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Competition Indices of Forage Turnip Cereal Mixtures in Different Seeding Ratio

Yem Şalgamı Tahıl Karışımlarının Farklı Ekim Oranlarında Rekabet İndeksi

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COMPETITION INDICES OF FORAGE TURNIP CEREAL MIXTURES IN DIFFERENT SEEDING RATIO

ABSTRACT

The aim of current study was to determine of intercropping forage turnip “FT” with cereals “C” (barley, “B”, wheat “W” and oat “O”) for herbage yield and competitive ratios in Bilecik conditions in 2019-2020 and 2020-2021 growing periods. Plants were sown as sole and in 3 different mixtures (75FT+25C%, 50FT+50C% and 25FT+75C%). Experiments were arranged in a randomized complete block design with three replications. In the study, herbage yield, land equivalent ratio (LER), competitive ratio (CR), aggressivity (A) and actual yield loss (AYL) values were determined. The herbage yield was ranged from 23.91 to 43.24 t ha^{-1}.The highest LER value 50FT+50O% (1.43), while the lowest was in 75FT+25W% (0.94) mixture. It was determined that the competitive ratios of cereals are higher than forage turnip. Besides, the AYL decreased with the increase in cereals ratio in mixtures.

As a result, it was determined that the addition of cereal to the forage turnip increased the herbage yield and the mixtures performed better than the monocrops. Besides, according to the all traits, it was concluded that it would be appropriate to sown forage turnip with barley and oats at a seed rate of 50FT+50B% and 25FT+75O% seed rates in Bilecik ecological conditions.

Keywords: Forage Turnip, Cereal, İntercropping, Herbage Yield, Competition.

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YEM ŞALGAMI TAHIL KARIŞIMLARININ FARKLI EKİM ORANLARINDA REKABET İNDEKSİ

ÖZ

Bu çalışma, 2019 ve 2020 vejetasyon döneminde Bilecik ekolojik koşullarında yem şalgamı “YŞ” ile farklı tahıl “T” (arpa, “A”, buğday “B” ve yulaf “Y”) karışımlarının yeşil ot verimi ve rekabet oranlarının belirlenmesi amacıyla yürütülmüştür. Bitkiler yalın ve 3 farklı karışım (75YŞ+%25T 50FT+%50C ve 25FT+%75C) oranında ekilmiştir. Çalışma Tesadüf Blokları Deneme Desenine göre üç tekerrürlü olarak kurulmuştur. Çalışmada yeşil ot verimi, alan eşdeğerlik oranı (LER), rekabet indeksi (Rİ), agresivite (A) ve gerçek verim kaybı (GVK) değerleri belirlenmiştir. Yeşil ot verimi 23.91 ile 43.24 t ha^{-1} arasında değişmiştir. AEO en yüksek 50YŞ+%50Y (1.43), en düşük ise 75YŞ+%25B (0.94) karışımında olmuştur. Tahılların rekabet oranlarının yem şalgamına göre daha yüksek olduğu belirlenmiştir. Ayrıca karışımlarda tahıl oranı arttıkça GVK azalmıştır.

Sonuç olarak, yem şalgamına tahıl ilavesinin yeşil ot verimini arttırdığı ve karışımların yalın ekimlere göre daha iyi performans gösterdiği belirlenmiştir. Ayrıca tüm özelliklere göre Bilecik ekolojik koşullarında arpa ve yulafın yemlik şalgam ile %50YŞ+50A ve %25YŞ+75Y tohum oranında ekiminin uygun olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Yem Şalgamı, Tahıl, Karışıkekim, Bitki Verimi, Rekabet.

1. INTRODUCTION

Animal-based food has occupies a significant place in people's diets in Turkey. However, there are some problems associated with livestock production, the primary ones being high input costs and the insufficiency of high-quality roughage. Meadows and grasslands are damaged as they have long been overused for grazing and overgrazing pasturing. Therefore, as the cheapest source of roughage, they have lost their efficiency to a significant extent. On the other hand, the gradual increase in the number of livestock in recent years led to the intensification of the roughage problem, one of the main challenges in the industry. Developing forage crop agriculture has become essential in overcoming this bottleneck. As a matter of fact, the latest data demonstrates that there are 19 million cattle units (BBHB) in Turkey. The annual roughage need of animal stock in Turkey is 86 million tons. The roughage yield obtained from forage crop fields, meadows and grasslands corresponds to 31 million tons, with the deficit being 55 million tons (Acar et al., 2020). This leads to an inability to feed the existing cattle with high-quality roughage, resulting in reduced yield.

