Bulgarian Journal of Agricultural Science, 16 (No 2) 2010, 212-219
Agricultural Academy

EFFECTS OF FERTILIZATION ON ROOT YIELD AND QUALITY OF FODDER BEET (*BETA VULGARIS* VAR. *CRASSA* MANSF.)

M. TURK
Suleyman Demirel University, Faculty of Agriculture, Department of Field Crops, Isparta, Turkey

Abstract

TURK, M., 2010. Effects of fertilization on root yield and quality of fodder beet (*Beta vulgaris* var. *crassa* Mansf.). *Bulg. J. Agric. Sci.,* 16: 212-219

This research was conducted to determine the effects of twenty four different fertilizer combinations included four different nitrogen doses (0, 75, 150 and 225 kg N ha^{-1}), two phosphorus doses (0 and 50 kg P_2O_5 ha^{-1}) and three potassium doses (0, 50 and 100 kg K_2O ha^{-1}) on root yield and yield components of fodder beet (*Beta vulgaris* var. *crassa* Mansf.) under Isparta conditions in the 2007 and 2008 growing seasons. It was determined that the effect of fertilization were significant all parameters except root dry matter content. Fertilizer applications increased root yield, dry matter yield, crude protein content, crude protein yield, root diameter and root length but decreased ADF and NDF contents of roots. The highest root yield and crude protein yields were obtained from 225 kg ha^{-1} N + 50 kg ha^{-1} P treatments.

Key words: fodder beet, root yield, yield components, neutral detergent fiber, acid detergent fiber

Introduction

Fodder beet offers a higher yield potential than any other "arable" fodder crop. The roots have an excellent feed quality and they are very palatable to ruminant stock. The leaf can be utilized if required to boost the total fodder output even further. Fodder beet when grown under suitable conditions, can produce almost 20 t ha^{-1} dry matter yield compared with 13±15 t DM/ha^{-1} from four harvests of grass. Approximately 75% of fodder beet dry matter is in the root component (DAF, 1998). Including fodder beet in diet of cattle increases intake of dry matter that is quantitative and qualitative factors affecting intake of the basal diet.

Fodder beet is successively grown as a fodder crop in the many European countries. The plant is used as a valuable source of fodder for cattle (Niazi et al., 2000; Slavova et al., 2004). Since fodder beet contains more water and sugar, it increases milk product and being suitable forage for dairy cows. The fodder beet is used by being chopped and by mixing with straw in European countries. It is also reported that the plant is suitable to make silage (Akyildiz, 1983 and Ozen et al., 1993).

Fodder beets have extremely high yield potential when grown on high fertility soils. The fodder beets require large amounts of nitrogen (Albayrak and Camas, 2007). Nitrogen fertilizers are one of the major costs for production of these crops (Abdel-Gwad et al., 2008 and Sarhan and Ismail, 2003). Zamfir et al. (2001) and Zaki (1999) reported that increasing nitrogen fertilization increased dry matter yield and crude

e-mail: mturk72@ziraat.sdu.edu.tr

protein content of fodder beet.

Previous studies with fodder beet indicated that the nitrogen rates influenced root yield and yield components (Prokopenko et al., 1997; Geweifel and Aly, 1996; Karzcmarczyk et al., 1995). Abd-El-Gwad et al. (1997) reported that dry matter yield and crude protein content of roots generally increased with increasing fertilizer rate for all fertilizers, while fiber concentration decreased.

The aim of the present study was to investigate the effects of fertilization rates on root yield and yield components of fodder beet. Our results were expected to be useful for assessing the optimal fertilizer rate for the best root yield and quality of fodder beet, especially in the Mediterranean region of Turkey.

Material and Methods

This study was conducted at Isparta (37є 45' N, 30є 33' E, elevation 1035 m) located on the Mediterranean region of Turkey during 2007 and 2008 growing season. 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 1.2% by Walkley-Black method; total salt was 0.3%; lime was 7% by Schiebler calcimeter, extractable P by 0.5N $NaHCO_3$ extraction was 3.1 mg kg^{-1}; exchangeable K by 1N NH_4OAc was 125 mg kg^{-1}; pH was 8.1 in soil saturation extract. Soil type was calcareous fulvisol. Climatic data for the research area are given in Table 1.

Fodder beet (*Beta vulgaris* var. *crassa* Mansf.) cultivar Ecdogelb was obtained from Ankara University, Faculty of Agriculture.

