EFFECTS OF DIFFERENT MIXTURE RATIOS AND HARVEST PERIODS ON GRASS QUALITY OF TRITICALE (*xTRITICOSECALE* WITTMACK) – FORAGE PEA (*PISUM SATIVUM* L.) INTERCROP

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Abstract. The aim of this study was to determine the effects of different mixture rates and harvest periods on the herbage quality of triticale (*xTriticosecale* Wittmack) and forage pea (*Pisum sativum* L.) intercrops. The research was carried out in Diyarbakir province of Turkey during the winter vegetation period of 2016-2017. The research was carried out in randomized block design in split parcels in which the harvest periods and mixture ratios formed the main parcels and sub-parcels, respectively. In the study, all harvests were conducted at spike and milking period of triticale. The mixing ratios were 100% forage peas (FP), 100% triticale (T), 75% FP + 25% T, 50% FP + 50% T, 25% FP + 75% T. As the harvest periods delayed, crude ash, crude protein, digestible dry matter, dry matter consumption and relative feed value decreased where Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) rates increased. As the proportion of forage pea in the mixture increased, the ratio of crude protein and ADF increased, while the rate of digestible dry matter decreased. The spiking period of triticale was found to be the suitable harvest period. Sowing mixture at 25% FP + 75% T was superior obtaining good ADF, digestible dry matter and relative feed value. In the case of favorable NDF and crude protein ratios, 75% FP + 25% T proved to be superior to other mixture combinations.
Keywords: *cereal, legume, mixed cropping, feed quality*

Introduction

Intercropping is co-cultivation of two or more plant species in same period in same field. Triticale (× *Triticosecale* Wittmack), as a cereal, is more tolerant to biotic and abiotic stress conditions than wheat. Therefore, it is more suitable for marginal areas (Villegas et al., 2010). Triticale has high adaptability, better nutrient content and higher yield compared to other cereals (Oettler, 2005).

Forage pea is an important and nutritious fodder plant. It is reported that harvesting and weed control is a problem due to the significant lodging when this species is grown sole (Kadziuliene et al., 2011). Intercropping has many advantages. The presence of at least one legume species in the intercrop results with higher quality herbage production. Protein content and feed value increase with this method. In addition, wheat improves resistance to soil erosion where legumes reduce or prevent frost damage. The danger of swelling in animals due to some legumes may be reduced by feeding with these mixtures. Existence of cereals in mixtures also prevents lodging and decay of some legume fodder crops. In mixtures, the herbage gets dry better and more successful results are obtained in case of silage making. In case of existence of legumes in the intercrop; organic matter and nitrogen in the soil also increase. Generally in plants, as the development progressed, the weight increases, but the feed value decreases, which is

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more rapid since cartilage is more rapid in wheat. Therefore, harvest times should be determined based on the development periods of cereals in intercrops (Asik, 2006).

In a study in Spain, Pereira-Crespo et al. (2010), used forage peas and triticale in mixtures where they reported that ADF and NDF content of triticale alone was higher compared to the mixture and sole forage pea. Lithourgidis et al. (2006) reported that they obtained highest crude protein yield from common vetch-triticale mixture containing 65% common vetch and 35% triticale. Karadag and Büyükburç (2004) reported that, with the Hungarian vetch and triticale mixtures, the ratio of crude protein increased when triticale ratio decreased in the mixture.

The ratio of the species in the mixture is very important in terms of yield and quality. In legume and cereal mixtures, with the increase in the ratio of leguminous, dry grass yield generally decreases but in order to obtain the desired quality feeds, the ratio of cereals should not be more than 20% (Yucel and Avci, 2009). In a study conducted in Mediterranean conditions of Turkey, it is reported that with triticale-berseem clover mixtures, 60% berseem clover + 40% triticale rate, and 100% flowering period of berseem clover was best for high yield and good silage quality values (Yucel et al., 2018a). In another study carried out in Mediterranean conditions of Turkey, it is reported that 60% berseem clovers with 40% Italian ryegrass harvested at 100% flowering period of the berseem clover were suitable for high yield and good silage quality values (Yucel et al., 2018b).

