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Response of Fodder Beet Cultivars to Water Stress and Nitrogen Fertilization in Semi-Arid Regions

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Abstract: Water and nitrogen deficits are the most important environmental factors greatly limiting crop production and plant distribution worldwide, especially in semi-arid regions. Two field experiments were conducted during 2009/2010 and 2010/2011 seasons in the Experimental Farm, Faculty of Environmental Agricultural Science, El-Arish, Suez Canal University, North Sinai Governorate, Egypt (31°08'04.3" N, 33°49'37.2"E). This study focuses on response of two fodder beet cultivars (Voroshinger & Rotta) to three water stress levels (50, 75, 100 % of field capacity, FC) and four nitrogen fertilizer levels (N1= 143, N2=214, N3=286, N4=357 kg Nha^{-1}). Superiority of Rotta cultivar in leaf area index and duration was observed as compared with Voroshenger cv. at most of growth periods. Net assimilation rate was increased with increasing water stress levels. Increasing nitrogen fertilizer levels from 143 to 357 t ha^{-1} increased root/top ratio, leaf area index and duration. Irrigating fodder beet plants with 100 % soil field capacity gave the highest fresh and dry top and root yields. The fresh and dry top and root yields in Rotta cultivar surpassed Voroshenger one under water deficit and low fertility level under semi-arid conditions, where, top and root fresh yield of Rotta cv. surpassed Voroshenger cv by 16.37 and 7.07%, respectively. However, increasing N levels up to 357 t ha^{-1} gave the maximum fresh and dry root yields, while adding more nitrogen fertilizer application had no significant increase in both yields. It could be concluded that fodder beet Rotta cultivar is more tolerant to water deficit and low fertility level under semi- arid conditions, where, it could gave an economic forage yield of top and root. For achieving this goal, we could recommend this cultivar to be irrigated when soil field capacity reached 75 % and fertilized with nitrogen nutrient at the rate of 286 kg N ha^{-1}.

Key words: Cultivars · Fodder beet · Leaf area duration · Leaf area index · Net assimilation rate · Nitrogen fertilizer · Top and root yields · Water stress

INTRODUCTION

Fodder beet (*Beta vulgaris*, L.) is one of the most promising winter forage crop under limited water and nutrients levels. The whole plant, i.e. above and under - ground parts can be used in animal feeding directly, processed as qualitative silage or/and stored in the soil for a period without great damage to be used when needed. So, its cultivation may help in overcoming the problem of animal feeding in summer season. Also, it is a good source of carbohydrates in dairy cows meal (about 72 % DM) and could survive with economic yield (ranged between 25-30 ton/feddan, one feddan = 0.42 ha) in marginal lands as semi-arid regions [1]. Water use has been growing at more than twice the rate of population increase in the last century and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water such as arid and semi-arid regions [2].Semi-arid regions is suffering from water deficit that may affect growth and physiological characteristics which reflected on forage yield. These effects could be characterized by decreasing water content, osmotic potential and total water potential accompanied by loss of turgor, close of stomata and decrease in photosynthesis process [3]. Growth analysis could be used to determine the most critical stages in life cycle of plants, which significantly affect the final yield. Leaf area index (LAI) is a key variable and global models

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for bio-atmosphere exchanges of energy, carbon dioxide, water vapor and other materials [4]. In fodder beet, root growth is less sensitive to water deficit than top growth, so, the ratio between root, as absorbance surface and top, as transpiration surface, affected significantly on plant ability to overcoming water stress damage [5]. Using sprinkler irrigation in sandy loam soil, increasing irrigation levels in form of field capacity led to significant increases in all growth and yield characters [6]. Nitrogen is the main nutrient for crop production. Hence, applying nitrogen fertilizers, especially, poor fertility soils, improved biomass and protein yields [7] and feeding value and leaves crude protein (11.4 and 15.8%) [8]. Applying 120 kg N/ha gave the greatest dry matter and nitrogen free extract [9]. Also, adding nitrogen fertilizers enhances the calculated energy content of fodder beet (tubers and leaves) and was about 61% TDN compared to 58% for Rhodes grass [10] and the absorption of minerals from soil [11].Cultivars yield responded differently to water stress and nutrients according to their genetically differences, but there are no palatability or feed quality differences between cultivars (www.dlfseeds.co.nz). So, the main objectives of this study are to study the response of fodder beet cultivars to water stress and nitrogen fertilization levels in semi-arid regions.

