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Full Length Research Paper

Effects of seeding rate on forage yield and quality of vetch (*Vicia sativa* L.) - triticale (*Triticosecale* Wittm.) mixtures under east mediterranean rainfed conditions

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This study was carried to determine the best seed mixture of vetch and triticale for East Mediterranean rainfed conditions of Turkey. The experiments were conducted in two locations, Adana and Kozan, during the years of 2003 - 2005. The field trials were arranged in a randomised block design with three replications. In the research, pure stands of vetch and triticale and their seed mixtures (80% vetch + 20% triticale, 60% vetch + 40% triticale, 40% vetch + 60% triticale, 20% vetch + 80% triticale) were studied. Crude protein concentrations, hay and crude protein yields of pure stands and the mixtures and the percentage of vetch in the dry matter yield were determined. In addition to these, relative yield total (RYT) values were calculated for the mixtures. The study showed that the characters studied were significantly influenced by years, locations and mixtures. According to the averaged values of two years, the seed mixture containing 20% vetch and 80% triticale gave highest dry matter yield with an average vetch content of 23.5% under Adana conditions, while the seed mixture of 40% Vetch + 60% triticale gave the highest dry matter yield with an average vetch content of 10% under Kozan conditions. RYT values for the mentioned mixtures were 1.12 and 1.20, respectively. It was concluded that the above mixtures of vetch and triticale could be recommended for the locations in Adana and Kozan, respectively.

Key words: Common vetch, triticale, mixtures, forage quality.

INTRODUCTION

Forage plants cultivated to provide good quality forage for farm animals can be grown either in a single or multiple species mixtures. Growing multiple species is generally preferred. Because, mixtures produce higher quality forage in addition to producing high yields and utilize the natural resources more effectively. However, selection of the species and the adjustment of the rates in these mixtures for attaining these advantages are important. Optimisation of plant density is also another important determiner of the yield.

Nutritious annual legumes such as common vetch (*Vicia sativa L.*) and grasspea (*Lathyrus sativus L.*) can be grown successfully under Cukurova conditions. They are prostrate types legumes, therefore they tend to lodge, especially when they grown alone without a companion crop. As a result, forage yield and quality start decreasing due to the decomposition of herbage (Tukel and Yilmaz, 1987; Gulcan et al., 1988; Aydin and Tosun, 1991).

Acikgoz and Cakmakci (1986) reported that the mean crude protein yields were between 0.496 and 0.873 t ha^{-1} with common vetch + cereal mixtures under the conditions in Bursa. The experiments conducted with common vetch + triticale mixtures under Cukurova conditions by Tukel et al. (1997) and showed that the mean dry matter yields varied between 0.98 and 2.69 t ha^{-1} and crude protein yields were between 0.54 and 0.98 t ha^{-1}. In experiments conducted with a wheat-hairy vetch mixture,

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Table 1. Dry matter yields (t ha^{-1}) for pure and mixture sowings at Adana and Kozan in 2004 and 2005.

Pure and Mixture Sowings	Adana			Kozan		
	2004	2005	Mean	2004	2005	Mean
100% Vetch	3.88 a*	3.87 d*	3.88 D*	1.17 c*	2.64 d*	1.91 C*
80% V + 20% T	3.26 ab	8.71 c	5.99 C	1.83 c	4.28 bc	3.05 B
60% V + 40% T	3.58 ab	10.25 bc	6.92 B	1.76 c	3.90 c	2.83 B
40% V + 60% T	2.92 b	10.95 b	6.94 B	3.00 b	5.73 a	4.36 A
20% V + 80% T	3.16 ab	12.71 a	7.94 A	2.74 b	5.87 a	4.30 A
100% Triticale	3.42 ab	9.67 bc	6.54 BC	3.86 a	4.45 b	4.15 A
Mean	3.37 B+	9.36 A	6.37 A++	2.39 B+	4.48 A	3.44 B

*Values with the same letters (within a column) do not differ significantly ($P < 0.01$) according to Duncan's test

+Means with the same letters (within a row) do not differ significantly ($P < 0.01$) according to Duncan's test

++Means in bold with the same letters (within a row) do not differ significantly ($P < 0.01$) according to Duncan's test

Roberts et al. (1989) obtained mean dry matter yields between 5.1 and 8.3 t ha^{-1}. Rauber et al. (2000) reported that the grain yield of pea and oats averaged 4.9 t ha^{-1} in monocultures and 5.5 t ha^{-1} in mixtures under the conditions in Germany.

This research was conducted to determine the suitable seed mixture rates of vetch + triticale under rainfed conditions in Adana and Kozan.