The diversity of the climate, soil and production pattern variety in Turkey allows the successful cultivation of many forage crops. However, the number of forage crop types cultivated has not yet reached a sufficient level, meaning a further increase in the roughage needed by the existing animal stock. As a matter of fact, the decline in farming areas due to the growing national and global population is a widely acknowledged fact. Therefore, cultivators have resorted to mixed planting systems to make better use of available farming areas in recent years.

Mixed planting refers to the cultivation of multiple species in the same area simultaneously. It enables an increase in both the overall yield and cultivator income. Also, plants cultivated in the same environment use the available soil, water, light and nutrients more effectively, causing less impact on the environment (Onal Asci et al., 2015; Acar et al., 2017).

As one of the most significant ways of increasing the yield of forage crops, mixed planting is a widespread choice, particularly in tropical and subtropical regions. In addition to enabling better use of available resources, a mixed planting system is an attractive option for other reasons as well. Firstly, it also reduces risk factors and protects soil fertility through simultaneous cultivation, where if one species fails to grow, the other can thrive. Moreover, it prevents erosion by forming dense vegetation and increases profitability by allowing for more effective use of the household workforce (Zohry et al., 2020).

Determining the species to be used in mixed planting is essential, as the potential competition among the plants can lead to problems. The plants included in the mixture can belong to the same family or different families. Thus, they may compete against each other in light, water and nutrient uptake due to their different morphological properties. Seed ratios in the mixture are as influential in competition as the species themselves. In fact, when the cereal ratio in the mix is high, the cereals would prevent the other species' growth as they grow faster in spring. Therefore, it is critical to adjust the species and seed ratios in the mixture well to ensure interspecies balance. Mugi-Ngenga et al. (2023) indicated that in intercrops, inter-specific competition is inevitable and counterbalances the benefits of potential improved total productivity and biological nitrogen fixation by the legumes. Competitive interactions and the potential for complementarity between the component species determine the performance of intercropping systems.

Lenox, also known as forage-type turnip, is a non-perennial forage crop, the cultivation of which requires no irrigation. Its high protein content improves livestock yield and quality. This plant, directly impacting milk yield and quality, adds value to cultivator income as well. The plant has a very high oil rate and is quite rich in vitamins and nutrients. The hair of animals that feed on forage turnip becomes shinier, with a marked decrease in foot diseases and diarrhea cases. Sheep, goats, heifers, cattle and dairy cows consume the leaves and roots of the plant with great appetite.

This study aims to determine the herbage yield and competition rates of forage turnip and barley, wheat and oat mixtures.

2. MATERIAL AND METHODS

The experiments were conducted at the Agricultural Practice and Research Area, Bilecik Şeyh Edebali University, Turkey, during 2019-2020 and 2020-2021 winter growing season. In this study, forage turnip (*Brassica rapa* L. cv. "Lenox"), barley (*Hordeum vulgare* L. cv. "Ramata"), wheat (*Triticum aestivum* L. cv. "Reis") and oat (*Avena sativa* L. cv. "Checota") was used as a material and they were sown in five different mixtures (100:0%, 75:25%, 50:50%, 25:75% and 0:100%).

The meteorological data of the experiment area during growth season (December – May) show in the Table 1. During to growing season, total precipitation was 322.0 mm at the long-term; it was 342.3 mm for 2019-2020 and 338.3 mm for 2020-2021 (Table 1). Besides, the long-term, 2019-2020 and 2020-2021 years average temperatures at 7.7 °C, 8.9 °C and 8.8 °C, respectively.

Table 1. Meteorological data of experiment area in the long-term and studied years

Months	Temperature (°C)			Precipitation (mm)			Moisture (%)		
	LT**	2019-20	2020-21	LT**	2019-20	2020-21	LT**	2019-20	2020-21
November	9.0	12.7	8.3	37.2	27.6	3.6	71.1	63.0	72.0
December	4.5	5.6	7.9	55.9	78.4	9.7	76.0	78.0	71.5
January	2.4	2.4	5.6	50.1	45.4	78.3	76.5	74.0	58.6
February	3.7	5.2	5.7	42.0	65.6	37.7	73.2	72.1	68.0
March	6.4	8.6	5.1	47.3	34.1	101.0	69.3	68.8	72.1
April	11.5	10.8	11.4	41.8	36.0	73.0	64.2	61.0	67.0
May	16.1	16.7	17.5	47.7	55.2	35.0	64.5	62.0	60.1
Average	**7.7**	**8.9**	**8.8**				**70.7**	**68.4**	**67.0**
Total				**322.0**	**342.3**	**338.3**			

*Tukish State Meterogical Service; **: Long-term

Experiment field soil properties were clay-loam type with pH of 7.71 and 7.82% $CaCO_3$, 257.2 kg ha-^{1} phosphorus, 1605.0 kg ha^{-1} potassium and 1.25% organic matter.