The experiment was established in a randomized complete block design with three replicates. Twenty four different fertilizer combinations included four different nitrogen doses (0, 75, 150 and 225 kg N ha^{-1}), two phosphorus doses (0 and 50 kg P_2O_5 ha^{-1}) and three potassium doses (0, 50 and 100 kg K_2O ha^{-1}) were used in the present research.

Fertilizer applications were randomly assigned to 24 plots within each of 3 blocks. Seeding rates were 30 kg ha^{-1}. Individual plot size was 3 x 5 m = 15 m^2. Sowing was done by hand on 24 and 27 March in 2007 and 2008, respectively. Nitrogen was applied as ammonium nitrate (33%), phosphorus was applied as triple super phosphate (46%) and potassium was applied as potassium sulphate (52%). Half of the N and all of P and K were applied in sowing time, the rest of the nitrogen fertilizer were applied after first hoeing on all plots in both years. Plots were irrigated four times and three times through growing period in 2007 and 2008, respectively. There were no problems with pests, diseases or weeds during the course of study. 10 plants from each replication were taken

Table 1
Growing season total precipitation and mean temperature in the experimental area

Months	Total rainfall, mm			Mean temperature, °C		
	Long-term	2007	2008	Long-term	2007	2008
March	61.9	33.8	51.4	5.8	7.1	8.4
April	51	14.8	49.2	10.7	9.5	11.5
May	59.7	13.4	24.6	15.4	17.5	14.4
June	36	16.6	4.8	19.7	21.6	20.9
July	11.9	1.5	1.6	23.1	25.1	23.6
August	10.4	10.6	19.4	22.8	24.3	24.6
September	19.2	1.6	21.2	18.4	18.3	18.9
October	40.4	25	56.5	13.1	14.4	13.1
Total	290.5	117.3	228.7	-	-	-
Mean	-	-	-	16.1	17.2	16.9

at harvest stage for morphological measurements. Root diameter and root length were measured in individual plants. Plots were harvested on 1 October and 3 October in 2007 and 2008, respectively.

Two square meters (2 times 1 m^2) area were harvested in each plot (Albayrak and Camas, 2006). After harvest, fresh yields of roots were determined and samples were dried in ovens at 70^{o}C to a constant weight for dry matter content (Martin et al., 1990). Dried samples were grounded and the amount of N was found by using Kijeldahl method (Kacar and Inal, 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 http://www.ankom.com/00_products/product_a2000.shtml; verified 10 September 2008).

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 and Discussion

The results of ANOVA for root yield and yield components of fodder beet summarized in Table 2. The results of variance analysis showed that the effect of fertilization were significant. Years were shown separately, because differences of years were significant all parameters except root dry matter content and root diameter.

Root yield: The application of fertilization had a significant effect on root yield, especially N and P fertilization increased root yield. Both first and second year, the highest root yields were obtained from

Table 2
Results of analysis of variance of the traits determined

Source of variance	df	Root yield	Root DM content	Root DM yield	CP content	CP yield	NDF	ADF	Root length	Root diameter
2007										
Block (b)	2*	**	*	*	*	**	**	**	*	*
Fertilization (F)	23*	***	ns	***	***	***	***	***	***	***
Error	46									
CV, %		12.39	7.34	14.79	12.55	25.47	7.7	7.5	12.39	12.38
2008										
Block (b)	2	ns	ns	ns	ns	ns	ns	ns	ns	ns
Fertilization (F)	23	***	ns	***	***	***	***	***	***	***
Error	46									
CV, %		12.55	3.05	13.03	12.54	24.29	7.49	7.49	12.56	12.55
Average of two years										
Year (Y)	1	***	ns	***	***	***	***	***	*	ns
Block (year)	4	**	*	**	**	**	*	*	ns	ns
Fertilization (F)	23	***	ns	***	***	***	***	***	***	***
Y x F	23	ns	ns	ns	ns	ns	ns	ns	ns	ns
Error	92									
CV, %		12.56	5.6	14.02	12.87	25.32	8.19	8.09	12.52	12.54

df, degrees of freedom; CV, coefficient of variation; ns, not significant. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Table 3
Root yield, dry matter content, dry matter yield, crude protein content and yield of fodder beet in different fertilizer applications