MATERIALS AND METHODS

Experimental Site and Treatments: Two field trials were conducted at the Experimental Farm in Faculty of Environmental Agricultural Science, El-Arish, Suez Canal University, North Sinai Governorate, Egypt (31°08'04.3" N, 33°49'37.2"E) during winter seasons of 2009/2010 and 2010/2011. The study aims to investigate the response of fodder beet cultivars to water stress and nitrogen fertilizer levels under semi-arid conditions. Each experiment included 24 treatments which were the combinations of: (I) Two fodder beet cultivars (*Beta vulgaris* cv. Voroshenger and Rotta), which imported by Seedico Import-Export Company, Egypt, (ii) Three irrigation water levels, i.e. 50, 75, 100 % of field capacity (FC,), where, soil moisture percentages of FC were 22.10 and 20.11 % in 2009/2010 and 2010/2011 seasons, respectively and (iii) Four nitrogen fertilizer levels, i.e. 143, 214, 286, 357 kg Nha^{-1}. Soil texture was sandy loam. The available N ranged between 11.20 and 12.50 ppm for two seasons, respectively, with pH 8.26 and EC 6.87 mhos/cm. Water salinity ranked between 3500 and 4100 ppm and drip irrigation system was used. Climatological data from Central Laboratory of Agricultural Climate (CLAC), El-Arish Station at the period from 2009 to 2012 are shown in Table 1.

Experimental Design: Split-split plot design with three replications in randomized complete blocks was used. Cultivars were arranged at the main plots, while irrigation levels assigned randomly to the sub-plots, then nitrogen fertilizer levels occupied the sub-sub plots. Plot area was 20 m^2 (2x10 m, 1/500 ha).

Agricultural Practices: The preceding crop was maize in both seasons. Fodder beet seeds were sown at the rate of 7 kg ha^{-1} at October 25th and November 5thin the 1st and 2nd seasons, respectively. The plants were thinned twice; the 1st at 30 days after planting (DAP) to leave two plants per hill and the 2nd at 45 DAP to leave one plant per hill till harvest time. Organic fertilization (71 m^3 ha^{-1}) and supper phosphate (15.5 % P_2O_5, 0.476 t ha^{-1}) were added during land preparation. Potassium fertilization in form of potassium sulphate (50 % K_2O) was added by fertigation method through plant growth till two weeks before harvesting. While, nitrogen fertilization in the form of ammonium nitrate (33.5%N) was divided to three equal portions, the first portion after thinning, the second one was added two weeks later and the last portion after one month later. The experiment site was irrigated immediately just after planting and thereafter, irrigation every 3 days pumped from a well till thinning. After thinning, irrigation-treatments levels were applied when field capacity reached the previous studied levels till two weeks before harvesting. The other cultural practices were carried out as recommended for such crop.

Recorded Data: Random samples of five plants were taken from each sub-sub plot at55, 85, 115, 145 and 175 days after planting (DAP), which reflected the growth stages, i.e. initial, establishment, mid-season, late-season and ripening stages, respectively [12]. Plants were separated into roots and tops to determine the following growth analysis characters basing on dry weights: Root/top ratio (R/T), leaf area index (LAI, cm^2 green area/cm^2 ground area per plant), leaf area duration (LAD) and net assimilation ratio (NAR, g/week) according to Beedle [13]. For yield attributes, five plants from the inner two ridges were pulled up on 21st and 29th May in the 1st and 2nd seasons, respectively to determine: root length and diameter (cm), root plasticity [14], while plants of one square meter were harvested to determine root and top fresh and dry yields (tha^{-1}).

Table 1: Monthly temperature (Temp., °C, maximum, Max.; minimum, Min.), means of relative humidity (RH, %) and perception rate (Per., mm) at seasons 2009-2012.