MATERIALS AND METHODS

The research was conducted during the growing seasons of 2003 - 2004 and 2004-2005 under Mediterranean rainfed conditions in Turkey. Field experiments were conducted in two locations, Adana (37° 00' N and 35° 21' E) and Kozan (37° 28' N and 35° 48' E). Experimental areas in Adana and Kozan were located at 110 m and at 650 m elevations, respectively. Soils of the experimental areas have a variable topography from almost flat to gentle slopes with clay texture (Ozbek et al., 1974).

The soils in Adana were neutral (pH 7.0), low in calcium carbonate (1.3%) and medium in phosphorus (85.9 kg ha^{-1} P_2O_5) and high in potassium (1412 kg ha^{-1} K_2O). On the other hand, Kozan's soils were alkaline (pH 7.8), high in calcium carbonate (26.85%) and low in phosphorus (47.65 kg ha^{-1} P_2O_5) and high in potassium (922.7 kg ha^{-1} K_2O).

Typical Mediterranean weather conditions prevail in both Adana and Kozan. In Adana the long-term average temperature from November to April is 12.7°C, and precipitation is 514.9 mm. Average temperatures for the period November to April in 2003 - 2004 was 12.7°C with 461 mm of rainfall. However, the same period in 2004-2005 was hotter (14°C) and drier (265 mm) than both the first year and the long-term average. The long-term average temperature from November to April in Kozan is 13.0°C and means rainfall 537 mm. Average temperatures for the period November to April in 2003 - 2004 was of 13.4°C and rainfall 544 mm. However, in 2004 - 2005 rainfall (420 mm) was lower than the long term average and the 2003 - 2004 seasons.

Vetch variety Kubilay-82 and triticale variety Tacettinbey were used as the test materials for this research. The field experiment was designed in a randomised complete block design with three replications. The size of plots was 5 x 1.2 = 6 m^2. Six different mixture rates (pure vetch, 80% vetch + 20% triticale, 60% vetch + 40% triticale, 40% vetch + 60% triticale, 20% vetch + 80% triticale and pure triticale) were tested. Germination of all seed materials was tested, and sowing densities were adjusted accordingly. Seeding rates of pure vetch and triticale were 120 and 250 kg ha^{-1}, respectively. Nitrogen and phosphorus fertilisers, at 50 kg ha^{-1} N and 50 kg ha^{-1} P_2O_5, were uniformly spread onto the soil before sowing.

The mixtures were clipped at ground level when the lower pods of vetches appeared. Green forage samples of each mixture component were dried at 70ºC for 48 h to determine dry matter yield. The contribution of vetch to the dry matter yield of the mixture was determined as percentage for each plot. Nitrogen concentration in ground subsamples of vetch hay and triticale straw were determined by the Kjeldahl procedure (Bulgurlu and Ergul, 1978) and crude protein concentration was calculated by the formula of N concentration × 6.25. Crude protein yield was calculated by multiplying dry matter yield by crude protein concentration. Relative yield totals (RYT) for the dry matter yields in the mixtures were calculated by using formula R = O/M, (R = relative yield, O = yield of X or Y species in the mixture, M = yield of X or Y species sown alone), RYT = RX + RY, (RYT = relative yield total, RX = relative yield of X species, RY = relative yield of Y species) (Hatipoglu and Tukel, 1997; Rauber et al., 2000).

Data were analysed by a randomised complete block design combined over locations and years by using MSTATC statistical package program.

RESULTS

Dry matter yield

Averaged dry matter yield in the second year was significantly higher than in the first year at both Adana and Kozan (Table 1).

Average dry matter yield was significantly higher in Adana (6.37 t ha^{-1}) than in Kozan (3.44 t ha^{-1}) (Table 1). In the first year, the highest dry matter yield (3.88 t ha^{-1}) was obtained from pure stand of vetch in Adana. However, dry matter yields of all mixtures with the exceptions

Table 2. Vetch contents (% of total dry matter) in mixture sowings at Adana and Kozan in 2004 and 2005.