The aim of this study was to investigate the effects of mixture ratio and harvest periods on forage quality of triticale and forage pea mixtures cropped in winter season in Diyarbakır condition which is a very important zone for feed and animal production in Turkey.

Materials and methods

Forage pea (*Pisum sativum* L. cv. Gap Pink) and triticale (× *Triticosecale* Wittmack cv. Karma 2000) were used as material in the research. The research was carried out in 2016-2017 winter (November-May) conditions in research fields of "GAP International Agricultural Research and Training Center" in Diyarbakir province of Turkey. Some climate data for the research period from the trial area are presented in *Table 1*.

Table 1. *Some climate data of Diyarbakir province of Turkey*

Month	Average temperature (°C)		Precipitation (mm)	
	2016-2017 season	Long-term	2016-2017 season	Long-term
September	24.2	24.8	5.2	4.1
October	18.8	17.2	13.6	34.7
November	8.2	9.2	52.0	51.8
December	2.4	4.0	135.6	71.4
January	1.5	1.8	20.6	68.0
February	1.5	3.5	3.8	68.8
March	9.4	8.5	90.2	67.3
April	12.8	13.8	98.8	68.7
May	18.8	19.3	30.6	41.3
June	26.9	26.3	2.6	7.9
Total			453.0	484.0

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Climatic data of trial year shows low deviation compared to long-term averages. The study was carried out with 3 replications based on divided parcels in randomized complete blocks design. Harvest times were at main parcels and mixture ratios were at sub-parcels. Harvest times were at two different times; spiking and milking period of triticale in the mixtures. Mixture ratios were 100% forage pea (FP), 100% triticale (T), 75% FP + 25%T, 50%FP + 50%T, and 25%FP + 75%T.

Each parcel was 6 m long containing 10 rows at 20 cm row spacings where both species were mixed before planting. 100 kg/ha forage pea and 220 kg/ha triticale seed applied at planting. Before planting, diammonium phosphate fertilizer (18.46.0) was applied to the parcels in order to provide 40 kg/ha pure nitrogen and 100 kg/ha pure phosphorus (Kir, 2014). Parcel border rows and 0.5 m of row end tails of parcels were eliminated before harvest and 8 m^2 areas of each parcel were harvested. 500 g of harvested green herbage materials were used for the determination of both species in each parcel. These samples were separated into two species (triticale and forage pea) to calculate the ratios of both species in each parcel. Green herbage samples were dried in a drying cabinet for 48 h at 70 °C before determining dry herbage ratios. Then botanical composition rates of dry herbage were determined and each sample was milled for quality analysis. Crude ash, crude protein, ADF and NDF analysis were performed on these milled herbage samples of forage peas and triticale separately and parcel values were calculated according to their ratio in botanical composition in accordance with Yucel et al. (2015). According to this method, during the harvests, 500 grams of green herbage samples taken from the mixture parcels were divided into pea and triticale species and green herbage weights were determined. Then, the proportional weights of the forage pea and triticale plants were calculated and assigned as botanical composition rate. Weende method for raw ash (AOAC, 1990), Kjeldahl method for raw protein (AOAC, 1990) and ANKOM method for ADF and NDF **(**Van Soest, 1967) were applied for quality analysis. Digestible dry matter (DDM), dry matter consumption (DMC) and relative feed value (RFV) of dry herbage were calculated by using *Equations 1–3* in accordance with Morrison (2003).

$$DDM = 88.9 - (0.779 \times ADF\%) \quad \text{(Eq.1)}$$

$$DMC = \frac{120}{NDF\%} \quad \text{(Eq.2)}$$

$$RFV = \frac{DDM \times DMC}{1.29} \quad \text{(Eq.3)}$$

Variance analysis of the data obtained from the study was conducted by using JUMP statistical package program and the significant averages were grouped into LSD, 5% (Kalayci, 2005).

