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EFFECTS OF DIFFERENT SOWING AND HARVESTING TIMES ON YIELD AND QUALITY OF FORAGE TURNIP (*Brassica rapa* L.) GROWN AS A SECOND CROP

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ABSTRACT

This research was conducted to determine the effects of different sowing and harvesting times on yield and quality of forage turnip (*Brassica rapa* L.) grown as a second crop in Isparta in 2010 and 2011 growing seasons. The field experiment was established in randomized complete block design with three replications. Three different sowing times (20 June, 5 July, 20 July) and three different harvesting times (1 October, 15 October, 30 October) were applied in this research. Root length, root diameter, root yield, leaf yield, dry matter yields, crude protein ratios, ADF and NDF ratios of root and leaf were investigated. According to the results, the effects of sowing and harvesting times were statistically significant at all components. The crude protein ratios increased with late sowing while root length, root diameter, root yield, leaf yield, dry matter yields, ADF and NDF ratios of root and leaf decreased. The root length, root diameter, root yield, leaf yield, dry matter yields, ADF and NDF ratios of root and leaf increased with late harvest while the crude protein ratios decreased.

Key Words: Forage turnip, sowing time, harvesting time, root yield, ADF, NDF

INTRODUCTION

Brassica species have been long known for their use forage crops in much of the world. Forage brassica is an annual crop which is highly productive and digestible can be grazed 80 to 150 days after seeding, depending on the species. In addition, crude protein (CP) levels are high, varying from 15 to 25 percent in the leaves and 8 to 15 percent in the roots, depending on the level of nitrogen fertilization and weather conditions. Most Brassicas are relatively low in dry matter (DM) content, but their total DM production per unit area is high relative to most cereals and forage grasses (Rao and Horn, 1986). The dry matter of 4 to 8 t ha-1 has been reported for *Brassica* ssp (Rao and Horn, 1986; Albayrak and Camas, 2005; Bookhari and Horn, 1982; Jung et al. 1986; Uzun, 1990). The CP content of forage turnip is higher in leaves than roots, but roots accumulate more NO3 than leaves (Pelletier et al., 1976).

Brassicas have high DM yield potential but actual DM yields will depend on factors such as environmental conditions, crop husbandry and management. Brassica crops require free-draining soils that are not prone to flooding, especially during establishment. Germination and seedling emergence can be restricted by cold soil temperatures and low soil moisture (Jung et al., 1983). This would suggest that crops should ideally be sown into a warm wet seedbed; however, it is likely that when seedbeds are wet, soil temperatures will be low and equally as the soil warms, the moisture content will reduce (Keogh et al., 2012).

Forage brassicas are relatively low in DM content, but their total DM production per unit area is high compared with most cereals and forage grasses (Rao and Horn, 1986). In addition, CP levels are generally high, ranging from 150 to 250 g kg^{-1} DM in the leaf and 80–150 g kg^{-1} DM in the roots (Nichol et al., 2003). The production and utilization of forage brassicas are commonly practised in America, New Zealand and Australia (Jung et al., 1986; Jacobs et al., 2001; Nichol et al., 2003; Wilson et al., 2006).

The hypothesis of this study was to evaluate the impact of sowing date and harvest date on the DM yield and nutritive quality of forage turnip agronomic and climatic conditions under Mediterranean Region of Turkey.

MATERIALS AND METHODS

The research was performed at Isparta (37º 45' N, 30º33' E, elevation 1035 m) located on the Mediterranean region of Turkey during 2010 and 2011 growing season. Forage turnip (*Brassica rapa* L.) cultivar Polybra was used in this research. Total precipitation was 213 mm in 2010 (June-October) and 128 mm in 2011. The long-term average is 94 mm. Average temperature was 18.7 ^{o}C in 2010 and 20.1 ^{o}C in 2011. The long- term average is 20.0 ^{o}C.

The major soil characteristics, based on the method described by Rowell (1996) were found to be as follows: the soil texture was clay, organic matter was 1.1% by Walkley-Black method, total salt was 0.21%, lime was 7.4% by Schiebler calcimeter, P extracted by 0.5 N NaHCO3 was 3.2 mg kg-1, exchangeable K extracted by 1 N NH4OAc was 141 mg kg-1and pH was 7.4 in soil saturation extract. Soil type was calcareous fulvisol.

