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EVALUATION OF FORAGE TURNIP + CEREAL MIXTURES FOR FORAGE YIELD AND QUALITY TRAITS

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ABSTRACT

The aim of current study was to investigate the effects of intercropping forage turnip "FT" with cereals (barley, "B", wheat "W" and oat "O") for improving forage yield and nutritive value in Bilecik conditions in 2019 and 2020 growing periods. The percentage of forage turnip and cereals in mixtures was 100+0%, 75+25%, 50+50%, 25+75%, and 0+100%, respectively. Experiments were arranged in a randomized complete block design with three replications. The hay yield, crude protein yield, relative feed value (RFV), condensed tannin, total phenolic, total flavonoid, and mineral contents (K, P, Ca, and Mg) were determined. The hay yield of treatments was ranged between 5.45-10.27 t ha^{-1}. The highest crude protein yield was obtained mixture of 50FT+50O% (1.80 t ha^{-1}). The pure forage turnip, 75FT+25B%, 75FT+25O%, and 50FT+50B% mixtures were statistically in the same group as 50FT+50O%.
The condensed tannin was ranged between 2.00-2.84%. The highest RFV was calculated for 75FT+25O% (136.29), and the 50FT+50O% mixture (125.42) was statistically in the same group as mixture of 75FT+25O%. The present study showed that intercropping of forage turnip with barley and oat improved the hay yield and quality. The best results regarding for forage yield and quality were obtained from the FT+B and FT+O mixtures with seed rates of 75:25% and 50:50%.

Keywords: Bilecik, cereals, forage turnip, hay yield, nutritive value.

INTORDUCTION

The roughages are one of the indispensable feed sources of livestock. In Turkey, there is a serious shortage of roughages for livestock. Acar et al. (2020) reported that the deficit of quality roughage was 55 million tons in Turkey. To meet this requirement, it is necessary to give importance to different forage plants and especially to the production of intermediate forage crops. Turkey has very different soil, climate, and production designs through which it is possible to successfully grow many forage plants, however, very few forage plant species and varieties are cultivated.

Leaf-type forage turnip (Lenox) is a very high protein rate and contains rich vitamins, therefore, it increases the efficiency of animals. Lenox is an easily digested plant. It is especially consumed by sheep, goats, cattle, and dairy cows with great appetite (Geren, 2002). In recent years, forage turnip, which is used as a source of roughage in ruminant feeding to close the roughage deficit gap, and has become attractive due to its rapid growth ability and not needing irrigation in the winter season. Besides, the forage turnip is resistant to frost in autumn and early winter and maintains its high nutrients.

Intercropping, which is the cultivation of plants belonging to more than one species in the same area, is considered one of the sustainable farming techniques (Bauman et al., 2002). While intercropping provides an increase in total product and income, it enables more efficient use of soil, water, and labor resources and inputs. In addition, it has important advantages in terms of compatibility with ecological agriculture and less damage to the environment (Hook and Gascho, 1988; Akman and Kara, 2001; Bauman et al., 2002).

The present study was aimed to explore the potential of forage turnip-cereals intercropping systems with different mixture ratio and the effects on yield and chemical composition of fodder in Bilecik-Turkey.

MATERIALS AND METHODS

The experiments were conducted during 2019-2020 and 2020-2021 winter growing season at the Agricultural Practice and Research Area, Bilecik Seyh Edebali University, Turkey. Soil proporties of the experiment field taken from 30 cm depth 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. The Table 1 shows the meteorological data of the experiment area during growth season (December – May), including monthly average temperature, monthly total precipitation and avarage moisture. 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).

Table 1. Meteorological data of experiment area in the longterm 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

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. Cekota) were sown in pure and in mixtures (forage turnip:cereals respectively as; 75:25, 50:50 and 25:75) on 21 November, 2019 and 20 November, 2020. 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 turnp and cereal.

Plant samples were dried 65 °C until constant weight to determine hay yield. Crude protein ratio (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), potassium (K), phosphorus (P), calcium (C) and magnesium (Mg) content of hay was determined by using Near Reflectance Spectroscopy (NIRS, 'Foss 6500') with software package program 'IC-0904FE'.

Relative feed value (RFV) was estimated according to the following equations adapted from Rohweder et al. (1978);

RFV = (DDM% * DMI%)/1.29; DDM%= 88.9 - (0.779 x ADF%);

DMI% = 120/NDF%,

DDM = Dry matter digestibility,

DMI = Dry matter intake.

