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EFFECTS OF DIFFERENT MIXTURE RATIOS OF COMMON VETCH AND TRITICALE ON FORAGE YIELD AND SILAGE QUALITY

Mehmet ÖTEN[1]*, Mertcan KOÇ[1], Alperen GÜMÜŞ[1]

[1]*Sakarya University of Applied Sciences, Faculty of Agriculture, Department of Field Crops, 54580, Sakarya, Türkiye*

Abstract: In order to obtain high amounts and quality forage in legume grain mixtures, the mixture ratios must be adjusted well. Since grains are tillered due to their physiology, their ratios in roughage are different from the mixing ratios in planting. This is a factor that increases roughage yield and reduces crude protein rate and yield. In addition, in cases where grains are insufficient in terms of minerals in animal nutrition and are planted in mixtures with legumes, the rapid development and high yield effects of grains should be combined with the balanced nutrition potential of legumes in order to obtain better quality feed. In the research, which was conducted to determine the effect of vetch and triticale mixture ratios on yield and silage quality in Sakarya ecological conditions, plantings were carried out at different mixture ratios. In this study, 100% Vetch, 100% Triticale, 75% Vetch + 25% Triticale, 50% Vetch + 50% Triticale and 25% Vetch + 75% Triticale were planted in Sakarya conditions and the effect of the mixture ratios on grass yield was revealed. Additionally, silage was made from the mixtures obtained, and the effect of the applied mixture ratios on silage quality was determined. Field trials of the research were carried out in the trial areas of Sakarya University of Applied Sciences, Faculty of Agriculture. In the experiment, plant height, green and dry forage yield observations were taken. At the end of the maturation period, silage was made in 2 kilogram containers from each parcel as a silage quality criterion; silage dry matter ratio, silage pH, crude protein ratio, ADF and NDF observations were taken. By calculating the physical and sensory analysis and fleig point used to determine silage quality, the silages obtained from the mixtures were defined in detail by chemical, physical and sensory analysis and the fleig point. In the study, the highest green forage yield, hay yield, crude protein, ADF, NDF ratio and fleig point were obtained from 100% Vetch, 100% Triticale, 100% Vetch, 100% Triticale, 100% Triticale and 50% Vetch+50% Triticale mixtures, respectively. Due to the favorable outcomes in terms of forage yield and silage quality, 25% Vetch + 75% Triticale mixture ratio can be recommended to producers.

Keywords: Common vetch, Triticale, Mixture, Silage, Quality

***Corresponding author:** S*akarya University of Applied Sciences, Faculty of Agriculture, Department of Field Crops, 54580, Sakarya, Türkiye*
E mail: mehmetoten@subu.edu.tr (M. ÖTEN)
Mehmet ÖTEN https://orcid.org/0000-0002-3737-2356
Mertcan KOÇ https://orcid.org/0009-0007-0127-4547
Alperen GÜMÜŞ https://orcid.org/0009-0009-8580-3411

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1. Introduction

The most extensively cultivated forage crop in our country is vetch, with a cultivated area of 288 thousand hectares (Anonymous, 1996). Except for narbon vetch, other vetch species tend to lodge due to the weakness of their stems. Lodging leads to a decrease in forage yield and quality, difficulty in harvesting, and leaf losses. To prevent lodging, mixed cropping is practiced with cereals (barley, oats, rye, and triticale) alongside vetch. As vetch develops, it wraps around with its tendrils, reducing yield losses and facilitating harvesting (Soya et al., 1996; Tan and Serin, 1996). Research indicates that mixed crops of vetch + cereals serve as an important forage source to compensate for the shortage of quality roughage during winter and can be easily cultivated (Iptas and Yılmaz, 1998). The type of cereals and legumes used in the mixture influences the yield and quality of the mixture. Furthermore, the most crucial factor determining forage yield and quality is the ratios of plants in the mixture (Carr et al., 2004).