Experiment was arranged in a randomized complete block design with three replications. The plots were formed 6 rows with 20 cm space and 5 m length. In pure sowings, 10 kg ha^{-1} for seed was used for forage turnip, 220 kg ha^{-1} for barley, 200 kg ha^{-1} for wheat, 200 kg ha^{-1} for oat. The P fertilizer (P_2O_5) 80 kg ha^{-1} was uniformly applied to the soil with sowing. Pure forage turnip and mixtures were harvested at the flowering stage based on forage turnip, while the cereals were harvested at milk-dough stages (Harvest was determined using Zadoks scale 73) (Zadoks et al., 1974; Mut et al., 2015; Mut et al., 2018). All treatments were manually harvested and then the species were separated as forage turnip and cereal.

The herbage yields were calculated by converting the plot weights to hectares of the treatments. The land equivalent ratio and other competitive indexes of the treatments were determined according to the herbage yield.

The land equivalent ratio (LER) was determined according to the method by Willey (1979). When LER values are <1, intercropping is disadvantageous compared to pure sowing, when LER = 1, intercropping is equal compared to pure sowing and when LER > 1, intercropping is advantageous compared to pure sowing, (Feng et al., 2022).

The land equivalent ratio (LER): LERFT + LERc

LERFT: FTHY/ FTSY

LERC : CHY/ CSY

FT : Forage Turnip

C : Cereals

FTHY : Herbage yield of forage turnip in the intercrops

FTSY : Herbage yield of forage turnip in sole crops.

CHY : Herbage yield of cerals in the intercrops

CSY : Herbage yield of cereals in sole crops.

The competition ratio (CR) and aggressivity (A) were determined according to the method by Willey ve Rao (1980) and Bantie et al. (2014).

CRFT : (LERFT/LERC) × (FTSR/ CSR)

CRC : (LERC/LERFT) × (CSR/FTSR)

FTSR : Seed ratio of forage turnip

CSR : Seed ratio of cereal

(AFT) : (FTHY / FTSY×FTSR) - (CHY/ CSY×CSR)

(AC) : (CHY/ CSY×CSR) - (FTHY / FTSY×FTSR)

If the AFT : 0, it is equal in both species, if the AFT is positive, forage turnip is dominant and if the AFT is negative, forage turnip is the suppressed species (Dhima et al., 2007; Lithourgidis et al., 2011).

Actual yield loss (AYL) of mixtures was calculated according to the method Banik et al. (2000). Accordingly, If AYL is positive, intercrops are advantageous compared to sole crops, If AYL is negative, intercrops are disadvantageous compared to sole crops

AYL : AYLFT + AYLC

AYLFT : ((FTHY/ FTSR)/(FTSY /100)-1)

AYLC : ((CHY/CSR)/(CSY/100)-1)

The results were analyzed according to the randomized complete block design using the SPSS.22 statistical package program. Differences between the considered traits were revealed by Duncan's multiple-range test.

3. RESUT AND DISCUSSION

Values of herbage yield and land equivalent ratio (LER) of forage turnip and cereal mixtures are given in Table 2, which demonstrates very significant statistical variance ($p<0.01$) between procedures in separate and combined years, with no variance between years in terms of herbage yield. In terms of LER, there was a variance of 5 percent between years on the level of possibility, with no variance between procedures in separate and combined years (Table 2).

In combined years, the highest herbage yield varied between 36.99 and 43.24 t ha^{-1}. The lowest herbage yield was obtained from the 75%FT+25%W procedure as 23.91 t ha^{-1} (Table 2). It is seen that cereals contribute positively to the herbage yield of mixtures. This results from the formation of a dense habitus by way of cereal tillering. In addition, barley and oat proved to be more suitable for forage turnip mixtures than wheat in this study. In individuals, forage turnip, barley and oat were in the same statistical group having a higher herbage yield compared to wheat (Table 2). Orak and Nizam (2012) stated that the herbage yield of lupin, Hungarian vetch, Narbonne vetch and common vetch mixtures with barley in different ratios varied between 7.27 and 46.32 t ha-1 and that mixtures exhibited better performance than individuals.