The total phenolic contents (TP) of samples were determined with slight modification according to the Folin-Ciocalteu reagent (FCR) method of Singleton et al. (1999). Samples (200 µL) were mixed with diluted FCR (200 µL) and shaken vigorously for 3 min. Then, 200 µL sodium carbonate (Na_2CO_3) solutions (20%) were added. Then samples absorbance of each sample was measured at a spectrophotometer at the absorbance value of 760 nm after incubating in dark at room temperature for 2 h. The total phenolic contents were expressed as mg equivalents of gallic acid (GAE) g^{-1} dry weight (DW) according to the equation obtained from the standard gallic acid graph and calculated from the calibration curve (R^2= 0.9994).

The total flavonoid content (TF) was determined by using Arvouet-Grand et al. (1994) with some modifications. Each sample (200 µL) was mixed with 100 µL of aluminum nitrate (10%) and 100 µL of potassium acetate (1 M). The total volume of the solution was adjusted to 5mL with ethanol. Similarly, a blank was prepared by adding methanol in place of the sample. Absorbance measurements were read at a spectrophotometer at the absorbance value of 417 nm after 40 min incubation at room temperature in dark conditions. Total flavonoid content was expressed as mg equivalents of quercetin (QE) g^{-1} DW according to the equation obtained from the standard quercetin graph and calculated from the calibration curve (R^2= 0.9994).

A 6 ml of tannin solution was added to 0.01 g of ground sample then placed in a tube and mixed on a vortex. The tubes were tightly capped and kept at 100 °C for 1 hour, and the samples were allowed to cool. Then, they were read at a spectrophotometer at the absorbance value of 550 nm (Bate-Smith, 1975). Condensed tannins (CT) were calculated by the following formula: Absorbance (550 nm x 156.5 x dilution factor) / Dry weight (%).

The data was analyzed in separate and combined years. ANOVA was performed by using SPSS 22.0 package program and, means were grouped with Duncan's multiple-range test.

RESULTS AND DISCUSSION

In combined years, botanical composition of forage turnip + cereal mixtures was given Figure 1. It is difficult to maintain the desired botanical composition in intercropping. Accordingly, it was observed that cereals were more dominant in the present study. This is due to the cereals being earlier germination than the forage turnip. Therefore, they are become dominant by tillering.

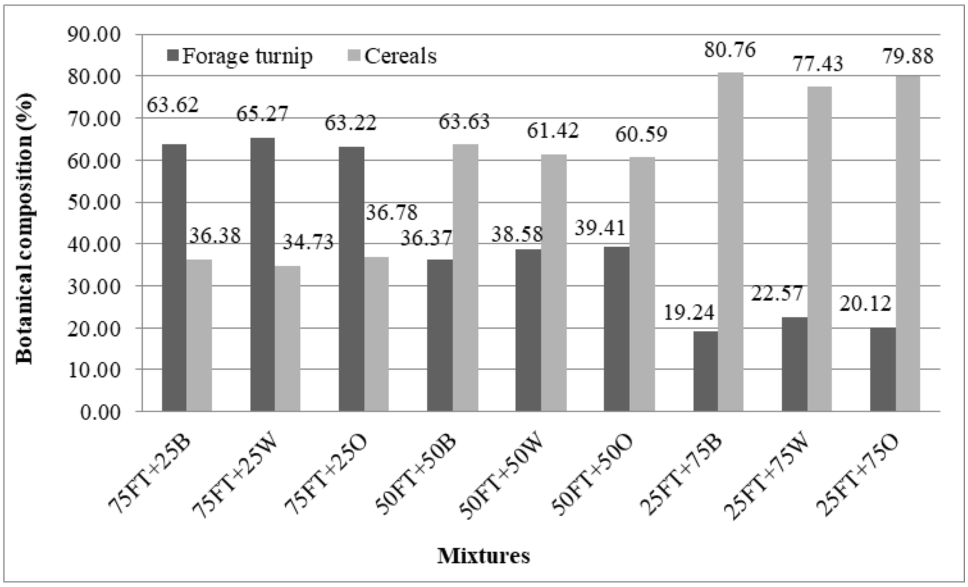

Figure 1. Botanical composition of forage turnip + cereal mixtures averaged over two years **(**FT: Forage turnip; B: Barley; W: Wheat; O: Oat)

Hay and crude protein yield of forage turnip + cereal mixtures were given in Table 2. The effect of intercropping on hay yield was significant (P<0.01) in the first (2019-2020) and combined years, while the second year (2020-2021) was not significant. It was determined that significant (P<0.01) differences between treatments in both separate and combined years in terms of crude protein yield. Besides, it was no significant differences among years in terms of hay and crude protein yield.