Results and discussion

Harvest period, mixture rate and harvest period x mixture rate interaction were found statistically significant for crude ash (CA) and crude protein (CP) ratios (*Table 2*). The CA ratio, which was 8.70% at the spike period, decreased to 7.34% at the milking

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period, meaning that the effect of the harvest period was significant on CA ratio. The average lowest CA ratio (7.67%) was obtained from the 75%FP + 25% T mixture and no statistically significant difference was observed between other mixtures. When the CA ratio is examined for the harvest period x mixture interaction; the highest CA ratio was found to be obtained from spiking period at 100% T, 25% FP + 75% T and 50% FP + 50% T mixtures. The lowest CA ratio was obtained from milking period at all applications except 100% FP (*Table 2*).

Table 2. *Rates of crude ash and crude protein examined in the dry herbage (%)*

Mixture rate (MR)		Crude ash ratio (%)			Crude protein ratio (%)		
		Harvest period (HP)			Harvest period (HP)		
		Spiking	Milking	Average	Spiking	Milking	Average
100% FP		8.35c[1]	8.03c	8.19A*	16.42a	15.66a	16.04A
100% T		8.93a	7.30d	8.12A	10.22c	5.50e	7.86E
25% FP + 75% T		8.87ab	7.15d	8.01A	10.27c	8.35d	9.31D
50% FP + 50% T		8.96a	7.28d	8.12A	12.90b	11.21c	12.06C
75% FP + 25% T		8.41bc	6.92d	7.67B	13.51b	12.70b	13.11B
Averages		8.70A+	7.34B	8.02	12.67A	10.69B	11.68
LSD (0.05)	HP	0.20**			0.51**		
	MR	0.32*			0.44**		
	HP × MR	0.47**			1.15**		

*The means with the same capital letter in the same column are not statistically significant different from each other according to the LSD test at P ≤ 0.05

+The means with the same capital letter in the same row are not statistically significant different from each other according to the LSD test at P ≤ 0.05

[1]The means of different treatment-harvest stage combinations with the same lower case are not statistically significant different from each other according to the LSD test at P ≤ 0.05

The effect of harvest period on the CP ratio was found significant. The CP ratio was decreased from 12.67% to 10.69% after the transition from the spike to the milking period. Kim et al. (1990) reported that the CP ratio decreased rapidly due to the reduction in photosynthetic leaf area during the post-spike period. Other investigators also reported decreases in CP ratio following delays in harvest period. For example, Asik (2006) reported a CP ratio decrease from 13.36% to 5.77% at barley-pea mixtures when barley harvest period was delayed from stem elongation stage to yellow dough stage. Kir et al. (2018) also reported CP ratio decrease from 16.3% to 14.0% at Hungarian vetch-cereal mixtures when cereal was progressed transition from booting stage to milk dough stage.

Table 2 shows that the effect of average CP on mixtures is significant. The highest and lowest CP ratio was obtained from sole forage pea with 16.04% and sole triticale with 7.86%, respectively. CP ratio of all mixtures was higher than sole triticale. The high CP ratio of sole pea sources probably from the high ratio of both pods number and leaves/stalk rate. Many investigators was reported an increase in the CP ratio in case of existence of higher proportion of legumes in the mixtures (Kavut et al., 2014; Yildirim and Ozaslan-Parlak, 2016; Kir et al., 2018).

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When *Table 2* is examined; the effect of HP x MR interaction on CP probably was found to be significant. The highest CP ratio was obtained from sole forage pea at milk period while the lowest CP ratio was obtained from sole triticale at milking stage.

The effect of harvest period on ADF and NDF ratios was found significant. There was a statistically significant increase in ADF ratio as the harvest period was delayed (*Table 2*). The mean ADF ratio was increased from 31.29% to 36.20% and the rate of NDF from 44.15% to 48.91% after transition from spiking period to milking period. Many investigators also reported an increase in ADF and NDF ratio with delayed harvest time. For example, Aksoy and Nursoy (2010) reported that, in Hungarian vetch-wheat mixture, the ratio of ADF and NDF ratio varied between 25.94-38.24% and 36.47-57.61%, respectively. Guzelogullari (2012) reported that, in different vetch species at different harvest time, the ADF and NDF ratio was varied between 25.53-34.58% and 33.21-38.68%, respectively. Turgut et al. (2006) observed that, at Hungarian vetch, common vetch and hairy vetch, delays in harvest time was increased NDF ratio. Kir et al. (2018) reported the ADF ratio in Hungarian vetch-cereal mixtures as between 29.5-32.1% and NDF ratio as between 49.7-52.3%. These results are supporting our findings.