Pure and Mixture Sowings	ADANA			KOZAN		
	2004	2005	Mean	2004	2005	Mean
80% V + 20% T	92.0 a*	36.7 a*	64.3 A*	54.3 a*	20.3 a*	37.3 A*
60% V + 40% T	85.3 a	28.3 b	56.8 B	38.0 b	9.7 b	23.8 B
40% V + 60% T	65.3 b	18.5 c	42.0 C	14.0 c	6.0 b	10.0 C
20% V + 80% T	45.7 c	1.3 d	23.5 D	11.3 c	3.7 b	7.5 C
Mean	72.1 A+	21.3 B	46.7 A++	29.4 A+	9.9 B	19.7 B

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of the mixture containing 40% vetch and 60% triticale and pure stands of triticale were not statistically different from that of the pure stand of vetch. In Kozan, the highest dry matter yield was obtained from the pure stand of triticale. In the second year, the mixture containing 20% vetch and 80% triticale gave significantly higher yield than the other mixtures and pure stands in Adana. The same mixture also gave highest dry matter yield in Kozan, but dry matter yield of the mixture containing 40% vetch and 60% triticale was not statistically different from it. Averaged over two years, the mixture comprising of 20% vetch and 80% triticale gave a significantly higher dry matter yield than the other mixtures and pure stands in Adana, while the mixtures containing 60% or 80% triticale and pure stand of triticale gave significantly higher dry matter yields than the other mixtures and pure stand of vetch in Kozan.

Vetch content of dry matter

The vetch content, averaged over mixture rates, was significantly influenced by the years and locations. While the content in Adana was 72.3% in the first year, it was 23.8% in the second year. But in Kozan, while the rate was 26.5% in the first year, it was 12.6% in the second year (Table 2). Averaged vetch content in Adana (48.1%) was significantly higher than that in Kozan (19.6%) (Table 2).

Vetch content was significantly influenced by seeding rate of vetch in the mixture, in both years and both locations. In the first year, vetch contents were higher than the seeding rates of vetch in the corresponding seeding mixtures in Adana. In contrast to this, the contribution of vetch to the dry matter yields of mixtures was lower than the seeding rates of vetch in the corresponding seeding mixtures in the second year in Adana, as well as in both years in Kozan.

Crude protein yield

Crude protein yields of pure sowings and mixtures were significantly influenced by year and location. Crude protein yield in Adana was 0.53 and 0.81 t ha^{-1} in the first and second year respectively. In Kozan, crude protein yield in the first year was 0.20 and 0.43 t ha^{-1} in the second year (Table 3).

Crude protein yield was significantly influenced by mixture. In the first year, pure sowing of vetch in Adana gave significantly higher crude protein yield than pure sowing of triticale. Pure vetch also produced more crude protein yield than the mixtures, with the exception of the mixture containing 60% vetch and 40% triticale. However, mixtures in Adana gave higher crude protein yields than the pure sowings in the second year. In Kozan, crude protein yield was not significantly influenced by mixtures in the first year. However, the pure sowing of vetch and the mixtures containing 80 or 40% vetch gave higher crude protein yield than the pure sowing of triticale in the second year.

Crude protein concentration

Crude protein concentrations of pure sowings and mixtures were significantly influenced by year and location. Crude protein concentration in Adana was 15.4 and 9.5% in the first and second year respectively. In Kozan, crude protein concentration in the first year was 9.8 and 10.6% in the second year (Table 4).

Crude protein concentration significantly influenced by the mixtures. In the first year, pure sowing of vetch in Adana gave significantly higher crude protein concentration than pure sowing of triticale. Pure vetch also produced more crude protein concentration than the mixtures, with the exception of the mixture containing 60% vetch and 40% triticale. In Kozan, highest crude

Table 3. Crude protein yield (t ha^{-1}) for pure and mixture sowings at Adana and Kozan in 2004 and 2005.

Pure and Mixture Sowings	ADANA			KOZAN		
	2004	2005	Mean	2004	2005	Mean
100% Vetch	0.76 a*	0.57 b*	0.66 A*	0.21 a*	0.55 a*	0.38 A*
80% V + 20% T	0.58 bc	1.07 a	0.83 A	0.22 a	0.50 a	0.36 A
60% V + 40% T	0.67 ab	0.93 a	0.80 A	0.20 a	0.38 ab	0.29 AB
40% V + 60% T	0.45 c	0.87 a	0.66 A	0.21 a	0.48 a	0.34 A
20% V + 80% T	0.46 c	0.89 a	0.67 A	0.17 a	0.41 ab	0.29 AB
100% Triticale	0.23 d	0.54 b	0.38 B	0.19 a	0.26 b	0.23 B
Mean	0.53 B+	0.81 A	0.67 A++	0.20 B+	0.43 A	0.32 B

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Table 4. Crude protein concentration (%) of pure and mixture sowings at Adana and Kozan in 2004 and 2005.