Mixed cultivation of legumes and cereals offers several advantages. One of the most significant advantages is that mixed crops generally yield higher compared to sole cultivation of legumes (Ghanbari-Bonjar and Lee, 2003). Proper incorporation of vetch and cereal species into the mixture is crucial for ensuring abundant and balanced forage. Otherwise, in imbalanced mixtures, excessively competitive cereals can suppress vetch over time, reducing its ratios in the mixture (Moreira, 1989; Roberts et al., 1989). Mixed cropping provides increased resistance to diseases and helps control certain weeds (Sarunaite et al., 2010; Ghanbari-Bonjar and Lee, 2003). The primary objective of mixtures is to prevent vetch lodging. Therefore, studies have utilized different species and climatic conditions to determine optimal mixture ratios (Saglamtimur et al., 1986).

Common vetch (*Vicia sativa* L.) is a lean vetch plant with high energy content, rich in protein and minerals (Parissi et al., 2022), used for green fodder and roughage as well as green manure (Ozyazıcı and Manga, 2000; Ozyazıcı,

2022). It is an annual legume forage plant that is suitable for crop rotation with cereals and/or as a mixture with cereals (Munoz Santa et al., 2023). In recent years, triticale, used as a substitute for wheat and barley in animal husbandry (Yagbasanlar and Ulger, 1989), can be grown in combination with vetches (Soya et al., 1996; Hasar and Tukel, 1994). Iptas and Yılmaz (1998) reported that research indicates the best yield is obtained from mixtures of Hungarian vetch + triticale. In a study involving various vetch + cereal mixtures, they found that an average yield of 1388.0 kg da^{-1} green forage, 316.0 kg da^{-1} dry matter, and 56.4 kg da^{-1} crude protein could be obtained from mixtures containing 2/3 Hungarian vetch + 1/3 Triticale. The mixture ratios significantly impact silage quality (Soya et al., 1991).

Silo feeds, used for the nutrition of ruminant animals, constitute a crucial source of roughage. Silage feeds hold significant economic importance, particularly in agriculturally advanced countries where a substantial portion of the feed volume is in the form of silage (Saricicek et al., 2002). Silage refers to the green and moisture-rich forage that undergoes fermentation (acidification) in an anaerobic environment and is stored as a result of the silage-making process (McDonald et al., 1991). Due to features such as palatability, long-lasting preservation without spoilage, and minimal susceptibility to adverse weather conditions, the use of silage has become widespread (Kılıc, 1986; Filya, 2001; Acıkgoz, 2001). Silages are composed of either grasses or leguminous plants, and these plants can be cultivated singly or in mixtures. It has been observed that silage obtained from grasses yields higher quality and is easier to ensile compared to leguminous plants. Leguminous forage crops are challenging to ensile due to their lower content of water-soluble carbohydrates (Pitt, 1990; Raques and Smith, 1966).

Both grasses and vetches are generally cultivated in our country for the purpose of obtaining forage and grain feed. The practice of making silage from the obtained vetch and grass forage is not yet widespread. Mixed cultivation of vetch and grasses, along with their evaluation as silage, could serve as an important source to meet the demand for high-quality feed.

This study was conducted with the aim of determining suitable mixture ratios for vetch and triticale mixed cultivation under Sakarya ecological conditions and assessing the silage quality at these mixture ratios.

2. Materials and Methods

The study was conducted at the Agricultural Sciences and Technologies Center of Sakarya Applied Sciences University in the Applied Research Field. The trial soils have a loamy texture. The soil pH was determined to be moderately alkaline (7.93), with a non-saline soil structure (0.12%), moderately calcareous (28.31%), and low organic matter (0.54%). In the research, vetch (*Vicia sativa* L.) (Yucel variety) and triticale (x *Triticosecale Wittmack*) (Okkan 54 variety) as a plant material were used. Field trials were established according to a three-replicate randomized block design. Plot dimensions were set at a row length of 5 m and an inter-row distance of 20 cm, with 6 rows in each plot. One row on each side and 50 cm sections at the beginning of each row were discarded as border effects and the remaining portion was subjected to evaluation. The experiment included five different plantings: 100% Vetch, 75% Vetch + 25% Triticale, 50% Vetch + 50% Triticale, 25% Vetch + 75% Triticale, and 100% Triticale. To determine forage yield, plant height (cm), green forage yield (kg da^{-1}), and dry forage yield (kg da^{-1}) observations were taken during the grain maturity stage for vetch and milk stage for triticale (Anonymous, 2001).