LER varied between 0.94 and 1.43 in combined years (Table 2). These results demonstrate that procedures other than 75%FT+25%W are more advantageous than individual planting. This indicates that the plants in the mixture have different root and stem structures, nutrient requirements and reactions to ecological conditions and thus use environmental resources more effectively than individuals. Çopur Doğrusöz et al. (2019) remarked that the LER values of forage turnip and Hungarian vetch, common vetch and pea vary between 0.61 and 2.39.

Table 2. Herbage yield and land equivalent ratios of forage turnip cereal mixtures

Treatments	Herbage Yield (t ha^{-1})			Land Equivalent Ratio (LER)		
	2019-20**	2020-21*	Mean**	2019-20	2020-21	Mean
100FT	28.82 bcd	28.98 bcd	28.90 bcd	-	-	-
100B	29.47 bcd	28.01 bcd	28.74 bcd	-	-	-
100W	25.00 cd	24.09 d	24.55 d	-	-	-
100O	30.27 bcd	27.20 bcd	28.74 bcd	-	-	-
75FT+25B	35.98 abc	40.98 ab	38.48 ab	1.26	1.44	1.35
75FT+25W	21.95 d	25.87 cd	23.91 d	0.82	1.06	0.94
75FT+25O	37.40 ab	39.00 abc	38.20 ab	1.27	1.48	1.38
50FT+50B	37.95 ab	36.02 a-d	36.99 abc	1.32	1.28	1.30
50FT+50W	25.43 cd	30.29 a-d	27.86 cd	1.44	1.11	1.28
50FT+50O	42.11 a	44.37 a	43.24 a	1.20	1.66	1.43
25FT+75B	39.72 ab	36.93 a-d	38.33 ab	1.34	1.34	1.34
25FT+75W	30.38 bcd	33.51 a-d	31.95 bcd	1.21	1.37	1.29
25FT+75O	38.19 ab	39.56 ab	38.88 ab	1.27	1.47	1.37
Mean	***32.51***	***33.44***		***1.24 B****	***1.36 A****	

FT: Forage Turnip; B: Barley; W: Wheat; O: Oat; *(p<0.05); **(p<0.01).

There was a variance between years in the competition rates of forage turnip and cereal mixtures on the level of 1% possibility, with no variance between treatments in separate and combined years (Table 3). Generally, it can be said that barley is more dominant in mixtures compared to wheat and oat. This is because barley is an early plant with a high tillering potential in comparison to other cereals (Acar et al., 2017). In a study they conducted with legume-cereal mixtures, Dordas et al. (2012) stated that cereals are more dominant than legumes. Similarly, cereals proved to be more dominant than forage turnip in this study.

Table 3. Competitive ratios of forage turnip cereal mixtures

Treatments	Competitive Ratios of Forage Turnip			Competitive Ratios of Cereals		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean
75FT+25B	0.19	0.21	0.20	5.62	4.73	5.17
75FT+25W	0.32	0.23	0.28	4.11	5.31	4.71
75FT+25O	0.28	0.34	0.31	4.17	6.12	5.15
50FT+50B	0.19	0.26	0.22	7.71	4.19	5.95
50FT+50W	0.37	0.53	0.45	2.78	2.23	2.50
50FT+50O	0.47	0.35	0.41	4.01	3.64	3.82
25FT+75B	0.40	0.49	0.45	3.44	2.32	2.88
25FT+75W	0.62	0.86	0.74	2.42	1.47	1.95
25FT+75O	0.31	0.52	0.41	3.52	2.34	2.93
Mean	***0.35 B*****	***0.42 A*****		***4.20 A*****	***3.59 B*****	

FT: Forage Turnip; B: Barley; W: Wheat; O: Oat; **(p<0.01).

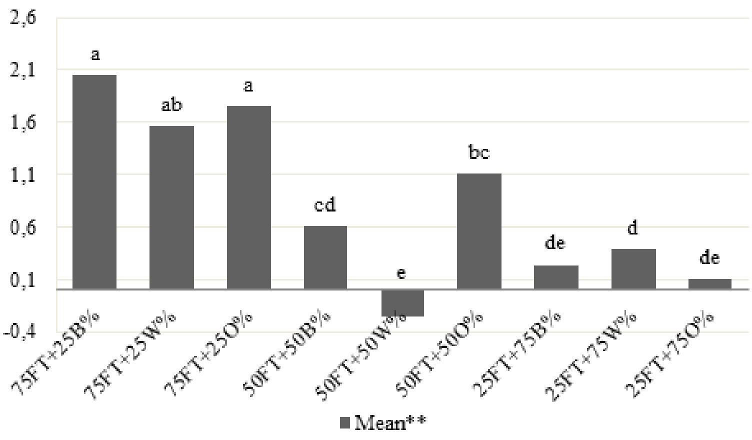
Table 4. Aggressivity values of forage turnip cereal mixtures