N	P	K	Root yield, t ha^{-1}			DM content, %			DM yield, t ha^{-1}			Crude protein, %			CP yield, t ha^{-1}		
			2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	0	0	65.74 j	68.12 h	66.93 j	12.15	11.77	11.96	7.99 h	8.02 h	8.00 k	8.32 j	8.83 j	8.58 j	0.66 i	0.71 j	0.69 h
0	0	50	66.10 j	68.63 h	67.37 j	11.87	12.27	12.07	7.85 h	8.42 h	8.13 jk	8.36 j	8.88 j	8.62 j	0.66 i	0.75 j	0.70 h
0	0	100	66.79 j	69.34 h	68.07 j	11.94	11.79	11.86	7.97 h	8.18 h	8.08 jk	8.45 j	8.97 j	8.71 j	0.67 i	0.74 j	0.71 h
0	50	0	71.40 i	74.10 g	72.75 i	12.05	12.1	12.08	8.61 gh	8.97 gh	8.79 i-k	9.04 i	9.59 i	9.32 i	0.78 hi	0.86 ij	0.82 g
0	50	50	72.71 i	75.14 g	73.93 i	12.19	11.01	11.6	8.86 fg	8.28 h	8.57 i-k	9.20 i	9.77 i	9.49 i	0.82 h	0.81 ij	0.82 g
0	50	100	71.96 i	74.71 g	73.33 i	11.95	12.15	12.05	8.60 gh	9.08 gh	8.84 ij	9.11 i	9.67 i	9.39 i	0.78 hi	0.88 ij	0.83 g
70	0	0	80.46 h	83.54 f	82.00 h	11.98	12.1	12.04	9.64 ef	10.11 e-g	9.87 f-h	10.18 h	10.81 h	10.50 h	0.98 g	1.09 gh	1.04 f
70	0	50	79.71 h	82.70 f	81.20 h	11.89	11.18	11.53	9.47 f	9.23 f-h	9.35 hi	10.09 h	10.71 h	10.40 h	0.96 g	0.99 hi	0.97 f
70	0	100	80.59 h	83.68 f	82.13 h	11.63	12.09	11.86	9.38 fg	10.15 d-g	9.77 gh	10.20 h	10.83 h	10.51 h	0.96 g	1.11 f-h	1.03 f
70	50	0	88.03 e-g	91.40 c-e	89.72 g	12.15	11.64	11.89	10.73 b-d	10.55 c-f	10.64 d-f	11.14 e-g	11.83 e-g	11.48 g	1.21 d-f	1.25 e-g	1.23 de
70	50	50	88.32 e-g	91.71 c-e	90.01 fg	11.87	11.96	11.92	10.49 cd	10.97 a-e	10.73 c-e	11.18 e-g	11.87 e-g	11.52 fg	1.17 f	1.30 c-e	1.24 de
150	50	100	87.00 fg	90.33 e	88.67 g	11.86	12.1	11.98	10.34 de	10.92 b-e	10.63 d-f	11.01 fg	11.69 f-g	11.35 g	1.14 f	1.28 d-f	1.21 e
150	0	0	86.74 g	90.06 e	88.40 g	11.93	11.88	11.9	10.35 de	10.69 c-e	10.52 e-g	10.98 g	11.65 g	11.32 g	1.13 f	1.24 e-g	1.19 e
150	0	50	87.37 e-g	90.71 de	89.04 g	12.04	11.64	11.84	10.51 cd	10.57 c-f	10.54 e-g	11.05 e-g	11.74 e-g	11.40 g	1.16 f	1.24 e-g	1.20 e
150	0	100	89.41 d-g	92.84 c-e	91.13 e-g	11.86	11.88	11.87	10.61 b-d	11.02 a-e	10.81 c-e	11.31 d-g	12.01 d-g	11.66 e-g	1.20 ef	1.32 c-e	1.26 de
150	50	0	93.45 b-d	97.03 ab	95.24 b-d	12.09	12.01	12.05	11.30 a-c	11.65 a-c	11.48 a-c	11.83 a-d	12.56 a-d	12.19 b-d	1.34 a-d	1.46 a-d	1.40 bc
150	50	50	93.97 a-c	97.56 ab	95.77 bc	11.65	12.6	12.13	10.95 a-d	12.29 ab	11.62 ab	11.89 a-c	12.63 a-c	12.26 bc	1.31 a-e	1.55 ab	1.43 b
225	50	100	94.24 a-c	97.84 ab	96.04 ab	11.99	11.98	11.98	11.30 a-c	11.72 a-c	11.51 a-c	11.92 a-c	12.66 a-c	12.29 b	1.35 a-c	1.48 a-c	1.42 bc
225	0	0	91.00 c-f	94.49 b-d	92.75 d-f	12.01	12.01	12.01	10.93 a-d	11.34 a-e	11.13 b-e	11.51 c-f	12.23 c-f	11.87 d-f	1.26 b-f	1.39 b-e	1.32 cd
225	0	50	91.30 b-e	94.79 bc	93.05 c-e	11.63	12.17	11.9	10.62 b-d	11.54 a-d	11.08 b-e	11.55 b-e	12.27 b-e	11.91 c-e	1.23 c-f	1.42 b-e	1.32 cd
225	0	100	91.30 b-e	94.80 bc	93.05 c-e	11.9	11.35	11.62	10.88 a-d	10.73 c-e	10.81 c-e	11.55 b-e	12.27 b-e	11.91 c-e	1.26 b-f	1.32 c-e	1.29 de
225	50	0	97.58 a	99.66 a	98.62 a	11.96	12.4	12.18	11.66 a	12.38 a	12.02 a	12.35 a	13.11 a	12.73 a	1.44 a	1.63 a	1.54 a
225	50	50	95.30 ab	100.16 a	97.73 ab	11.96	11.81	11.88	11.40 ab	11.83 a-c	11.62 ab	12.06 ab	12.81 ab	12.43 ab	1.38 ab	1.52 ab	1.45 ab
225	50	100	94.20 a-c	97.80 ab	96.00 ab	12.07	11.67	11.87	11.37 ab	11.44 a-e	11.41 a-d	11.92 a-c	12.66 a-c	12,29 b	1.35 a-c	1.45 a-d	1.40 bc
			84.36 b	87.55 a		11.94	11.9		10.08 b	10.42 a		10.68 b	11.34 a		1.09 b	1.20 a	