Table 2. Hay and crude protein yield of forage turnip + cereal mixtures

Treatments	Hay yield (t ha^{-1})			Crude protein yield (t ha^{-1})		
	2019-20**	**2020-21^{ns}**	**Mean****	**2019-20****	**2020-21****	**Mean****
100^{FT}	5.77 cd	7.24	6.50 cde	1.23 bc	1.64 ab	1.44 a-d
100^{B}	8.84 ab	8.40	8.62 a-d	1.08 c	0.93 c	1.01 de
100^{W}	7.50 abc	7.23	7.37 b-e	1.02 c	0.91 c	0.97 e
100^{O}	9.09 ab	8.16	8.62 a-d	1.20 bc	1.07 bc	1.14 cde
75^{FT}+25^{B}	8.38 ab	9.43	8.91 ab	1.62 ab	1.85 a	1.74 ab
75^{FT}+25^{W}	4.96 d	5.94	5.45 e	0.97 c	1.19 abc	1.08 cde
75^{FT}+25^{O}	8.56 ab	8.79	8.67 abc	1.66 ab	1.82 a	1.74 ab
50^{FT}+50^{B}	9.21 ab	8.64	8.93 ab	1.56 ab	1.44 abc	1.50 abc
50^{FT}+50^{W}	5.80 cd	6.92	6.36 de	1.04 c	1.22 abc	1.13 cde
50^{FT}+50^{O}	9.96 a	10.58	10.27 a	1.73 a	1.86 a	1.80 a
25^{FT}+75^{B}	9.72 ab	9.00	9.35 ab	1.41 abc	1.24 abc	1.33 b-e
25^{FT}+75^{W}	7.34 bcd	8.01	7.67 b-e	0.98 c	1.20 abc	1.09 cde
25^{FT}+75^{O}	9.39 ab	9.62	9.50 ab	1.23 bc	1.46 abc	1.35 b-e
Mean	***8.04^{ns}***	***8.30^{ns}***		***1.29^{ns}***	***1.37^{ns}***	

FT: Forage turnip; B: Barley; W: Wheat; O: Oat; ^{ns} is not significant, ** is significant at $P \leq 0.01$.

In combined years, the highest hay yield was determined in 50FT+50O% (10.27 t ha^{-1}). The pure barley (8.62 t ha^{-1}), pure oat (8.62 t ha^{-1}), 75FT+25B% (8.91 t ha^{-1}), 75FT+25O% (8.67 t ha^{-1}), 50FT+50B% (8.93 t ha^{-1}), 25FT+75B% (9.35 t ha^{-1}), and 25FT+75O% (9.50 t ha^{-1}) mixtures were statistically in the same group as 50FT+50O%. The lowest hay yield was determined in mixture of 75FT+25W% (5.45 t ha^{-1}) (Table 2). The cereal seed ratio in the mixture had a positive effect on hay yield. Accordingly, the hay yield of mixtures was increased with increasing cereal seed ratio excepted the 25FT+75O% mixture. Besides, the hay yield of forage turnip + barley and forage turnip + oat mixtures were higher than mixture of forage turnip + wheat. This is due to the hay yield of barley and oats have higher than wheat. When pure sowings were compared, barley and oats were in the same statistical group and had a higher hay yield than wheat and forage turnip. Zeybek (2017) reported that hay yield of forage turnip and companion crops (Hungarian vetch, forage pea, common vetch, and oat) mixtures ranged between 4.27 and 9.25 t ha^{-1}. The hay yields obtained in the present study are similar to the findings by Zeybek (2017).

In combined years, the highest crude protein yield (1.80 t ha^{-1}) was obtained from the mixture containing 50% forage turnip and 50% oat, and the lowest protein yield was obtained from the pure wheat (0.97 t ha^{-1}) sowing (Table 2). Copur Dogrusoz et al. (2019) reported that the crude protein yield of turnip-legume mixtures ranged between 0.41-1.09 t ha^{-1}. In the current study, the crude protein yield of forage turnip and cereal mixtures was higher than the findings by Copur Dogrusoz et al. (2019). Environmental conditions, cultural applications, and the cultivars used in the trials could cause such differences. Besides, the high hay yield could be another reason for the difference.

The relative feed values (RFV) and condensed tannin contents of forage turnip + cereal mixtures were given in Table 3. The effect of intercropping on RFV and condensed tannin content was significant (P<0.01) in separate and combined years. Besides, the effect of years was a significant at 5% level on RFV and condensed tannin.