Subsequently, 2 kilograms of samples were taken from each plot, cut into 1.5-2.0 cm pieces, placed in silage bags, vacuum-sealed, and closed. After a fermentation period of 60 days in laboratory conditions, matured silages were opened, and after discarding a 3-4 cm portion from the top of the silage containers, analyses were conducted on the remaining silage samples. Silage parameters such as dry matter content (%), silage pH (Budaklı Carpıcı, 2009), crude protein content (%) (Akyıldız, 1984), ADF (%), and NDF (%) were observed (Van Soest et al., 1991). Additionally, the quality class of the silage was calculated using the Fleig score method reported by Kılıc (1986) [Fleig Score = 220 + (2 x % Dry matter - 15) - 40 x pH] (Ozata et al., 2012). Physical assessment of silages, including color, odor, and structure, was conducted by assigning scores according to the method specified by Alcicek and Ozkan (1997) (those in the range of 16-20 points were considered excellent-good (VG-G), 10-15 points were satisfactory (S), 5-9 points were medium (M), and 0-4 points were deemed low (L)).

2.1. Statistical Analysis

The obtained results were statistically analyzed using the Jump statistical analysis package program, and the averages were examined using the Duncan multiple comparison test (Anonymous, 2002).

3. Results and Discussion

3.1. Yield and Morphological Observation Values for Vetch-Triticale Mixtures

The plant height, green forage yield, dry matter content, and dry matter yield values obtained from vetch-triticale mixtures are presented in Table 1. The highest dry matter content was observed in 100% triticale with 44.13%. Similarly, in the study conducted by Kaplan et al. (2014), the dry matter content of the silage varied between 35.54% and 41.46%.

100% Triticale had a plant height of 83.22 cm, while in the 75% Vetch + 25% Triticale mixture, it was determined as 98.33 cm. Similarly, vetch had a plant height of 127.00 cm in sole planting, while in the 25% Vetch + 75% Triticale mixture; it was recorded as 142.67 cm (Table 1). As observed, mixed plantings positively influenced the plant height of both vetch and triticale. In a study conducted by Binici (2020) in Kahramanmaras,

the highest vetch natural plant height was obtained from the 50% Wheat + 50% Vetch mixture with 72.20 cm, and the highest wheat plant height was 83.32 cm from the 75% Wheat + 25% Vetch mixture. In a study conducted by Egritas (2014) in Ordu ecological conditions, the longest cereal plant height, 108.25 cm, was obtained from the 50% Vetch + 50% Triticale mixture, both in pure and mixed plantings. Results from a study by Olgun (2018), on vetch-triticale mixtures in Kahramanmaras conditions, obtained the highest triticale plant height of 135.53 cm from the 50:17 triticale-vetch mixture, and the highest vetch plant height was 108.40 cm from the 50:33 triticale-vetch mixture. Acıkgoz and Cakmakcı (1986) also stated that the highest green herbage and dry matter yield was obtained from vetch + barley mixtures. The data obtained in other studies are in agreement with findings in line with our study.

The highest green forage yield in the experiment was obtained from 100% Vetch. The lowest green forage yield was obtained from the 75% Vetch + 25% Triticale mixture. Dry matter content was highest in 100% Triticale (44.13%) and lowest in 100% Vetch (13.87%), as expected. Dry forage yield was highest in 100% Vetch and the 25% Vetch + 75% Triticale mixture, parallel to the green forage yield (Table 1).

