cereal) forages increases the yield of green and dry matter per unit area. These findings have been found higher than findings of Karadağ[24]. These differences might be resulted in ecological factors and the cultivars in the experiment.

Crude protein content: Differences in crude protein content were significant among the pure sowings and mixture sowings (Table 3). For the both experimental years, the lowest crude protein content was obtained from the pure triticale while the highest crude protein content was obtained from the pure common vetch (Table 3). The pure common vetch had the highest crude protein content, averaging 19.08%, while the pure triticale had the lowest crude protein content, averaging 10.39% (Table 3). Haj Ayed *et al.*[25] reported that the nutritive value at flowering of common vetch was higher than hairy vetch hay's. This result was similar to our findings. The mean crude protein concentration in 2004 was lower than that in 2003 due to the higher precipitation received (Table 3). Cox and Atkins[26] indicated that more precipitation increased the carbohydrate/protein ratio. In addition, since the crude protein concentrations of legumes are higher than those of cereals the crude protein concentrations of the mixtures increased as the legume rate increased in the mixture[5,16,27,28].

Crude protein yield: The crude protein yields of the pure sowings and mixtures were significantly different ($p<0.01$)

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

	Precipitation (mm)			Temperature (°C)			Relative humidity (%)		
Months	Long years	2002-2003	2003-2004	Long years	2002-2003	2003-2004	Long years	2002-2003	2003-2004
November	79.8	29.7	64	11.8	14.1	11.5	70.9	65.9	79.7
December	71.0	71.3	104	9.0	6.6	9.3	67.2	57.2	64.6
January	57.8	28.1	84.2	6.9	9.3	8.1	68.1	72.2	61.3
February	48.2	77.8	43.9	6.6	4.8	7.5	69.9	74.0	66.3
March	52.6	73.5	66.2	7.8	5.0	8.5	75.9	75.4	75.4
April	58.8	45.0	101	11.2	8.7	11.4	79.3	79.6	77.5
May	50.7	54.7	56.2	15.2	16.2	15.0	81.1	78.4	83.1
Total	418.9	380.1	519.5	-	-	-	-	-	-
Mean	-	-	-	9.79	9.24	10.19	73.2	71.8	72.6

Table 2: Green forage yield and dry matter yield for pure and mixture sowings and vetch rate in dry matter at Samsun in 2003 and 2004. VS: Common vetch VV: Hairy vetch, VP: Hungarian vetch, T: Triticale

	Green forage yield (t ha^{-1})			Dry matter yield (t ha^{-1})			Vetch rate in dry matter (%)		
Treatments	2003	2004	mean	2003	2004	mean	2003	2004	mean
T	11.60e	11.15e	11.37g	2.98c	2.78f	2.88d	-	-	-
VS	23.00bd	29.66ac	26.33bf	4.44bc	4.57de	4.50c	-	-	-
VS+T: 80+20	26.33bd	32.00a	29.16ad	5.47ab	5.86ac	5.67ab	73.47ac	75.68a	74.58a
VS+T: 70+30	23.66bd	34.16a	28.91ad	4.92ab	6.50a	5.71ab	68.99ad	71.99ab	70.49a
VS+T: 60+40	24.33bd	31.50a	27.91bd	5.13ab	6.39ab	5.76ab	54.96de	58.26ce	56.61b
VS+T: 50+50	24.33bd	29.50ac	26.91be	6.05ab	6.14ac	6.10a	45.79e	49.14 f	47.47c
VV	29.33ac	30.73ab	30.03ac	5.03ab	4.92ce	4.98bc	-	-	-
VV+T: 80+20	30.66ab	31.56a	31.11ab	5.52ab	5.80ad	5.66ab	78.79a	74.65ab	76.72a
VV+T: 70+30	34.33a	31.55a	32.94a	6.48a	5.99ac	6.23a	77.59ab	74.44ab	76.02a
VV+T: 60+40	29.33ac	30.03ac	29.68ac	5.48ab	5.59ae	5.33ac	73.76ac	69.15b	71.45a
VV+T: 50+50	28.33ad	29.33ac	28.33ad	5.59ab	6.01ac	5.80ab	67.62ad	57.34de	62.48b
VP	23.66bd	25.50bd	24.58df	4.74ab	4.41e	4.57c	-	-	-
VP+T: 80+20	25.00bd	25.60bd	25.30cf	5.21ab	5.19be	5.20ac	73.36ac	69.56b	71.46a
VP+T: 70+30	24.66bd	28.50ac	26.58bf	5.33ab	5.66ae	5.50ac	63.92bd	63.69c	63.81b
VP+T: 60+40	20.33d	24.23cd	22.28ef	4.45bc	5.26ae	4.85bc	60.87cd	61.67cd	61.27b
VP+T: 50+50	21.33cd	22.58d	21.95f	4.67ab	4.93ce	4.80bc	60.74cd	53.77ef	57.25b
Mean	25.01b	27.97a	26.49	5.09	5.38	5.23	66.65	64.95	65.80
CV%	16.96	10.93	13.96	17.95	12.40	15.29	11.23	4.77	8.71