Table 3. Relative feed values and condansed tannin content of forage turnip + cereal mixtures

Treatments	**Relative Feed Value**			**Condensed tannin content (%)**		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
100^{FT}	107.1 def	110.44 c	108.66 cd	2.29 b	2.04 bcd	2.17 bcd
100^{B}	91.4 gh	84.97 e	88.06 e	2.85 a	2.83 a	2.84 a
100^{W}	82.7 h	87.27 e	84.96 e	2.87 a	2.74 a	2.80 a
100^{O}	100.8 fg	93.29 de	96.78 de	2.91 a	2.59 a	2.75 a
$75^{FT}+25^{B}$	117.7 bcd	124.57 bc	121.00 bc	2.26 b	2.10 bcd	2.18 bcd
$75^{FT}+25^{W}$	111.7 c-f	125.49 bc	118.34 bc	2.26 b	1.99 bcd	2.13 bcd
$75^{FT}+25^{O}$	130.0 a	143.28 a	136.29 a	2.10 bc	2.14 bc	2.12 bcd
$50^{FT}+50^{B}$	114.3 cde	113.89 bc	114.03 bc	2.25 b	2.12 bc	2.19 bcd
$50^{FT}+50^{W}$	119.5 abc	116.51 bc	117.94 bc	2.27 b	2.18 bc	2.23 bc
$50^{FT}+50^{O}$	128.3 ab	123.03 bc	125.42 ab	2.30 b	2.20 bc	2.24 b
$25^{FT}+75^{B}$	104.8 ef	113.09 bc	108.76 cd	1.79 c	2.21 b	2.00 d
$25^{FT}+75^{W}$	117.4 bcd	108.29 cd	112.60 bc	2.14 b	1.91 cd	2.02 c
$25^{FT}+75^{O}$	109.5 c-f	129.52 ab	119.04 bc	2.20 b	1.82 d	2.01 d
Mean	***110.40 B****	***113.36 A****		***2.34 A****	***2.22 B****	

FT: Forage turnip; B: Barley; W: Wheat; O: Oat; * is significant at P< 0.05; ** is significant at P< 0.01.

In combined years, The highest RFV was calculated for 75FT+25O% (136.29), however, the 50FT+50O% (125.42) mixture was statistically in the same group as 75FT+25O% (Table 3). When pure sowings were compared, the highest RFV was calculated in pure forage turnip compared to the pure cereals. This is due to the forage turnip having a lower ratio of ADF and NDF. Generally, the RFV of the forage turnip + oat mixture was higher than other mixtures. Yılmaz et al. (2015) reported that RFV values decrease with increasing ratio of cereals in the mixtures. Similar results were obtained in the current study. The relative feed value (RFV) is the widely used index of feed quality worldwide and based on estimates of feed intake from NDF content and digestibility from ADF content. Acordingly, the RFV value for beginning quality standard is > 151, for the first quality standard is 151–125, for the second quality standard is 124–103, for the third quality standard is 102–87, for the fourth quality standard is 86–75 and for the fifth quality standard is < 75 represented the forage quality (Rohweder et al., 1978). The RFV values determined in the study ranged between fourth and first quality class of fodder.

It is estimated that ¼ of the methane gas released into the atmosphere is produced in the digestive system of ruminants (Lascano and Cardenas, 2010). Condensed tannins are inhibited some hydrogen-producing protozoans and methane-producing organisms that use hydrogen directly in the rumen, and reduce greenhouse gas emissions. (Martin et al., 2016). Besides, the condensed tannins show an anthelmintic effect, reduce animal internal parasites and increase productivity in the animals (Luscher et al., 2016). Barry (1987) indicated that plants with low tannin content have a beneficial effect as they reduce protein degradation in the rumen, while Kumar and Singh (1984) stated that high amounts of condensed tannin negatively affect protein digestion and microbial and enzyme activities. Onal Asci and Acar (2018) indicated that the feeds with low condensed tannin led to increase in protein content of milk Accordingly, the condensed tannin content of plants is required to be 2-3% or less. In the present study, the condensed tannin content ranged between 2.00-2.84% in the combined years and below the critical level (Table 3). In previous studies, the condensed tannin content of different forage crops ranged from 0.21% to 0.45% (Bal et al., 2006; Kokten et al., 2017; Yıldız et al., 2021).