$N_{225}P_{50}K_0$, $N_{225}P_{50}K_{50}$, $N_{225}P_{50}K_{100}$, $N_{150}P_{50}K_{50}$ and $N_{150}P_{50}K_{100}$ applications. When data combined for two years, root yield significantly increased depending on the N and P doses used. The highest root yields (98.62, 97.73 and 96.00 t ha^{-1}) were obtained from 225 $kgha^{-1}$ N + 50 $kgha^{-1}$ P treatments.

Grzes et al. (1996), Prokopenko et al. (1997), Ceglarek and Gasiorowska (1997), Zaki (1999) and Abdel-Gwad et al. (2008) reported that fertilization increased average root yield of fodder beet. These results are consistent with the present results.

The root yield at the first year of experiment was 84.36 t ha^{-1} and then it increased to 87.55 t ha^{-1} at the second year. This could be explained that total rainfall in second year was more than first year.

Root dry matter contents and yield: Fertilization applications no effect DM content of fodder beet in 2007, 2008 and averages of two years. DM content of fodder beet changed from 11.53% to 12.18% (Table 3).

Bieniaszewski et al. (1995) reported that root DM content was not affected by N and K rates. This result is consistent with the present results. It was previously reported that rates of dry matter in fodder beet might change from 11.82 % to 18.60 % (Rzekanowski, 1994; Lukic and Vasilijevic, 1996). Prokopenko et al. (1997) found that dry matter content of the fodder beet increased directly with the level of fertilization.

The root DM yield exhibited a similar trend to root yield. DM yield increased depending on the N and P doses while control plots had the lowest DM yields in both years and averages of two years. $N_{150}P_{50}$ and $N_{225}P_{50}$ treatments gave the highest root DM yields.

Bieniaszewski et al. (1995) reported that root dry matter yields increased from 8.36 to 9.68 t ha^{-1} with increasing nitrogen rates. Lukic and Vasiljevic (1996) found that root yield of fooder beet was 11.3 t ha^{-1}. Grzes et al. (1996) found that average dry matter yields were highest with 160 kg ha^{-1} nitrogen fertilization. Sarhan and Ismail (2003) reported that root dry matter yield and crude protein yield of fodder beet was significantly increased by increasing nitrogen fertilizer level. These results are consistent with the present results.

The root DM yield was 10.08 t ha^{-1} at the first year and it was 10.42 t ha^{-1} at the second year of experiment.