Climatic Data	Season	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. Temp. (°C)	2009	21.1	22.3	23.0	26.1	28.3	33.8	32.6	32.9	31.7	31.1	25.2	22.9
	2010	22.5	23.6	25.3	26.7	29.2	32.3	32.0	33.9	32.3	31.2	27.7	23.4
	2011	19.2	19.9	21.3	23.7	26.9	30.6	28.9	31.1	29.9	28.5	25.3	21.4
	2012	21.2	19.7	21.2	22.3	26.7	30.9	28.3	31.2	29.6	27.6	25.2	21.2
Mean over 4th seasons	21.0	21.4	22.7	25.5	27.8	31.9	30.5	32.3	30.9	29.6	25.9	22.2	
Min. Temp (°C)	2009	6.9	8.0	9.0	11.8	14.8	21.7	18.8	21.8	20.2	18.2	11.8	10.4
	2010	8.5	10.7	12.8	13.0	15.8	22.2	20.2	23.9	21.4	18.7	13.7	8.5
	2011	8.5	9.1	18.8	13.3	16.1	21.3	18.9	21.9	20.4	18.0	14.4	10.2
	2012	8.3	9.3	19.2	13.6	16.7	21.2	18.8	22.3	20.2	18.3	14.6	10.6
Mean over 4th seasons		8.1	9.3	14.9	12.9	15.9	21.6	19.2	22.5	20.6	18.3	13.6	9.9
Relative Humidity (%)	2009	63	62	60	69	68	69	70	70	68	70	67	66
	2010	67	66	66	66	66	72	66	74	70	74	76	67
	2011	70	69	67	67	68	74	72	75	71	73	71	66
	2012	71	72	67	68	67	75	73	74	72	74	73	66
Mean over 4th seasons	67.8	67.3	65.0	67.5	67.3	72.5	70.3	73.3	70.3	72.8	71.8	66.3	
Per. (mm)	2009	22.3	22.5	4.5	0.1	0	0	0	0	0	0.9	0.3	7.6
	2010	22.9	25.2	5.1	0.1	0.1	0	0	0	0.1	1	0	1.5
	2011	20.3	17.1	12.0	6.1	3.2	0	0	0.2	0.6	6	16.2	22.2
	2012	18.6	15.2	11.0	5.6	3.1	0	0	0.1	0.2	5	14.3	21.6
Mean over 4th seasons	21.1	20.0	8.25	2.9	1.6	0	0	0.11	0.12	3.1	7.7	13.2	

Source (CLAC, El-Arish station, ARC, Egypt, 2013)

Statistical Analysis: Data were statistically analyzed for the two seasons by using Fisher's analysis of variance technique and Duncan multiple range test at 0.05 probability level to compare the treatments means [15].

RESULTS AND DISCUSSION

Growth Analysis Characters: Data in Table 2 shows that as plant age increased root/top ratio (R/T) basing on dry weight increased, this refer to the loosing and senescence of eldest leaves with more accumulating dry matter in roots. Voroshenger cultivar R/T revealed less tolerance to water stress levels than Rotta one at most of growth stages, especially, at mid-season stage and repining one in combined analysis. A significant reduction on R/T ratio was obtained when water stress levels increased from 100 to 50 % FC. These reduction may refer to that root growth is less sensitive to decrease available soil water level than shoots [16].As nitrogen fertilizer levels increased from 143 to 357 kg Nha^{-1}, R/T ratio was gradually decreased with increasing plant age for both cultivars in combined analysis. These results reflected that nitrogen enhanced fodder beet growth and gave more rapid rate for accumulating dry matter for tops than roots which in turn may decrease the translocation of photosynthetic materials from tops to roots. Previous work of Abdel-Gawad *et al.* [17] and Turk [18] characterized the nitrogen fertilizers as the major factor for fodder beet production because of their positive effect on both top and root growth and weight. Leaf area index (LAI) and leaf area duration (LAD) affect the amount of solar radiation intercepted by the vegetative green area which reflected on canopy photosynthesis and evapo-transpiration. There were no significant differences between Voroshenger and Rotta cultivars in LAI at all growth stages (Table 3).

Concerning to irrigation levels, a significant reduction was observed in LAI as water stress levels increased (50% FC), where, the highest values (0.220 & 0.226) were obtained when fodder beet cultivars (Voroshenger & Rotta) irrigated with 100% soil moisture of field capacity during repining stage. This reduction in LAI with increasing water stress levels may be due to the reduction in cell division and expansion, which in turn reduced photosynthetic surface of fodder beet plants cultivars. However, increasing nitrogen fertilizer levels (from 143 to 357 kg Nha^{-1}) gradually increased significantly LAI at 85 DAP (0.032-0.041 & 0.036 - 0.044), 115 DAP (0.151-0.197 & 0.155-0.203), 145 DAP (0.182-0.229 & 0.186-0.232) and 175 DAP (0.200-0.224 & 0.204-0.228) for Voroshenger and Rotta cultivars, respectively. These increases may be due to the positive effect of nitrogen on number and size of leaves which gave more leaf area in relation to ground occupied by these leaves and the accumulation of leaf area in the weeks after planting is a key to success growing fodder beet [19]. Subjecting Rotta cultivar to the