In his study, Olgun (2018) obtained the highest dry forage ratio in the triticale-vetch mixture with 30.54% from the 50 Vetch + 50 Triticale- mixtures. In mixed legume-cereal crops, Binici (2020) obtained the highest green forage yield of 2706.0 kg da^{-1} from the 25% Vetch + 75% Barley mixture. Enayat et al. (2016), in a study investigating the effects of common vetch and barley mixture ratios on forage yield, found an average green forage yield of 824.41 kg da^{-1} and an average dry forage yield of 464.56 kg da^{-1}. Soya et al. (1991) obtained an average green forage yield of 1388.0 kg da^{-1} from the 2/3 Hungarian vetch + 1/3 Triticale mixture. Demiroglu Topcu et al. (2020) determined the highest green forage yield in a pure plot with a 100-0 mixture ratio of 4250 kg da^{-1}. Olgun (2018) found a total green forage yield of 2979 kg da^{-1} in the 50:50 triticale-vetch mixtures. Onal Ascı and Egritas (2017) reported the highest dry forage yield in the 50% Oat and 50% Vetch mixture at 8731.7 kg da^{-1}, while the lowest dry forage yield was obtained in plots with 100% Vetch planting (3627 kg da^{-1}). Binici (2020) obtained the highest dry forage yield of 1786.4 kg da^{-1} from the 25% Vetch + 75% Wheat mixture. Enayat et al. (2016) determined an average dry forage yield of 464.56 kg da^{-1} in a common vetch and barley mixture. Yucel and Avcı (2009) stated that triticale dry matter yield ranged from 1034 to 1252 kg da^{-1} under Cukurova ecological conditions between 2004-2008. Albayrak et al. (2006), in their study on triticale, hay yield was 638.0-1892.5 kg/da. Demiroglu Topcu et al. (2020) obtained the highest dry forage yield of 717 kg da^{-1} from 100% Vetch plots. While the dry matter content in our study is similar, it can be observed that our study has lower values in terms of green forage and dry forage yields. Yousıf (2016) stated that dry forage yield ranged from 290.83 to 644.24 kg da^{-1} in his research. This difference could be attributed to the use of different species and varieties, as well as location variations.

Table 1. Observation values and Duncan groups for Vetch-Triticale mixture ratios

Mixture Ratios	Triticale Plant Height (cm)	Vetch Plant Height (cm)	Green Forage Yield (kg da^{-1})	Dry Matter Content (%)	Dry Forage Yield (kg da^{-1})
100% Vetch	-	127.00b	852.78a	13.87e	295.99a
100% Triticale	83.22b	-	670.56bc	44.13a	118.34d
75% Vetch + 25% Triticale	98.33a	80.00c	662.78c	34.20d	226.65c
50% Vetch + 50% Triticale	92.33ab	83.00c	693.33bc	36.93c	255.95b
25% Vetch + 75% Triticale	93.44ab	142.67a	717.78b	38.73b	278.05a

[a-d] Means with different letters in the same column are significantly different at P<0.05.

3.2. Observation Values for Vetch-Triticale Mixture Silages

The observation values obtained from the chemical analysis of mature silages are presented in Table 2. In the study, 100% Triticale had the highest ADF (acid detergent fiber) content (40.69%) and NDF (neutral detergent fiber) content (63.77%). The lowest ADF and NDF content was obtained from the mixture of 75% Vetch + 25% Triticale, with values of 34.54% and 50.47%, respectively. Since an ideal silage mixture is characterized by high protein content and low ADF and NDF content, it can be stated that the most suitable silage was obtained from the mixture of 75% Vetch + 25% Triticale (Table 2). In a study conducted by Egritas (2014), the highest protein content (16.93%), lowest ADF (34.40%), and NDF (56.76%) were obtained from 100% Vetch plots. Yıldırım and Ozaslan Parlak (2016) reported that the highest NDF content (55.99%) was obtained from the mixture of 75% Triticale + 25% Peas, and the highest ADF content (36.23%) was obtained from the 100% Faba bean plot. Similarly, Seydosoglu et al. (2020) found that NDF and ADF content decreased as the legume ratio increased in mixed crops, with the highest NDF and ADF content obtained from 100% Barley plots and the lowest from 100% legume plots.