When *Table 3* is examined, it can be noticed that averages ADF and NDF values of mixtures were statistically significant. The highest and the lowest ADF ratio was obtained from sole triticale with 37.89% and sole forage pea with 29.95%, respectively. The lowest NDF ratio was also obtained from sole forage pea. Yildirim and Ozaslan-Parlak (2016) found ratio of ADF as 29.59%, NDF as 55.53% for triticale, and ADF as 23.10% and NDF as 46.34% for forage pea. Gocmen and Ozaslan-Parlak (2017), reported the ADF ratio of triticale as 45.16% and NDF ratio as 63.22% and forage pea ADF ratio as 41.23% and NDF ratio as 50.31%. These results are in accordance with our results.

Table 3. *Rates of acid detergent fiber (ADF) and neutral detergent fiber (NDF) examined in the dry herbage (%)*

Mixture rate (MR)		ADF (%)			NDF (%)		
		Harvest period (HP)			Harvest period (HP)		
		Spiking	**Milking**	**Average**	**Spiking**	**Milking**	**Average**
100% FP		28.10	31.80	29.95E*	47.60c[1]	39.87g	43.74C
100% T		34.97	40.81	37.89A	51.31a	46.03d	48.67C
25% FP + 75% T		28.67	33.98	31.33D	48.17c	44.25e	46.21B
50% FP + 50% T		31.43	35.68	33.56C	49.61b	48.17c	48.89A
75% FP + 25% T		33.30	38.70	36.00B	47.89c	42.43f	45.16B
Averages		31.29B[+]	36.20A	33.75	48.91A	44.15B	46.53
LSD (0.05)	HP	1.04**			0.44**		
	MR	0.53**			1.06**		
	HP x MR	n.s.			1.01**		

[*]The means with the same capital letter in the same column are not statistically significant different from each other according to the LSD test at P ≤ 0.05
[+]The means with the same capital letter in the same row are not statistically significant different from each other according to the LSD test at P ≤ 0.05
[1]The means of different treatment-harvest stage combinations with the same lower case are not statistically significant different from each other according to the LSD test at P ≤ 0.05

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When *Table 4* is examined, it is noticed that the effect of harvest period on the DDM rate is significant. Significant reductions was realised in the ratio of DDM as the harvest period was delayed. The rate of DDM was 64.52% and 60.70% at the spike period and milking period, respectively. Prolonged vegetation period probably resulted with structural changes in plant tissues with increased ADF ratios and finally these changes decreased DDM rate. One of the most important factors affecting the quality of feed is harvest time. Because the differences in the ADF value due to developmental periods significantly affect the digestibility of the feed (Caddel and Allen, 1997; Cinar, 2012).

The effect of mixtures on DDM ratios was found significant. The highest and lowest DDM ratios were obtained from sole forage pea and sole triticale, respectively (*Table 4*).

In studies conducted by different researchers, the ratio of DDM was between 59.1-68.7% at Hungarian vetch-wheat mixture (Aksoy and Nursoy, 2010), 65.5% at barley, 65.8% at triticale (Canpolat, 2012), 60.7-64.4% at Hungarian vetch-barley (Yilmaz et al. (2014) and average 63.9% at different Hungarian vetch-cereal mixtures (Kir et al., 2018). Our findings were similar to these results.