Factorial arrangements of three sowing times (20 June, 5 July and 20 July) and three harvest times (1 October, 15 October and 30 October) were evaluated in a randomized complete block design with three replications. Seeding rates were 5 kg ha^{-1}. Individual plot size was 3.2 m x 5 m = 16 m^2. Nitrogen (ammonium nitrate 33%) and phosphorus (triple super phosphate 44%) were applied in sowing time in both years. Plots were irrigated through growing period. There were no problems with pests, diseases or weeds during the course of study. Ten plants from each replication were taken at harvest stage for morphological measurements. Root diameter and root length were measured in individual plants.

Two square metres (2 times 1 m^2) area was harvested in each plot. After harvest, fresh yields of roots and leaves were determined and samples were dried in oven at 70^o C to a constant weight for dry matter content (Martin et al., 1990). Dried samples were ground and the amount of N was determined by Kjehldahl method (Kacar and İnal, 2008). Crude protein content was calculated multiplying N amount of each sample by 6.25. ADF (Acid detergent fiber) and NDF (Neutral detergent fiber) concentrations were determined according to standard laboratory procedures of forage quality analysis outlined by Ankom Technology (Anonymous, 2006).

Data were analyzed using the standard analysis of variance (ANOVA) technique and means were separated using the comparisons based upon the least significant difference (LSD) using GLM producers of SAS (1998).

RESULTS

The results of ANOVA for root yield and yield components of forage turnip summarized in Table 1. The results of variance analysis showed that the effects of sowing and harvesting times doses were significant at all components.

Table 1. Results of Analysis of Variance Traits Determined.

Source of Variance	DF	Root Lenght	Root Diameter	Root Yield	Leaf Yield	Root DMY	Leaf DMY	Root CP	Leaf CP	Root ADF	Leaf ADF	Root NDF	Leaf NDF
Year (Y)	1	*	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
Block (year)	4	*	ns	ns	*	*	ns	ns	ns	ns	ns	ns	ns
Sowing Times (ST)	2	**	**	**	**	**	**	**	**	**	**	**	**
ST x Y int.	2	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
Harvesting Times	2	**	**	**	**	**	**	**	**	**	**	**	**
HT x Y int.	2	ns	*	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
ST x HT int.	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
ST x HT x Y int.	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

DF, degrees of freedom; ns, not significant. * : P < 0.05, ** : P < 0.01.

Table 2. Dry matter yield and forage quality of forage turnip measured in different sowing and harvesting times (averages of 2 years)

	Root Lenght (cm)	Root Diameter (cm)	Root Yield (t ha^{-1})	Leaf Yield (t ha^{-1})	Root DMY (t ha^{-1})	Leaf DMY (t ha^{-1})	Root CP (%)	Leaf CP (%)	Root ADF (%)	Leaf ADF (%)	Root NDF (%)	Leaf NDF (%)
Sowing Times												
20 June	13.7 a	8.3 a	74.4 a	31.6 a	10.42 a	4.47 a	10.54 c	12.55 c	10.27 a	17.47 a	12.32 a	21.14 a
5 July	11.7 b	6.6 b	65.7 b	26.1 b	8.33 b	3.34 b	11.24 b	13.33 b	9.36 b	16.11 b	11.22 b	19.56 b
20 July	10.8 c	5.9 c	54.7 c	20.9 c	5.86 c	2.31 c	12.22 a	14.31 a	8.37 c	14.82 c	10.31 c	18.05 c
Harvesting Times												
1 October	10.5 c	5.5 c	54.5 c	21.1 c	6.34 c	2.23 c	12.33 a	14.29 a	8.62 c	14.91 c	10.38 c	18.04 c
15 October	11.8 b	6.7 b	65.1 b	25.8 b	8.41 b	3.49 b	11.37 b	13.34 b	9.31 b	16.15 b	11.27 b	19.35 b
30 October	13.9 a	8.6 a	75.2 a	31.7 a	9.86 a	4.40 a	10.30 c	12.56 c	10.07 a	17.34 a	12.20 a	21.36 a
LSD	0.5	0.7	5.9	2.2	0.8	0.6	0.42	0.45	0.31	1.03	0.44	1.08

Means followed by the same letter and column are not significantly different at p:0.05 level.