Pure and Mixture Sowings	ADANA			KOZAN		
	2004	2005	Mean	2004	2005	Mean
100% Vetch	19.5 a*	14.9 a*	17.2 A*	17.6 a*	20.9 a*	19.3 A*
80% V + 20% T	17.8 b	12.2 b	15.0 B	11.9 b	11.7 b	11.8 B
60% V + 40% T	18.5 ab	9.1 c	13.9 B	10.9 b	9.9 bc	10.4 B
40% V + 60% T	15.6 c	8.0 cd	11.8 C	7.1 c	8.2 cd	7.7 C
20% V + 80% T	14.5 c	7.1 cd	10.8 C	6.2 c	7.0 cd	6.6 CD
100% Triticale	6.7 d	5.6 d	6.1 D	4.9 d	5.9 d	5.4 D
Mean	15.4 B+	9.5 A	12.5 A++	9.8 B+	10.6 A	10.2 B

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protein concentration was obtained from the pure stand of vetch in both years. On the average over two years, the pure of vetch gave significantly higher crude protein concentration than the other mixtures and pure stand of triticale in both locations.

Relative yield total

Relative yield total (RYT) values averaged over the mixtures were influenced by both years and locations (Table 5). Averaged RYT values in the second year were higher than those in the first year in both locations. Average RYT value over the years and mixtures in Adana was higher than that in Kozan.

In Adana, RYT values were not significantly influenced by mixture in either year. In the first year, RYT values for all mixtures in Adana were P < 0.01. However, the RYT values for all mixtures in Adana were P > 0.01, in the second year. In Kozan, RYT value was not significantly influenced by mixtures in the first year. In the second year, mixtures containing 20 or 40% vetch gave significantly higher RYT values that other mixtures.

DISCUSSION

Dry matter, crude protein yields and crude protein concentrations were higher in the second year than that in the first year. This might have resulted from the different climatic conditions which prevailed, especially during March and April, which were hot and dry in the first year but cool and wet in the second year (this sentence are rewritten). Significant changes in the studied characters

Table 5. Relative yield total for pure and mixture sowings at Adana and Kozan in 2004 and 2005.

Pure and Mixture Sowings	ADANA			KOZAN		
	2004	2005	Mean	2004	2005	Mean
80% V + 20% T	0.873	1.420	1.147	1.067	1.100 b*	1.083 AB*
60% V + 40% T	0.967	1.523	1.245	0.857	0.937c	0.897 B
40% V + 60% T	0.810	1.460	1.135	1.063	1.343 a	1.203 A
20% V + 80% T	0.897	1.347	1.122	0.913	1.353 a	1.133 A
Mean	0.887 B	1.438 A	1.283 A++	0.975 B+	1.183 A	1.079 B

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by the locations could be due to climate and especially to soil conditions prevailing in the locations. This indicates that vetch may be more susceptible to drought than triticale in high pH soils.

The mixtures containing high rates of triticale gave higher dry matter yields than those containing lower rates of triticale in both locations. This finding confirms those of Hatipoglu et al. (1999), Karadag and Buyukburc (2003) and Lithourgidis et al. (2006).

Lodging of vetch due to higher rainfall in the second year, especially in March and April, resulted in lower vetch yields in the mixtures than in the first year. Higher vetch yields in Adana than in Kozan could be explained by site differences, including soil, climate and elevation. Vetch yields were significantly influenced by seeding rate in both years and both locations. This finding supports the results of Tansi et al. (1990), Aydin and Tosun (1991), Silbir et al. (1991), Tukel et al. (1997), Altin and Ucan (1996) and Kilic (1999).

Pure vetch produced more crude protein yield than pure triticale and the mixtures, with the exception of the mixture containing 60% vetch and 40% triticale. This result supports the finding of Lithourgidis et al. (2006). However, mixtures in Adana gave higher crude protein yields than the pure sowings in the second year. This result confirms that of Kilic (1999). In Kozan, pure sowing of vetch and the mixtures containing 80 or 40% vetch gave higher crude protein yield than pure sowing of triticale in the second year. The same result was also obtained by Cil (1998) under South Eastern Anatolian Conditions.

Significant differences in the RYT between years and location could be explained by climate and soil differences between years and locations. RYT value was not influenced by mixture in Adana, while the mixtures containing 20 or 40% vetch gave significantly higher RYT values that the other mixtures in Kozan.

Conclusions

Seed mixtures containing 20% vetch and 80% triticale with an averaged dry matter yield of 7.94 t ha^{-1} containing 23.5% vetch with a crude protein yield of 0.66 t ha^{-1} could be recommended for the dryland conditions of Adana. However, at Kozan, dry matter yield was maximised with vetch seeding rates of between 0 and 40% and protein yield maximised with a wider range of 40 - 100% vetch, but protein yield was largely unaffected by vetch sowing rate.

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