Table 4. *Rates of digestible dry matter (DDM) and dry matter consumption (DMC) examined in the dry herbage (%)*

Mixture rates (MR)		DDM rate (%)			DMC rate (%)		
		Harvest periods (HP)			Harvest periods (HP)		
		Spiking	**Milking**	**Average**	**Spiking**	**Milking**	**Average**
100% FP		67.01	64.13	65.57A*	2.52e[1]	3.01a	2.77A
100% T		61.66	57.11	59.38E	2.34g	2.61d	2.47D
25% FP + 75% T		66.57	62.43	64.50B	2.49e	2.71c	2.60C
50% FP + 50% T		64.42	61.11	62.76C	2.42f	2.49e	2.46D
75% FP + 25% T		62.96	58.75	60.85D	2.51e	2.83b	2.67B
Averages		64.52A[+]	60.70B	62.61	2.46B	2.73A	2.59
LSD (0.05)	HP	0.42**			0.02**		
	MR	0.81**			0.05**		
	HP x MR	n.s.			0.07**		

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+The means with the same capital letter in the same row are not statistically significant different from each other according to the LSD test at P ≤ 0.05

1The means of different treatment-harvest stage combinations with the same lower case are not statistically significant different from each other according to the LSD test at P ≤ 0.05

When the effect of harvest periods on DMC ratio was examined (*Table 4*), statistically significant differences were observed. The rate of DMC was 2.73% at spiking period, and 2.46% at the milking period. DMC rate was significantly decreased when harvest period was delayed. The effect of mixtures on DMC ratios was also found significant (*Table 4*). The highest DMC ratio was obtained from sole forage pea (2.77%), where the lowest was obtained from sole triticale and 50% YB + 50% T mixture.

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The effect of harvest periods on RFV was found significant. A statistically significant decrease was observed in the RFV as the harvest period was delayed (*Table 5*). RFV was 136.69 and 115.64 at the spiking period and milking period, respectively. It was determined that the effect of the different mixtures on the RFV was significant, where the highest and lowest RFV was obtained from sole forage pea and sole triticale, respectively.

Table 5. *Rates of relative feed value (RFV) examined in the dry herbage (%)*

Mixture rates (MR)		**RFV**		
		Harvest periods (HP)		
		Spiking	**Milking**	**Average**
100% FP		156.42a	125.33c[1]	140.87A*
100% T		124.64c	103.59f	114.11E
25% FP + 75% T		139.94b	120.57d	130.26B
50% FP + 50% T		124.42c	114.60e	119.51D
75% FP + 25% T		138.03b	114.12e	126.08C
Average		136.69A +	115.64B	126.17
LSD (0.05)	HP	1.95**		
	MR	3.27**		
	HP x MR	4.37**		

[*]The means with the same capital letter in the same column are not statistically significant different from each other according to the LSD test at P ≤ 0.05
[+]The means with the same capital letter in the same row are not statistically significant different from each other according to the LSD test at P ≤ 0.05
[1]The means of different treatment-harvest stage combinations with the same lower case are not statistically significant different from each other according to the LSD test at P ≤ 0.05

When quality classification of Rohweder et al. (1978) was considered as reference, which is based on the 100% flowering period of clover, where RFV > 151 = premium quality, 151-125 = 1st quality (very good), 124-103 = 2nd quality (good), 102-87 = 3rd quality (medium), 86-75 = 4th quality (bad), < 75 = 5th quality (unacceptable), quality scores ranged between 1st and 2nd quality at different harvest periods and mixture combinations in our study.

In different studies, relative feed value in different harvest periods was between 98-114 for pure triticale (Yucel et al., 2018a), 106-108 for wheat-Hungarian vetch mixture (Aksoy and Nursoy, 2010), 96.2-118.8 for Hungarian vetch-barley (Yilmaz et al., 2014) and 109 for Hungarian vetch-lolium mixture (Kusvuran et al., 2014). Our findings were similar to these results.

Conclusions

Main aim of inclusion of forage pea in triticale is to increase its protein content. Shifting forage pea rate in the mixture from 25% to 50% increases the CP approximately 33% whereas shifting forage pea rate from 50% to 75% increases CP approximately 8%. But in the same time, RFV is 6 points and DMC is 0.2% higher when shifted forage pea rate from 50% to 75%. Milking period of triticale was found the most appropriate harvest period. So, when these important quality parameters

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considered together, it is found appropriate to propose 75% FP + 25%T mixture under arid climate conditions similar to East Anatolia according to this study. Testing morphologically different forage pea and triticale cultivars may produce different information related to the subject which is proposed to future researchers.

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