International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:7, No:12, 2013

Determination of Yield and Yield Components of Fodder Beet (*Beta vulgaris* L. var. *rapacea* Koch.) Cultivars under the Konya Region Conditions

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***Abstract*—**This study was conducted to determination of yield and yield components of some fodder beet types (Amarilla Barres, Feldherr, Kyros, Magnum ve Rota) under the Konya region conditions. Fodder beet was obtained from the Selcuk University, Faculty of Agriculture, at 2006-2007 season and the experiment was established in a randomized complete block design with three replicates. Differences among the averages of the fodder beet cultivars are statistically important in terms of all the characteristics investigated. Leaf attitude value was 1.2 – 2.2 (1=erect; 5= prostrate), root shape scale value was (1=spheroidal – 9=cylindrical), root diameter 11.0 – 12.2cm, remaining part of root on the ground was 6.3 – 13.7cm, root length was 21.4 – 29.6cm, leaf yield 1592 – 1917 kg/da, root yield was 10083 – 12258 kg/da, root dry matter content was %8.2 – 18.6 and root dry matter yield was 889 – 1887 kg/da. As a result of the study, it was determined that fodder beet cultivars are different conditions in terms of yield and yield components. Therefore, determination of appropriate cultivars for each region affect crop yield importantly.

***Keywords*—**Fodder beet, root yield, yield components.

I. Introduction

THE fodder beet is a biennial plant from the Chenopodiaceous family, the vegetative part develops during first year of growth and generative part second year [1], [2]. Fodder beet culture offers a higher yield than other fodder crops. Root of fodder beet is basically grown for animal feeding. Due to the higher water and lower dry matter percentage, fodder beet is consumed by animals and it is mostly used for dairy cattle.

The animal feed obtained from natural grassland is not sufficient for animal feeding. Forage crops growing rate should be increased in the corps cultivation. Due to the population growth, to meet the need for animal food, number and the size of livestock enterprises are increasing also. In parallel, forage crops need is increasing. Due to the higher yield percentage, high water content, being delicious and low cost, fodder beet is noteworthy among others [3]-[5]. Fodder beet is similar with sugar beet in terms of farming and mechanization [6]. Sugar beet is successfully cultivated in our region. If the fodder beet value, storage, and using for animal feed is explained livestock operators; fodder beet farming will increase in our region.

The types of the fodder beet varieties are different from each other in terms of some important characteristics such as root shape, root color, root dry matter content, rood and leaf yield, proportion of the root above ground. Determination of appropriate cultivars for each region is important for increasing food better farming.

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II. Material and Method

This study is conducted in 2006 and 2007 growing season in Konya, Central Anatolia Region. Experiment area is 1016 meters above sea level. The city in which experiment carried out, is located southern part of the Central Anatolia and it has a terrestrial climate. Winters are harsh, cold, and snowy, summers are hot and rainless. The soil samples obtained from 0-30 depth at the territory of the experiment and they were analyzed. As a result of the analyses, it was determined that the soil was clay and it has colloid structure and alkaline. Soil alkaline rate (pH = 7.8), organic matter % 1.20, EC (µS / cm) = 189, P_2O_5 = 10.74 ppm, K_2O = 219.96 ppm, Zn = 2.16 ppm, Fe = 1.28 ppm, Cu = 0.82 ppm, Mn = 4.95 ppm, Ca = 5863.00 ppm and Na = 66.09 ppm. The rainfall, mean temperature, mean humidity through vegetation period (November-April) were 219.5 mm, 17.1°C and %56 in 2006, 152.3mm, 18.5°C and %46 in 2007, respectively.

The trial was arranged in randomized complete blocks experimental designs with four replications. Five fodder beet types (Amarilla Barres, Rota, Feldherr, Magnum, and Kyros) were used as trial material. Cultivation was made between 26 May 2006 and 26 April 2007; harvest was made between 24 November 2006 and 29 November 2006. Individual plot size was 3x5=15m^2. . 6 row Fodder beet was cultivated per parcel a 50cm row width and 20cm plant spacing. 15kg N, 10kg P_2O_5 and 10kg K_2O is fertilized per da. In addition to maintenance operations, dilution, weed control, pest spraying and irrigation were performed.