Means followed by the same letter(s) and columns are not significantly different

Table 3: Crude protein content and crude protein yield for pure and mixture sowings and land equivalent ratio at Samsun in 2003 and 2004. VS: Common vetch, VV: Hairy vetch, VP: Hungarian vetch, T: Triticale

	Crude protein content (%)			Crude protein yield (t ha^{-1})			Land Equivalent Ratio (LER)		
Treatments	2003	2004	mean	2003	2004	mean	2003	2004	mean
T	10.85e	9.93d	10.39f	0.32d	0.28d	0.30e	-	-	-
VS	19.94a	18.22a	19.08a	0.89ac	0.83ab	0.86bc	-	-	-
VS+T: 80+20	15.22cd	13.25c	14.23ce	0.93ac	0.89ab	0.91ab	1.40	1.50	1.45
VS+T: 70+30	15.46cd	13.71c	14.59cd	0.83bc	0.99a	0.91ab	1.26	1.71	1.48
VS+T: 60+40	14.92cd	13.45c	14.19ce	0.78bc	0.90ab	0.84bc	1.41	1.80	1.61
VS+T: 50+50	15.03cd	13.59c	14.31ce	0.89ac	0.83ab	0.86bc	1.73	1.79	1.76
VV	19.44a	17.74ab	18.59a	0.98ab	0.87ab	0.92ab	-	-	-
VV+T: 80+20	15.32cd	13.29c	14.31ce	0.96ab	0.89ab	0.93ab	1.25	1.40	1.33
VV+T: 70+30	15.53cd	13.77c	14.65cd	1.16a	0.96a	1.06a	1.50	1.46	1.48
VV+T: 60+40	15.89c	13.67c	14.78c	0.98ab	0.86ab	0.92ab	1.28	1.41	1.35
VV+T: 50+50	14.95cd	13.35c	14.19ce	0.91ac	0.84ab	0.87bc	1.37	1.61	1.49
VP	17.46b	16.65b	17.06b	0.83bc	0.74bc	0.78bd	-	-	-
VP+T: 80+20	14.59cd	12.83c	13.71de	0.84bc	0.73bc	0.79bd	1.29	1.40	1.35
VP+T: 70+30	14.28d	12.57c	13.42e	0.78bc	0.76bc	0.78bd	1.38	1.56	1.47
VP+T: 60+40	14.44cd	13.27c	13.86ce	0.67c	0.74bc	0.71cd	1.16	1.46	1.31
VP+T: 50+50	14.24d	12.63c	13.44e	0.69bc	0.63c	0.66d	1.23	1.43	1.33
Mean	15.47a	13.87b	14.67	0.84	0.76	0.82	1.36b	1.54a	1.45
CV %	4.93	5.41	5.16	17.61	12.48	15.41	23.25	13.13	18.28

Means followed by the same letter(s) and columns are not significantly different

in both years. There were no differences between the years (Table 3). Crude protein yield ranged from 0.32 to 1.16 t ha^{-1} in the first year and from 0.28 to 0.99 t ha^{-1} in the second year (Table 3). For the average results of two years, the highest protein yield (1.06 t ha^{-1}) was obtained from the 70 hairy vetch + 30% triticale mixture while the

lowest protein yield (0.30 t ha^{-1}) was obtained from the pure triticale sowing due to the lower dry matter yield and protein content of triticale (Table 3). These results were different from the findings of some other researchers[14,15,19,20]. Environmental conditions and the cultivars used in the trials could cause such a difference. In addition high total dry matter per area could result in such a difference. In fact, dry matter yields in this trial were higher, resulting in a higher yield than in the above-mentioned experiments. Furthermore, crude protein yields of the mixtures were more productive than those of pure sowings. Present results are in agreement with those of Sobkowicz and Sniady[29].

Land Equivalent Ratio (LER): LER values from the 2 years of the experiments are presented in Table 3. In the data averaged over the 2 years, the highest LER value for dry matter yield (1.76) was obtained from the 50% common vetch and 50% triticale mixture. The mixtures out yielded the pure sowings (LER = 1.45). The LER values was above 1 in both years (respectively, 1.36 and 1.54). Therefore, this means that a mixture uses environmental resources better than pure sowing and competition between mixture components is not high[18,30].

As average of two year, the highest green forage, dry matter and crude protein yield were determined from 70% hairy vetch + 30% triticale mixture. The highest crude protein content was determined from pure common vetch, hairy vetch and hungarian vetch, respectively. It was determined that 80% hairy vetch + 20% triticale mixture had the highest vetch rate in dry matter of mixtures. The mixtures out yielded the pure sowings with respect to dry matter yield (LER=1.45). As result of this study, 70% hairy vetch + 30% triticale mixture in arid seasons, 70% common vetch + 30% triticale in rainfall seasons can be recommended in the similar ecologies because of theirs high forage and crude protein yield.

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