There were significant (P<0.01) differences between mixture rates (P<0.01) and years (P<0.05) in terms of total phenolic and flavonoid content (Table 4). In combined years, the highest total phenolic and flavonoid contents were determined in the mixture of 25 FT+75O% (8.36 mg GAE g-1 and 5.32 mg QE g-1, respectively) (Table 4). The studies of ruminant nutrition have shown that flavonoids and phenolic compounds are very important for rumen health and animal productivity (Rochfort et al., 2008; Patra et al., 2016; Lee et al., 2017). These compounds have antioxidant and antimicrobial effects, and they have significant potential to improve animal yield and quality (O'Connell and Fox, 2001; Robbins, 2003; Santos Neto et al., 2009; Frozza et al., 2013). Besides, the positive effect of flavonoids and phenolic compounds on the productivity and health of animals as well as rumen fermentation and control of nutritional stress such as bloat and acidosis have been demonstrated in several studies (Seradj et al., 2014; Paula et al., 2016). Kuppusamy et al. (2018) reported that the total the phenolic and flavonoids content of *Lolium multiflorum* was determined as 3.90 mg GAE g^{-1} and 6.83 mg QE g^{-1}, respectively.

Table 4. Total phenolic and flavonoid contents of forage turnip + cereal mixtures

Treatments	Total phenolic content (mg GA g^{-1})			Total flavonoid content (mg QE g^{-1})		
	2019-20**	2020-21**	Mean**	2019-20**	2020-21**	Mean**
100^{FT}	6.20 bcd	6.93 b	6.56 cde	3.31 de	3.65 c	3.48 fg
100^{B}	5.25 e	3.23 d	4.24 h	2.47 f	1.14 e	1.80 i
100^{W}	5.73 cde	6.24 b	5.99 f	3.08 ef	2.44 d	2.76 h
100^{O}	5.11 e	4.74 c	4.93 g	2.47 f	2.21 d	2.34 ı
75^{FT}+25^{B}	6.44 bc	7.18 b	6.81 cd	4.73 b	5.00 b	4.86 b
75^{FT}+25^{W}	6.22 bcd	6.29 b	6.26 def	3.05 ef	4.46 b	3.76 ef
75^{FT}+25^{O}	6.33 bc	9.01 a	7.67 b	4.63 b	5.95 a	5.29 a
50^{FT}+50^{B}	6.23 bcd	6.02 b	6.12 ef	3.30 de	4.89 b	4.10 de
50^{FT}+50^{W}	5.65 cde	6.24 b	5.94 f	4.04 bcd	4.86 b	4.45 cd
50^{FT}+50^{O}	5.59 cde	7.10 b	6.35 c-f	2.78 ef	4.80 b	3.79 ef
25^{FT}+75^{B}	5.37 de	4.30 c	4.83 g	3.55 cde	3.10 c	3.33 g
25^{FT}+75^{W}	6.72 b	7.06 b	6.88 c	4.21 bc	4.88 b	4.55 bc
25^{FT}+75^{O}	7.83 a	8.90 a	8.36 a	5.48 a	5.16 b	5.32 a
Mean	***6.05 B****	***6.40 A****		***3.62 B****	***4.04 A****	

FT: Forage turnip; B: Barley; W: Wheat; O: Oat, * is significant at P <0.05; ** is significant at P <0.01.

Mineral matter content of hay including potassium (K) and phosphorus (P) were significantly (P<0.01) different among treatments and between years (Table 5). In combined years, K and P contents were ranged between 1.747-3.056% and 0.355-0.514%, respectively. K and P contents of the mixtures were higher than pure treatments. Mut et al. (2017) reported that K and P content of maize + legume mixtures were ranged between 1.79-2.33% and 0.25-0.32%, respectively. Kidambi et al. (1989) and Anonymous (1971) reported that the requirements for diary cattle are 0.8% for K, 0.20% for P. Within this respect, in this study, ratios of K and P were very high (Table 5).