The observations and measurements were made in order to determine the characteristics of fodder beet varieties in 2007 and 2008. After breaking edges of the each parcel, samples for observation were taken and yields were determined by harvest at remaining 5m^2 area. Characteristics and their units are given in Table I. The results obtained from the study were analyzed using MSTAT-C statistic packet program according to randomized complete block designed and the differences among the averages were classified ($p<0.01$ or $p<0.05$) according to Least Significant Differences (LSD) Tests [7].

TABLE I
MORPHOLOGICAL CHARACTERS AND DESCRIPTIONS EXAMINED OF FODDER BEET [8]

Character examined	Description of character
Leaf attitude 1-5 scale	1=erect; 2=semi erect; 3=medium; 4=semi prostrate 5=prostrate
Root shape 1-9 scale	1=spherical; 3=oval; 5=conic; 7=cylindrical conical; 9=cylindrical
Root diameter cm	The most swollen part root was measured by ruler.
Part of the root above the ground (cm)	Part of the root above the ground was measured by ruler.
Root length (cm)	The distance between from the head of the root to the tip of the root 0.5 cm.
Leaf yield (kg/da)	The leafs taken from the harvested area were weighed and turned per da
Root yield (kg/da)	The roots taken from the harvested area were weighed and turned per da
Root dry matter content (%)	100 g. samples taken from the root were dried 24 hour at 105 C and dry matter content was measured.
Root dry matter yield (kg/da)	Root yield and dry matter content is determined by multiplying.

III. RESULTS AND DISCUSSION

The distance among the averages at the level $p<0.01$ in terms of the leaf position is important. (Table II). Although leaf position was accepted characteristic of cultivars, to be importance of the cultivar x year interaction, show changing of the leaf positions according to different years. For this reason, the differences among the averages of the year were important.

Mean averages values of shape of the root of fodder beet cultivars examined are given in Table II. Analysis of variance showed that the difference between the means of the cultivars $p<0.01$ level and the cultivar x year interaction $p<0.05$ level significant differences were determined in terms of the root shape. Root shape was oval in Amarilla Barres, cylindrical conic in Rota and conic in Feldherr, Mağnum, Kyros. Reference [9] in his study stated that the conic form dominant than the other types of cultivars.

The differences between the cultivars averages was significant at the level $p<0.01$ and the cultivars x years interactions was significant at the level $p<0.05$ for root diameter (Table II). The highest root diameter was obtained as 12.2cm from Rota and Feldherr cultivars and the lowest root diameter was obtained as 11.0cm from the Magnum cultivar. Root diameters were different in different years and they changed from 10.1 to 12.8cm. Root diameter of fodder beet was determined as 4.9-6.7cm by [10], as 9.34–11.89cm by [6], as 8.28-15.69cm by [4], as 9.39-14.22cm by [5], as 7.5-11.0cm by [11].

The results regarding the part of the root above the ground of the fodder beet cultivars are shown in Table III. While the differences between cultivars averages were statistically significant at the level $p<0.01$, cultivar x year interaction were not significant. When biennial cultivars averages were examined, the highest value was obtained from Feldherr as 13.7cm and the lowest was obtained from Magnum as 6.3cm. Reference [10] found that the proportion of the root above the ground was 10.7-12.3cm in similar study.

Mean averages values of fodder beet types examined were given in Table III. While differences between cultivars averages were significant at the $p<0.01$ level, the differences between year averages and cultivar x year interaction averages were not significant in terms of root length. The highest root length was obtained from Feldherr as 29.6cm; the lowest root length was obtained Amarilla Barres type as 21.4cm. It was previously reported that root length in fodder beet was found as 14.3-18.5cm by [10], as 16.40-22.43cm by [6], as 13.0-20.59cm by [4], as 10.56–15.99cm by [5] and as 14.8–24.7cm by [11].