Root crude protein contents and yields: Both first and second year, the highest root crude protein contents and yields were obtained from $N_{225}P_{50}K_0$, $N_{225}P_{50}K_{50}$, $N_{225}P_{50}K_{100}$, $N_{150}P_{50}K_0$, $N_{150}P_{50}K_{50}$ and $N_{150}P_{50}K_{100}$ applications (Table 3). According to averages of two years, $N_{225}P_{50}K_0$ and $N_{225}P_{50}K_{50}$ applications gave the highest root crude protein contents (12.73 and 12.43%) and yields (1.54 and 1.45 t ha^{-1}). The lowest values were obtained from control plot, $N_0P_0K_{50}$ and $N_0P_0K_{100}$ treatments in both years and averages of two years. The increase N and P doses caused increase in CP yields in present study, because CP yield depends on DM yields in plots.

Abdel-Gwad et al. (1997) and Abdel-Gwad et al. (2008) reported crude protein content of fodder beet was significantly increased by increasing nitrogen fertilizer level. Geweifel and Aly (1996) reported that root CP yield of fodder beet increased directly with the level of fertilization. Karczmarczyk et al. (1995) reported that root crude protein content and crude protein yield of fodder beet increased with increasing nitrogen rate. Similarly, Prokopenko et al. (1997) indicated that crude protein yield of the fodder beet increased directly with the level of fertilization. Zaki (1999), Turk et al. (2009), Albayrak and Camas (2005) found that root dry matter yield and crude protein yield of fodder beet was significantly increased by increasing nitrogen fertilizer level. These results are consistent with the present results.

The effects of years on root CP contents and yields were significant. The CP contents of root increased from 10.68% to 11.34%, CP yields increased from 1.09 t ha^{-1} to 1.20 t ha^{-1} during years.

Root ADF and NDF contents: ADF and NDF contents of fodder beet roots were significantly decreased by increasing fertilizer level in 2007, 2008 and averages of two years. According to averages of two years, the control plot, N0P0K50 and N0P0K100 treatments had the highest ADF contents (14.52, 14.53 and 14.41%, respectively) and NDF

Table 4
NDF, ADF contents, root diameter and root length of fodder beet in different fertilizer applications