In the study, 100% Vetch had the highest protein content, while all other mixture ratios were in the same group (Table 2). Demiroglu Topcu et al. (2020) obtained the

highest protein content (23.1%) from the 100% Vetch plot (100-0). In a study investigating the nutrient content of winter silage feeds, the protein content of vetch silage was found to be 10.60-12.50% (Karakozak and Ayasan, 2010). Yıldırım and Ozaslan Parlak (2016) reported the highest protein content (21.47%) from 100% vetch and the lowest protein content (9.53%) from 100% Triticale plots.

The highest crude ash, Ca, K, Mg, P, and pH values of silage mixtures were obtained as follows: in 100% Vetch respectively, (20.72%), (1.40%), (5.28%), (0.40%), (0.42%), and (4.92) (Table 2). Sahin et al. (2023) reported in their study that parallel to the increase in the clover ratio in silage, the pH of the silage also increased. They indicated that the lowest pH was obtained in 100% Triticale silage, while the highest pH was observed in 100% Vetch silage.

Yousif (2016) determined calcium at 0.68-1.14%, potassium at 0.642-0.864%, magnesium at 0.205-0.322%, phosphorus at 0.107-0.167%, and sodium at 0.007-0.032% in his study. Karakozak and Ayasan (2010) reported an ash content of 8.13-14.06% for vetch silage.

Table 2. Values obtained from Vetch-Triticale mixture silages with different mixing ratios and Duncan groups

Mixture Ratios	ADF (%)	NDF (%)	Crude Protein (%)	Crude Ash (%)	Ca (%)	K (%)	Mg (%)	P (%)	pH
100% Vetch	37.59b	44.40d	19.16a	20.72a	1.40a	5.28a	0.40a	0.42a	4.92a
100% Triticale	40.69a	63.77a	9.33b	11.26c	0.26c	3.78b	0.14cd	0.33b	4.22b
75% Vetch + 25% Triticale	34.54c	50.47c	11.19b	5.41d	0.49bc	3.34b	0.18bc	0.36ab	4.18b
50% Vetch + 50% Triticale	36.36bc	53.62bc	10.89b	5.67d	0.50b	3.47b	0.13d	0.33b	4.06b
25% Vetch + 75% Triticale	38.14b	56.32b	10.08b	13.47b	0.53b	3.32b	0.19b	0.22c	4.31b

[a-d] Means with different letters in the same column are significantly different at P<0.05.

3.3. Fleig Scores of Silages Obtained from Vetch-Triticale Mixtures

The evaluation based on Fleig scores indicates that silage obtained from a 50% Vetch + 50% Triticale mixture is considered good, while silage from a 25% Vetch + 75% Triticale mixture is deemed satisfactory. Silage obtained from a 75% Vetch + 25% Triticale mixture and 100% Triticale is evaluated as medium, whereas silage from 100% Vetch is considered low (Table 3).

In their study, Sahin et al. (2023) obtained the lowest dry matter (DM) content from 100% Vetch (22.96%) and the highest DM content from 100% Triticale (29.87%). In a study conducted by Karadeniz et al. (2020) under ecological conditions in Mardin, they determined the quality characteristics of silage obtained by mixing different ratios of Grass pea + Triticale. The same study reported the highest DM content at 33.3% from 100% Triticale and the lowest at 28.5% from 100% Grass pea, which aligns with the DM ratios obtained in our study.