Differences were important among the cultivars averages and cultivar x year interaction in terms of leaf yield was $p<0.05$, differences among the year averages $p<0.01$ was $p<0.05$ (Table III). The highest yield was obtained from Feldherr as 1917 kg/da and the lowest from Amarilla Barres as 1592 kg/da. The averages of 2007 were higher leaf yield than others. Leaf yields were different in different years. The highest leaf yield in cultivar x year interaction obtained from Feldherr 2283 kg/da in 2007, the lowest leaf yield was obtained from Magnum 1083 kg/da in 2006. According to previous reports, leaf yield was found as 745.4–4578.4 kg/da by [3], as 970-1390 kg/da by [11], as 1328.0–2792.7 kg/da by [6], as 1200-1514 kg/da [12], as 428.8-638.8 kg/da by [10]. Reference [13] reported that leaf yield in fodder beet was different according to years, types, environment conditions, cultural operations and cultivation time.

Differences among the cultivars averages in terms of root yield were important at $p<0.05$ level and differences among year averages were significant at $p<0.01$ and cultivar x year interaction was not significant (Table IV). Highest root yield was obtained from Feldherr type as 12258 kg/da, the lowest root yield was obtained from Kyros as 10083 kg/da. The averages of root yield in 2007 (12427 kg/da) was higher than that of 2006 (9410 kg/da). According to previous reports, root yield was found as 8041.6-14514.8 kg/da by [3], as 6326-11541 kg/da by [4], as 4550-9440 kg/da by [11], as 3433.0–6528.7 kg/da by [6], as 2976-4798 kg/da by [12], as 11750-18433 kg/da [2], 6574-10016 kg/da by [5], as 2542.5 – 5185.0 kg/da by [10]. Root yield show differences according to cultivars, climate and soil conditions, cultivation time, cultivation frequency, irrigation and fertilization.

TABLE II
LEAF ATTITUDE, ROOT SHAPE, ROOT DIAMETER OF DIFFERENT FODDER BEET CULTIVARS AND LSD TESTS

Cultivars	Leafattitude (1-5)			Rootshape (1-9)			Rootdiameter (cm)		
	2006	2007	Ort.	2006	2007	Ort.	2006	2007	Ort.
AmarillaBarres	1.0 e	2.0 bc	1.5 BC	3.0 d	3.0 d	3.0 C	11.2 bcd	11.5 abc	11.3 AB
Rota	1.0 e	1.3 bc	1.2 C	8.3 a	7.0 b	7.7 A	11.5 abc	12.8 a	12.2 A
Feldherr	1.0 e	2.3 ab	1.7 ABC	5.0 c	5.0 c	5.0 B	12.5 ab	11.9 abc	12.2 A
Magnum	1.7 cd	2.7 a	2.2 A	5.0 c	5.0 c	5.0 B	10.1 d	11.9 abc	11.0 B
Kyros	2.0 bc	2.0 bc	2.0AB	5.0 c	5.0 c	5.0 B	11.5 abc	10.8 cd	11.2 B
Mean	1.3 B	2.1 A	1.7	5.3	5.0	5.1	11.4	11.8	11.6
LSD	Cultivar: 0.5636**			Cultivar: 0.6061**			Cultivar: 0.9647**		
	Year: 0.3564**			Year: ns			Year: ns		
	Cultivar x Year: 0.5817 *			Cultivar x Year: 0.6256 *			Cultivar x Year: 1.364**		

*:p<0.05; **:p<0.01; ns: not significant

TABLE III
PART OF THE ROOT ABOVE THE GROUND (CM), ROOT LENGTH (CM) AND LEAF YIELD (KG/DA) OF DIFFERENT FODDER BEET CULTIVARS AND LSD TESTS