The CP contents of root and leaf increased (10.54-12.22%, 12.55-14.31%, respectively) with delayed sowing time while root length, root diameter, root yield, leaf yield, root DM yield, leaf DM yield, root ADF, leaf ADF,

root NDF, leaf NDF contents decreased (13.7-10.8 cm, 8.3-5.9 cm, 74.4-54.7 t ha^{-1}, 31.6-20.9 t ha^{-1}, 10.42-5.86 t ha^{-1}, 4.47-2.31 t ha^{-1}, 10.27-8.37%, 17.47-14.82%, 12.32-10.31%, 21.14-18.05%, respectively) (Table 2).

The effects of harvesting stages were significant for all components in two year averages. CP contents of root and leaf decreased (12.33-10.30%, 14.29-12.56%, respectively) with advancing growth while root length, root diameter, root yield, leaf yield, root DM yield, leaf DM yield, root ADF, leaf ADF, root NDF, leaf NDF contents increased (10.5-13.9 cm, 5.5-8.6 cm, 54.5-75.2 t ha^{-1}, 21.1-31.7 t ha^{-1}, 6.34-9.86 t ha^{-1}, 2.23-4.40 t ha^{-1}, 8.62-10.07%, 14.91-17.34%, 10.38-12.20%, 18.04-21.36%, respectively) (Table 2).

DISCUSSION

Root length and diameter

The effects of sowing and harvesting times were significant for length and diameter of root. The delayed sowing time caused an decrease in root length and diameter. The highest root length and diameters were obtained from first sowing time (20 June) (Table 2). Parlak and Sevimay (2005) reported that root length and diameter of forage turnip decreased with delayed sowing time. This result is consistent with the present results.

The root length and diameter increased with delaying harvesting time. The highest root length (13.9 cm) and diameter (8.6 cm) were obtained from third harvest time (30 October). These results are consistent with the results of Albayrak and Yuksel (2010).

Root and Leaf Yield

The effects of sowing and harvesting times on root yield were significant. The highest root yield was obtained from first sowing time with 74.4 t ha^{-1}. Root yield of forage turnip decreased with delayed sowing time. These results are consistent with the results of Smart et al. (2004), Parlak and Sevimay (2005) and Keogh et al. (2012). Root yield increased with advancing stages in the present study. Root yield increased 38% from 1 October to 30 October in this research. An enhanced root yield with advancing maturity is consistent with results of several researchers (Mulayim et al., 1996; Albayrak and Yuksel, 2010).

The effects of sowing and harvesting times on leaf yield were significant. Leaf yield of forage turnip decreased with delayed sowing time, the highest leaf yield (31.6 t ha^{-1}) was obtained from first sowing time while the lowest leaf yield (20.9 t ha^{-1}) was obtained from third sowing time. These results are consistent with the results of Smart et al. (2004), Parlak and Sevimay (2005) and Keogh et al. (2012). Leaf yield increased with advancing stages in the present study. Root yield increased 50% from 1 October to 30 October in this research. Albayrak and Yuksel (2010) reported that leaf yield of fodder beet increased with delaying harvest time. Turk et al. (2009) reported that leaf yield of forage turnip changed from 17.6 to 36.8 t ha^{-1}. These results are consistent with the present results.

Root and Leaf DM yield

The root DM yield exhibited a similar trend to root yield. The highest root DM yield was obtained from first sowing time while the lowest root DM yield was obtained from third sowing time. Parlak and Sevimay (2005) and Keogh et al. (2012) found that root DM yield decreased delaying sowing time in forage turnip. These results are consistent with the present results. Root DM yield increased 55.5% from 1 October to 30 October in this research. Keogh et al. (2012) and Albayrak and Yuksel (2010) reported that root DM yield increased with delaying harvest time.