Karadeniz et al. (2020) reported in their study that 100% Triticale and 20% Grass pea + 80% Triticale mixtures had the highest Fleig scores. Sahin et al. (2023) found the highest Fleig score in 100% Triticale silage (101.34), noting that an increase in the vetch ratio in mixtures resulted in a decrease in Fleig scores. They reported the lowest Fleig score in 100% Vetch silage (79.32). Dogan and Terzioglu (2010) investigated the effects of mixture ratios on silage quality in forage pea-barley mixtures in Van conditions, determining that the silage was of medium quality according to the Fleig scoring. The results obtained in this study are supportive of findings in other research.

Table 3. Fleig scores of vetch triticale silage mixtures

Mixture Ratios	Dry Matter (%)	pH	Fleig point	Assessment
100% Vetch	0.14	4.92	8.61	Low
100% Triticale	0.46	4.22	36.99	Medium
75% Vetch + 25% Triticale	0.34	4.18	38.62	Medium
50% Vetch + 50% Triticale	0.37	4.06	43.35	Good
25% Vetch + 75% Triticale	0.39	4.31	33.52	Satisfactory

3.4. Physical Analysis Values of Vetch Triticale Silage Mixtures

The evaluations based on the physical and sensory analyses of the obtained silage are presented in Table 4. In the physical analysis of silage, an assessment is made based on scores given for color, odor, and structure. Accordingly, 100% Triticale silage is considered very good, all other mixed silages are regarded as satisfactory, and 100% Vetch silage is evaluated as medium and satisfactory (Table 4).

High scores are observed to be obtained from the odor and color characteristics of 100% Triticale silage, and as the ratio of triticale in the mixture increases, the overall score also increases (Table 4).

Bulgurlu and Ergul (1978) reported that in legume and cereal mixed silage, legumes easily deteriorated in color and structure, negatively affecting the silage quality.

Table 4. Vetch triticale silage mixtures physical analysis scores

Mixture Ratios	Physical Analysis Scores	Assessment
100% Vetch	9.54	Medium/Satisfactory
100% Triticale	15.75	Very Good
75% Vetch + 25% Triticale	12.62	Satisfactory
50% Vetch + 50% Triticale	13.04	Satisfactory
25% Vetch + 75% Triticale	14.75	Satisfactory

In conclusion, upon evaluating the data obtained from the mixtures, it has been determined that planting both vetch and triticale together in a mixed cultivation results in better plant development. The mixture of 25% Vetch + 75% Triticale stands out in terms of both green and dry forage yield. Silages were assessed in three groups based on chemical content, Fleig score, and physical analysis criteria. It was observed that the mixtures of 25% Vetch + 75% Triticale, 50% Vetch + 50% Triticale, and 100% Triticale silages were prominent in these categories. It can be said that producing forage crops in a legume and cereal forage mixture provides a significant advantage for achieving a balanced ration to meet the roughage needs of livestock.

4. Conclusion

In terms of animal nutrition, it is observed that standalone cereal forage crops may not sufficiently meet the needs of animals. However, the cultivation of legumes and cereals together can provide a significant amount of protein and carbohydrates to meet the nutritional requirements of animals. In addition, making silage as a mixture of graminea forage crops and legume forage crops gave better results in terms of nutrient content than silage alone. As the ratios of legumes increases in the mixtures, the protein content also increases, positively impacting fermentation. On the other hand, an increase in the amount of cereals contributes to a higher level of easily digestible carbohydrates, enhancing silage quality. The examined mixture of 25% Vetch + 75% Triticale has been shown to yield high green and dry forage from a unit area, and the silage obtained from this mixture is of good quality. Therefore, due to the favorable outcomes in terms of both forage yield and silage quality, this mixture ratio can be recommended to producers.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	M.Ö.	M.K	A.G.
C	100		
D	100		
S	100		
DCP		50	50
DAI	100		
L		50	50
W	50	25	25
SR	20	20	20
PM		50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, SR= submission and revision, PM= project management.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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