N	P	K	NDF			ADF			Root diameter, cm			Root length, cm		
			2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	0	0	20.73 a	19.49 a	20.11 a	14.96 a	14.07 a	14.52 a	9.39 j	9.67 h	9.53 j	10.56 j	10.87 h	10.72 j
0	0	50	20.60 ab	19.69 a	20.15 a	14.87 ab	13.98 ab	14.53 a	9.44 j	9.75 h	9.60 j	10.62 j	10.96 h	10.79 j
0	0	100	20.57 ab	19.34 ab	19.96 ab	14.85 ab	13.96 ab	14.41 ab	9.54 j	9.85 h	9.69 j	10.73 j	11.07 h	10.90 j
0	50	0	20.32 bc	19.10 bc	19.71 bc	14.67 bc	13.79 bc	14.23 bc	10.20 i	10.52 g	10.36 i	11.47 i	11.83 g	11.65 i
0	50	50	19.91 b-d	18.71 b-d	19.31 bc	14.38 b-d	13.51 b-d	13.94 c	10.39 i	10.67 g	10.53 i	11.68 i	11.99 g	11.84 i
0	50	100	19.74 cd	18.56 cd	19.15 c	14.26 cd	13.40 cd	13.83 c	10.28 i	10.61 g	10.45 i	11.56 i	11.93 g	11.74 i
70	0	0	19.54 d	18.36 d	18.95 c	14.11 d	13.26 d	13.69 c	11.50 h	11.86 f	11.68 h	12.92 h	13.34 f	13.13 h
70	0	50	19.52 d	18.34 d	18.93 c	14.09 d	13.24 d	13.67 c	11.39 h	11.74 f	11.57 h	12.81 h	13.20 f	13.00 h
70	0	100	19.45 de	18.28 de	18.87 c	14.04 de	13.20 de	13.62 c	11.52 h	11.88 f	11.70 h	12.94 h	13.36 f	13.15 h
70	50	0	18.72 ef	17.60 ef	18.16 d	13.52 ef	12.71 ef	13.11 d	12.58 e-g	12.98 c-e	12.78 g	14.14 e-g	14.59 c-e	14.37 g
70	50	50	18.68 fg	17.56 fg	18.12 d	13.49 fg	12.67 fg	13.08 d	12.62 e-g	13.02 c-e	12.82 fg	14.19 e-g	14.64 c-e	14.41 fg
150	50	100	18.70 f	17.57 e-g	18.14 d	13.50 e-g	12.69 f	13.09 d	12.43 fg	12.83 e	12.63 g	13.97 fg	14.42 e	14.20 g
150	0	0	18.16 f-h	17.06 f-h	17.61 e	13.11 f-h	12.32 f-h	12.71 e	12.39 g	12.79 e	12.59 g	13.93 g	14.37 e	14.15 g
150	0	50	17.67 h-j	16.61 h-j	17.14 e-g	12.75 h-j	11.99 h-j	12.37 e-g	12.49 e-g	12.88 de	12.68 g	14.03 e-g	14.48 de	14.26 g
150	0	100	17..95 g-i	16.87 g-i	17.41 ef	12.96 g-i	12.18 g-i	12.57 ef	12.78 d-g	13.18 c-e	12.98 e-g	14.36 d-g	14.82 c-e	14.59 e-g
150	50	0	17.60 h-j	16.54 h-j	17.07 fg	12.71 h-j	11.94 h-j	12.33 fg	13.35 b-d	13.78 ab	13.57 b-d	15.01 a-d	15.49 ab	15.25 b-d
150	50	50	17.60 h-j	16.54 h-j	17.07 fg	12.70 h-j	11.94 h-j	12.32 f-h	13.43 a-c	13.85 ab	13.64 bc	15.09 a-c	15.57 ab	15.33 bc
225	50	100	17.59 h-j	16.53 h-j	17.06 f-h	12.70 h-j	11.93 h-j	12.32 f-h	13.47 a-c	13.89 ab	13.68 ab	15.13 a-c	15.62 ab	15.38 ab
225	0	0	17.61 h-j	16.55 h-j	17.08 fg	12.72 h-j	11.95 h-j	12.36 fg	13.00 c-f	13.42 b-d	13.21 d-f	14.62 c-f	15.08 b-d	14.85 d-f
225	0	50	17.71 h-j	16.65 h-j	17.18 e-g	12.79 h-j	12.02 h-j	12.40 e-g	13.05 b-e	13.46 bc	13.26 c-e	14.66 b-e	15.13 bc	14.90 c-e
225	0	100	17.37 ij	16.32 i-k	16.85 gh	12.54 i-k	11.79 ij	12.16 g-i	13.05 b-e	13.46 bc	13.26 c-e	14.67 b-e	15.13 bc	14.90 c-e
225	50	0	17.07 jk	16.06 j-l	16.56 hi	12.33 jk	11.58 jk	11.96 h-j	13.94 a	14.15 a	14.05 a	15.67 a	15.91 a	15.79 a
225	50	50	17.06 jk	15.54 l	16.30 i	12.32 jk	11.58 jk	11.95 ij	13.62 ab	14.22 a	13.92 ab	15.31 ab	15.99 a	15.65 ab
225	50	100	16.62 k	15.62 kl	16.12 i	12.00 k	11.28 k	11.64 j	13.46 a-c	13.89 ab	13.67 ab	15.13 a-c	15.61 ab	15.37 ab
			18.60 a	17.48 b		13.43 a	12.62 b		12.06	12.43		13.55 b	13.98 a	

contents (20.11, 20.15 and 19.96%, respectively). The lowest ADF and NDF contents were obtained from $N_{225}P_{50}K_0$, $N_{225}P_{50}K_{50}$ and $N_{225}P_{50}K_{100}$ treatments in both years and averages of two years (Table 4).

Abdel-Gwad et al. (2008) reported crude protein content of fodder beet was significantly increased by increasing nitrogen fertilizer level, while crude fibers take an opposite trend. Avarvarei (1999) demonstrated that the fodder beet was given 100, 150 and 200 kg ha^{-1} nitrogen fertilizer. Researcher also reported that fertilizer application increased organic matter digestibility, except for that of cellulose. Abdel-Gwad et al. (1997) found that fresh and dry matter yield and crude protein and total carbohydrate concentration of roots generally increased with increasing fertilizer rate for all fertilizers, while fibre concentration decreased. Geweifel and Aly (1996) reported that fertilizer was decreased crude fiber content of roots. These results are consistent with the present results.