Treatments	Aggressivity Values of Forage Turnip			Aggressivity Values of Cereals		
	2019-20**	2020-21**	Mean**	2019-20**	2020-21**	Mean**
75FT+25B	-0.0258 c	-0.0278 e	-0.0268 e	0.0258 a	0.0278 a	0.0268 a
75FT+25W	-0.0134 ab	-0.0198 de	-0.0197 de	0.0134 bc	0.0198 ab	0.0166 bc
75FT+25O	-0.0204 bc	-0.0190 de	-0.0166 cd	0.0204 ab	0.0190 ab	0.0197 ab
50FT+50B	-0.0180 bc	-0.0151 bcd	-0.0166 cd	0.0180 ab	0.0151 bcd	0.0166 bc
50FT+50W	-0.0035 a	-0.0064 ab	-0.0141 cd	0.0035 c	0.0064 de	0.0050 de
50FT+50O	-0.0115 ab	-0.0167 cd	-0.0124 bcd	0.0115 bc	0.0167 bc	0.0141 bc
25FT+75B	-0.0101 ab	-0.0077 abc	-0.0089 abc	0.0101 bc	0.0077 cde	0.0089 cde
25FT+75W	-0.0053 a	-0.0028 a	-0.0050 ab	0.0053 c	0.0028 e	0.0041 e
25FT+75O	-0.0108 ab	-0.0139 bcd	-0.0041 a	0.0108 bc	0.0139 bcd	0.0124 bcd
Mean	***-0.0132 A*****	***-0.0144 B*****		***0.0132 B*****	***0.0144 A*****	

FT: Forage Turnip; B: Barley; W: Wheat; O: Oat; **(p<0.01).

Table 4 shows the aggressivity values of forage turnip and cereal mixtures. There was a very significant variance ($p<0.01$) between forage turnip and cereal mixtures in separate and combined years. It was seen that aggressivity values decreased as the planting rates of cereal seed ratios did. The opposite was observed in forage turnip. Since cereals tiller, they can tolerate the decrease in seed ratios. Thus, cereals can tiller more and grow in sparse planting (Önal Aşçı and Eğritaş, 2017). Moreover, aggressivity values varied between cereals. This results from the varying tillering properties, primary stem lengths and development rates of different species. The aggressivity values in this study were coherent with those obtained by Dhima et al. (2007), who stated that the species and planting ratios used in mixtures determined interspecies competition.

In terms of actual yield loss (AYL), the variance was very significant ($p<0.01$) between forage turnip and cereal mixtures in separate and combined (Figure 1). AYL ranged between -0.26 and 2.05 in combined years. It was observed that actual yield loss was higher in mixtures with a forage turnip rate of 75%. As the cereal ratio in mixtures increased, actual yield loss decreased. Yılmaz et al. (2015) remarked that the AYL values of barley and vetch mixtures ranged between –0.382 and 2.002.



FT: Forage turnip; B: Barley; W: Wheat; O: Oat; **($p<0.01$).

Figure 1. Actual yield loss of forage turnip cereal mixtures in combined years

4. CONCLUSION

In this study, it was aimed to determine intercropping herbage yield and competition ratios of forage turnip with barley, wheat and oat mixtures in Bilecik ecological conditions in the 2019-2002 and 2020-2021 growing periods.

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The highest herbage yield was determined in 75FT+25B% (38.48 t ha^{-1}), 75FT+25O% (38.20 t ha^{-1}), 50FT+50B% (36.99 t ha^{-1}), 50FT+50O% (43.24 t ha^{-1}), 25FT+75B% (38.33 t ha^{-1}), 25FT+75O% (38.88 t ha^{-1}) mixtures. The LER value was ranged between 0.94-1.43. It has been determined that the competitive ratios of cereals are higher than forage turnip. Besides, The AYL decreased with the increase in cereals ratio in mixtures.

As a result, it was determined that the addition of cereal to the forage turnip increased the herbage yield and the mixtures performed better than the monocrops. Besides, according to the all traits, it was concluded that it would be appropriate to sown forage turnip with barley and oats at a seed rate of 50+50% and 25+75% in Bilecik ecological conditions.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval

Author Contribution Rates

Design of the Study: EG(50%), HM(50%)

Data Collection: EG(100%)

Data Analysis: EG(50%), HM(50%)

Writing of the Article: EG and HM(100%)

Submission and Revision of the Article: EG and HM(100%)

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