Table 5. Potassium and phosphorus raito of forage turnip + cereal mixtures

Treatments	Potassium (%)			Phosphorus (%)		
	2019-20**	2020-21**	Mean**	2019-20**	2020-21**	Mean**
100^{FT}	2.230 c	2.503 d	2.366 cd	0.413 c	0.473 b	0.443 c
100^{B}	2.129 c	2.497 d	2.313 d	0.389 d	0.354 d	0.371 e
100^{W}	1.840 d	1.653 e	1.747 e	0.359 e	0.352 d	0.355 f
100^{O}	2.633 b	2.429 d	2.531 c	0.423 e	0.399 c	0.411 d
75^{FT}+25^{B}	2.556 b	3.218 abc	2.887 ab	0.471 b	0.525 a	0.498 b
75^{FT}+25^{W}	2.685 ab	2.979 bc	2.832 b	0.480 ab	0.534 a	0.507 ab
75^{FT}+25^{O}	2.551 b	3.124 abc	2.837 b	0.487 ab	0.521 a	0.504 ab
50^{FT}+50^{B}	2.633 b	3.362 a	2.997 ab	0.493 ab	0.533 a	0.513 ab
50^{FT}+50^{W}	2.870 a	3.024 abc	2.947 ab	0.476 ab	0.528 a	0.502 ab
50^{FT}+50^{O}	2.723 ab	3.228 abc	2.976 ab	0.487 ab	0.536 a	0.512 ab
25^{FT}+75^{B}	2.866 a	3.245 ab	3.056 a	0.475 ab	0.533 a	0.504 ab
25^{FT}+75^{W}	2.583 b	3.029 abc	2.806 b	0.484 ab	0.545 a	0.514 a
25^{FT}+75^{O}	2.847 a	2.890 c	2.868 ab	0.482 ab	0.536 a	0.509 ab
Mean	***2.550 B*****	***2.860 A*****		***0.455 B*****	***0.490 A*****	

FT: Forage turnip; B: Barley; W: Wheat; O: Oat; ** is significant at P <0.01.

The calcium (Ca) and magnesium (Mg) content of forage turnip + cereal mixtures were significant differences among treatments (p<0.01) and between years (p<0.05). The highest Ca (1.131%, 0.984%, and 1.057%) and Mg (0.326%, 0.308%, and 0.317%) contents were determined in pure forage turnip in both separate and combined years. Tajeda et al. (1985) indicated that forage should contain 0.30% Ca and between 0.12-0.20% Mg. In the current study, Ca and Mg values of all treatments were higher than suggested by Tajeda et al. (1985) (Table 6).

Table 6. Calcium and magnesium raito of forage turnip + cereal mixtures

Treatments	Calcium (%)			Magnesium (%)		
	2019-20**	2020-21**	Mean**	2019-20**	2020-21**	Mean**
100^{FT}	1.131 a	0.984 a	1.057 a	0.326 a	0.308 a	0.317 a
100^{B}	0.213 g	0.182 ı	0.198 g	0.154 g	0.130 f	0.142 h
100^{W}	0.282 g	0.262 hı	0.272 fg	0.157 g	0.176 e	0.167 h
100^{O}	0.344 fg	0.292 ghı	0.318 f	0.221 def	0.179 e	0.200 g
$75^{FT}+25^{B}$	0.667 bcd	0.601 cd	0.634 bc	0.251 bcd	0.242 cd	0.247 cde
$75^{FT}+25^{W}$	0.772 b	0.661 c	0.717 b	0.266 b	0.260 bcd	0.263 bc
$75^{FT}+25^{O}$	0.697 bc	0.808 b	0.753 b	0.267 b	0.290 ab	0.279 b
$50^{FT}+50^{B}$	0.480 ef	0.482 def	0.481 de	0.222 def	0.231 d	0.226 efg
$50^{FT}+50^{W}$	0.721 bc	0.636 cd	0.678 bc	0.248 b-e	0.254 bcd	0.251 b-e
$50^{FT}+50^{O}$	0.575 cde	0.595 cd	0.585 cd	0.254 bc	0.262 bcd	0.258 bcd
$25^{FT}+75^{B}$	0.489 ef	0.406 fgh	0.447 e	0.208 f	0.223 d	0.215 fg
$25^{FT}+75^{W}$	0.542 de	0.436 efg	0.489 de	0.217 ef	0.245 cd	0.231 def
$25^{FT}+75^{O}$	0.467 ef	0.561 cde	0.514 de	0.226 c-f	0.282 abc	0.254 b-e
Mean	***0.568 A****	***0.531 B****		***0.232 B****	***0.237 A****	

FT: Forage turnip; B: Barley; W: Wheat; O: Oat; * is significant at P <0.05; ** is significant at P< 0.01.

CONCLUSION

The current study showed that intercropping forage turnip with barley and oat improved the forage yield and quality compared to their monocrops. Besides, it was determined that the seed rate selection was important in intercropping in this study. Accordingly, mixtures of forage turnip with barley and oat at seed rate of 25+75% and 50+50% exhibited superior performance compared to other treatments in Bilecik ecological condition.

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