Root ADF and NDF contents were 13.43 and 18.60% in 2007, 12.62 and 17.48% in 2008 (Table 4). They were decreased in second year. This could be explained by increasing CP content in 2008.

Root length and diameter: The increase in fertilizer doses caused an increase in root length and diameter. The highest root length and diameters were obtained from $N_{225}P_{50}$ and $N_{150}P_{50}$ treatments both first and second year (Table 4). According to averages of two years, $N_{150}P_{50}K_{100}$, $N_{225}P_{50}K_0$, $N_{225}P_{50}K_{50}$ and $N_{225}P_{50}K_{100}$ treatments had the highest root length (15.38, 15.79, 15.65 and 15.37 cm, respectively) and root diameter (13.68, 14.05, 13.92 and 13.67 cm, respectively).

It was previously reported that root length and diameter in fodder beet ranged from 7.50 to 12.99 cm and 13.51 to 24.70 cm, respectively (Albayrak and Camas, 2005; Albayrak and Camas, 2006, Parlak and Ekiz, 2008; Albayrak et al., 2004). Present results similar to those researchers' findings.

The effects of years on root length were significant. The root length increased from 13.55 cm (2007) to 13.98 cm (2008).

Conclusion

The results of this study showed that fertilization application increased root yield, root dry matter yield, crude protein content and yields, root length, and diameter, while it decreased ADF and NDF content. The highest root yield and crude protein yields were obtained from 225 kg ha^{-1} N + 50 kg ha^{-1} P treatments.

References

Abdel-Gawad, A. A., H. M. Abdel-Aziz, M. S. Reiad and S. T. Ahmed, 1997. Effect of nitrogen, potassium and organic manure on yield and chemical composition of fodder beet (*Beta vulgaris*, L.). ***Annals of Agricultural Science*** **(Cairo). 42 (2): 377-397.**

Abdel-Gwad, M. S. A., T. K. A. El-Aziz and M. A. A El-Galil, 2008. Effect of intercropping wheat with fodder beet under different levels of N-application on yield and quality. ***Annals of Agricultural Science*** **(Cairo). 53 (2): 353-362.**

Akyildiz A. R., 1983. Yemler Bilgisi ve Teknolojisi. Ankara Univ . Ziraat Fak. No: 868.

Albayrak, S. and N. Зamas, 2005. Effects of different levels and application times of humic acid on root and leaf yield and yield components of forage turnip (*Brassica rapa* L.). *Journal of Agronomy*. **4** (2): 130-133.

Albayrak, S. and N. Зamas, 2005. Influence of row spacing on root yield and yield components of fodder beet (*Beta vulgaris* var. *crassa* Mansf.) in the Black Sea Coastal Region. *Tarэm Bilimleri Dergisi*. **11** (2): 160-164.

Albayrak, S. and N. Camas, 2007. Effects of Temperature and Light Intensity on Growth of Fodder Beet (*Beta vulgaris* var. crassa Mansf.). *Bangladesh J. Bot*., **36** (1): 1-12.

Albayrak, S. and N. Camaє, 2006. Yield components of fodder beet (*Beta vulgaris* var. *crassa* Mansf.) under the Middle Black Sea region conditions. *Tarэm Bilimleri Dergisi,* **12** (1): 65-69.

Albayrak, S., N. Camas and C. S. Sevimay, 2004. The Influence of row spacing on root and leaf yields and yield components of forage turnip (*Brassica rapa* L.). *Turk-*

ish Journal of Field Crops, **9** (2): 72-77.

Avarvarei, T., 1999. Effect of mineral and organic fertilization on the digestibility of fodder beet. *Cercetari Agronomice in Moldova,* **32** (3/4): 31-34.

Bieniaszewski, T., G. Fordonski and Z. Klupczynski, 1995. Effects of nitrogen and potassium fertilizer application on yield and feeding value of fodder beet cultivars. ***Acta*** *Academiae Agriculturae ac Technicae Olstenensis, Agricultura,* **60:** 73-84.

Ceglarek, F. and B. Gasiorowska, 1997. Response of fodder beet to irrigation and differential NPK fertilization. *Biul.Instytutu Hodowli i Aklimatyzacji Roslin.*, **202:** 185-191.

DAF (Department of Agriculture and Food), 1998. Root, fodder crop, pulse and oilseed varieties. Irish recommended list. Government Stationary Office, Dublin, 17 pp.