Cultivars	Part of therootabovetheground (cm)			Rootlength (cm)			Leafyield (kg/da)		
	2006	2007	Ort.	2006	2007	Ort.	2006	2007	Ort.
AmarillaBarres	10.6	12.1	11.3 B	20.9	21.8	21.4 C	1217 de	1967 b	1592 B
Rota	12.0	11.4	11.7 B	23.7	22.3	23.0 C	1550 c	2000 b	1775 AB
Feldherr	14.0	13.3	13.7 A	30.4	28.9	29.6 A	1550 c	2283 a	1917 A
Magnum	7.1	5.6	6.3 C	21.9	25.5	23.7 BC	1083 e	2217 ab	1650 B
Kyros	10.8	10.9	10.9 B	24.7	27.4	26.1 B	1383 cd	2017 b	1700 B
Mean	10.9	10.7	10.8	24.3	25.2	24.7	1357 B	2097 A	1727
LSD	Cultivar: 1.951**			Cultivar: 3.001**			Cultivar: 187.3*		
	Year: ns			Year: ns			Year: 162.3**		
	Cultivar x Year: ns			Cultivar x Year: ns			Cultivar x Year: 264.8*		

*:p<0.05; **:p<0.01; ns: not significant

TABLE IV
ROOT YIELD (KG/DA), ROOT DRY MATTER CONTENT (%) AND ROOT DRY MATTER YIELD (KG/DA) OF DIFFERENT FODDER BEET CULTIVARS AND LSD TESTS

Cultivars	Root yield (kg/da)			Rootdrymattercontent (%)			Rootdrymatteryield (kg/da)		
	2006	2007	Ort.	2006	2007	Ort.	2006	2007	Ort.
AmarillaBarres	9200	12433	10817 B	8.0	8.4	8.2 D	737	1042	889 C
Rota	9767	12717	11242 AB	9.3	11.6	10.5 C	899	1483	1191 B
Feldherr	10967	13550	12258 A	11.7	12.0	11.8 C	1275	1625	1450 B
Magnum	8350	12033	10192 B	18.9	18.3	18.6 A	1577	2196	1887 A
Kyros	8767	11400	10083 B	13.1	15.2	14.2 B	1154	1732	1443 B
Mean	9410 B	12427 A	10918	12.2 B	13.1 A	12.7	1128 A	1615 B	1372
LSD	Cultivar: 1290*			Cultivar: 1.762**			Cultivar: 290.6**		
	Year: 1118**			Year: 0.8133*			Year: 183.8**		
	Cultivar x Year: ns			Cultivar x Year: ns			Cultivar x Year: ns		

*:p<0.05; **:p<0.01; ns: not significant

In this study, the differences between fodder beet root cultivars were significant at p<0.01 level, averages of the year were significant at p<0.05 level; whereas there was no significant difference between cultivar x year interaction statistically (Table IV). Highest root dry matter content among the fodder beet types was obtained Magnum as %18.6 and lowest root dry matter content was obtained from Amarilla Barres as %8.2. Root dry matter contents were determined as %12.2 and %13.1 in 2006 and 2007 year, respectively. Dry matter content was determined as %10.66-13.36 by [13], as % 10.59-14.36 by [4], as %11.2-14.6 by [11], as %15.14-18.03 by [6] and as % 11.01-12.40 by [5].

Mean averages of the root dry matter yields observed were given in Table IV. The differences between cultivars averages and year averages determined as significant at p<0.01 level statistically. The highest dry matter yield was obtained from Magnum cultivar as 1887 kg/da and the lowest from Amarilla Barres as 899 kg/da. According to previous reports, dry matter yield was found as 867.0-1741.2 kg/da by [13], as 669-1634 kg/da by [4], as 650-1130 kg/da by [11], as 717.9-986.8 kg/da by [6], as 799-1238 kg/da by [5].

IV. CONCLUSION

Konya has appropriate ecology for cultivation of fodder beet. If appropriate cultivation methods were used, the yields rates increase. Nowadays, there are a lot of cultivars of fodder beet was developed by plant breeder's organization. So, choosing appropriate cultivar according to region and cultivation conditions was important. In this study, 9 characteristic of 5 different types of fodder beet were determined at during two years. As a result of the study, it was determined that the yield and yield components have different characteristic. Thus, determination of appropriate types was very important for increasing yield for each region.

ACKNOWLEDGMENT

The author thanks Prof Dr. Hayrettin Ekiz and Prof. Dr. Cafer Sırrı Sevimay for this study directed and providing material.

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