The leaf DM yield exhibited a similar trend to leaf yield. Early sowing (20 June) gave the highest leaf DM yields with 4.47 t ha^{-1}. Keogh et al. (2012) found that leaf DM yield decreased delaying sowing time in forage turnip. This result is consistent with the present results. The lowest leaf DM yield was obtained from first harvest time while the highest leaf DM yield was obtained from third sowing time. Turk et al. (2009) reported that leaf DM yield of forage turnip changed from 2.2 to 4.6 t ha^{-1}.

Root and Leaf CP Contents

The effects of sowing and harvesting times on CP contents of forage turnip were significant. The lowest root CP content (10.54%) was obtained from first sowing time while the highest root CP content (12.22%) was obtained from third sowing times. Turk et al. (2009) reported that CP content in root of forage turnip changed from 10.08 to 12.34%. Nichol et al. (2003) found that CP content in root of forage turnip changed from 8 to 15%. These CP contents are consistent with the present results. CP contents of root decreased from 12.33 to 10.30% with advancing stages in the present study. Maturity stage at harvest is the most important factor determining forage quality. Smart et al. (2004) reported that CP content in root of forage turnip decreased with delaying harvest time. Besides N, and hence protein, most minerals also decline with advancing plant development (Rauzi et al., 1969).

The leaf CP content exhibited a similar trend to root CP content. The lowest leaf CP content (12.55%) was obtained from first sowing time while the highest leaf CP content (14.31%) was obtained from third sowing times. Turk et al. (2009) reported that CP content in leaf of forage turnip changed from 13 to 16%. These CP contents are consistent with the present results. CP contents of leaf decreased from 14.29 to 12.56% with advancing stages in the present study. Smart et al. (2004) reported that leaf CP content was 15.4% in 15 October, but it decreased to 12.8% in 1 November. This result is consistent with our results.

Root and Leaf ADF Contents

The effects of sowing and harvesting times on ADF contents of forage turnip were significant. The highest root ADF content (10.27%) was obtained from first

sowing time while the lowest root ADF content (8.37%) was obtained from third sowing times. ADF contents of root increased from 8.62 to 10.07% with advancing stages in the present study. These results are consistent with the results of Guillard and Allinson (1988), Smart et al. (2004), Turk et al. (2009) and Albayrak and Yuksel (2010).

The lowest leaf ADF content (14.82%) was obtained from third sowing time while the highest leaf ADF content (17.47%) was obtained from first sowing times. ADF contents of leaf increased from 12.55 to 14.31% with advancing stages in the present study. An enhanced ADF content with advancing maturity is consistent with results of Smart et al. 2004. Turk et al. (2009) reported that ADF content in leaf of forage turnip changed from 14.5-19.7%. These values are consistent with the present results.

Root and Leaf NDF Contents

The effects of sowing and harvesting times on NDF contents of forage turnip were significant. The highest root NDF content (12.32%) was obtained from first sowing time while the lowest root NDF content (10.31%) was obtained from third sowing times. NDF contents of root increased from 10.38 to 12.20% with advancing stages in the present study. These results are consistent with the results of Guillard and Allinson (1988), Turk et al. (2009) and Albayrak and Yuksel (2010).

The leaf NDF content exhibited a similar trend to root NDF content. The lowest leaf NDF content (18.05%) was obtained from third sowing time while the highest leaf NDF content (21.14%) was obtained from first sowing times. NDF contents of leaf increased from 18.04 to 21.36% with advancing stages in the present study. Smart et al. (2004) reported that leaf NDF content increased with delaying harvest time. Turk et al. (2009) reported that NDF content in leaf of forage turnip changed from 17.2-23.5%. These values are consistent with the present results.

CONCLUSIONS

The results from the different sowing and harvesting times applied in forage turnip in Mediterranean conditions of Turkey can be summarised as follows:

(1) Forage yield and quality changed with harvesting times. Delaying harvest resulted in decreased forage quality and increased yield.

(2) The highest root length, root diameter, root yield, leaf yield, dry matter yields, ADF and NDF ratios of root and leaf were obtained from first sowing time (20 June) and third harvesting time (30 October).

(3) The highest CP ratios of root and leaf were obtained from third time (20 July) and first harvesting time (1 October).

(4) At the end of the two year research conducted in Mediterranean conditions of Turkey, sowing at the end of the July and harvesting at end of the October are recommended for high yield in forage turnip.

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