Geweifel, H. G. M. and R. M. Aly, 1996. Effect of nitrogen and potassium fertilization treatments on growth, yield and quality of some fodder beet varieties. *Annals of Agricultural Science, Moshtohor,* **34** (2): 441-454.

Grzes, S., S. Sobiech, T. Maciejewski and J. Szukula, 1996. Yield od fodder beet as influenced by sprinkler irrigation, method of sowing the proceeding crop and nitrogen fertilizer application. *Prace Zakresu Nauk Rolniczych,* **81**: 87-94.

Kacar, B. and A. Inal, 2008. Bitki Analizleri. Nobel Yayэnlarэ. No: 1241, Ankara, 892 pp.

Karczmarczyk, S., Z. Koszanski, M. Roy and D. Sciazko, 1995. Effect of sprinkler irrigation and nitrogen fertilizer application on sugar and fodder beets cultivated on a good rye complex soil. II. Chemical composition of the crop. *Zeszyty Naukowe Akademii Rolniczej w Szczecinie, Rolnictwo,* **59**: 65-72.

Lukic, D. and S. Vasilijevic, 1996. Production characteristics of some domestic and foregin fodder beet cultivars. *Selekcija i Semenarstvo*, **3** (3-4): 86-91.

Martin, R. C., H. D. Voldeng and D. L. Smith, 1990. Intercropping soybean for silage in a cool temperate region: yield, protein and economic effects. *Field Crops Research,* **23**: 295-310.

Niazi, B. H., J. Rozema, R. A. Broekman and M. Salim, 2000. Dynamics of growth and water relations of fodder beet and sea beet in response to salinity. *J. Agronomy and Crop Science,* **184**: 101-109.

Ozen, N., A. Cakir, S. Hasimoglu and S. Aksoy, 1993. Yemler Bilgisi ve Yem Teknolojisi Ders Notlarэ: 50. Ataturk Univ . Erzurum.

Parlak, A. O. and H. Ekiz, 2008. Ankara kosullarinda bazi yemlik pancar (*Beta vulgaris* L. ssp. *crassa* Mansf.) cesitlerinin verim ve verim ogeleri bakimindan karsilastirilmasi. *Tarэm Bilimleri Dergisi*. **14** (2): 95-100.

Prokopenko, L. S., R. V. Olonicheva and I. F. Pidpalii, 1997. Amino acid composition and protein nutritive value of fodder beet. *Visnik Agrarnoi Nauki,* **1**: 26-28.

Rowell, D. R., 1996. Soil Science: Methods and Applications. Longman. Harlow.

Rzekanowski, C., 1994. The reaction of fodder beet grown on very ligth soil so sprinkler irrigation and nitrogen fertilizer application. *Roczniki Nauk Rolniczych. Seria F, melioracjii Uzytkow Zielonych,* **83** (3-4): 57-62.

Sarhan, G. M. A. and S. A. Ismail, 2003. Response of fodder beet (*Beta vulgaris* L.) to different sources and levels of nitrogen fewer than two levels of potassium fertilization. *Annals of Agricultural Science*, Moshtohor, **41 (1):** 461-473.

SAS, 1998. SAS/STAT User's Guide.Version 7.0. SAS Institute, Inc.Cary. NC.USA.

Slavova, Y., D. Nenkova and I. Ivanova, 2004. Optimization of nutritive medium with the purpose of rooting of fodder beet (*Beta vulgaris* L. var. *crassa*). *Bulg. J. Agric. Sci.*, **10**: 465-468.

Turk, M., S. Albayrak, C. Balabanlэ and O. Yuksel, 2009. Effects of fertilization on root and leaf yields and quality of forage turnip (*Brassica rapa* L.). *Journal of Food, Agric & Environment,* **7** (3-4):339-342.

Zaki, N. M., 1999. Growth and yield responses of fodder beet (*Beta vulgaris* L.) to application methods for nitrogen and potassium fertilizers. *Annals of Agricultural Science, Moshtohor*. **37** (4): 2179-2193.

Zamfir, I., M. C. Zamfir, A. Dihoru and E. Dumitru, 2001. The long-term fertilization influence on both fodder beet yield and some features of argilluvial chernozem from Burnas plain. *Analele Institutului de Cercetari pentru Cereale si Plante Tehnice*, Fundulea. **68:** 289-299.

Received June, 2, 2009; accepted for printing December, 22, 2009.