Table 2: Response of root/top ratio (dry weight basis) of fodder beet cultivars (Voroshenger & Rotta) to water stress and nitrogen fertilization levels at 85, 115, 145 and 175 days after planting (DAP) in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Days after planting (DAP)							
FC %	85	115	145	175	85	115	145	175
50	0.360	0.521 c	0.509 c	1.443 c	0.348 c	0.524 c	0.611 c	2.045 c
75	0.363	0.543 b	0.811 b	2.351 b	0.363 b	0.548 b	0.816 b	2.457 b
100	0.351	0.594 a	0.922 a	2.557 a	0.365 a	0.596 a	0.928 a	2.563 a
Significant	NS	**	*	**	**	**	**	**
	N levels (kg Nha^{-1})							
143	0.442 a	0.611 a	1.045 a	2.802 a	0.445 a	0.616 a	1.047 a	2.808 a
214	0.369 b	0.537 b	0.945 b	2.531 b	0.371 b	0.539 b	0.949 b	2.537 b
286	0.256 c	0.524 c	0.899 c	2.512 b	0.259 c	0.527 c	0.905 c	2.517 c
357	0.245 d	0. 533 c	0.882 d	2.486 c	0.248 d	0. 538 c	0.888 d	2.488 d
Significant	**	**	**	**	**	**	**	**

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test.

Table 3: Response of leaf area index (LAI, based area unit dm2) of fodder beet cultivars (Voroshenger & Rotta) to water stress and nitrogen fertilization levels at 85, 115, 145 and 175 DAP in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Days after planting (DAP)							
FC %	85	115	145	175	85	115	145	175
50	0.031 c	0.174 c	0.172 c	0.165 c	0.031 c	0.174 c	0.172 c	0.165 c
75	0.036 b	0.186 b	0.223 b	0.183 b	0.036 b	0.186 b	0.223 b	0.183 b
100	0.039 a	0.200 a	0.237 a	0.220 a	0.039 a	0.200 a	0.237 a	0.226 a
Significant	*	**	**	**	*	**	**	**
	N levels (kg Nha^{-1})							
143	0.032 c	0.151 c	0.182 c	0.200 d	0.036 c	0.155 c	0.186 c	0.204 d
214	0.036 b	0.174 b	0.205 b	0.201 c	0.039 b	0.178 b	0.209b	0.205 c
286	0.039 a	0.195 a	0.227a	0.219 b	0.043 a	0.199 a	0.228a	0.223 b
357	0.041 a	0.197 a	0.229 a	0.224 a	0.044 a	0.203 a	0.232 a	0.228 a
Significant	**	**	**	**	**	**	**	**

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test

Table 4: Response of leaf area duration (LAD) of fodder beet cultivars (Voroshenger & Rotta) to water stress and nitrogen fertilization levels at different growth periods in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Leaf area duration (LAD)							
FC %	55-85	85-115	115-145	145-175	55-85	85-115	115-145	145-175
50	176.5 c	708.3 c	1236.1 c	1387.7 c	189.5 c	710.3 c	1266.1 c	1405.7 c
75	201.3 b	766.6 b	1324.3 b	1544.1 b	211.3 b	786.6 b	1354.3 b	1554.1 b
100	211.1 a	837.1 a	1553.1 a	1664.9 a	216.1 a	857.1 a	1563.1 a	1670.9 a
Significant	**	**	**	**	**	**	**	**
	N levels (kg Nha^{-1})							
143	181.3 d	694.4 d	1254.4 d	1430.9 c	183.3 d	698.4 d	1258.4 d	1434.9 c
214	203.5 c	784.4 c	1407.5 c	1514.7 b	206.5 c	787.4 c	1411.5 c	1517.7 b
286	223.1 b	872.3 b	1581.9 b	1669.4 a	227.1 b	875.3 b	1585.9 b	1673.4 a
357	225.6 a	888.6 a	1611.6 a	1678.8 a	228.6 a	891.6 a	1615.6 a	1681.8 a
Significant	**	**	**	**	**	**	**	**

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test same agricultural practices and environment proved that it is more adapted by giving more leaf area duration values than to semi-arid condition than Voroshenger one (Table 4). This may refer to more numbers and areas of green leaves for Rotta cv. than Voroshenger one. In this concern, LAD was decreased as water stress levels increased at all growth stages, where, the highest value (1670.9) was obtained from 100 % FC treatments with Rotta cultivar at the fourth growth stage. This reduction may be attributed that lower radiation interception as lower number and leaf area per plants under low available soil water content [20]. Rotta cultivar irrigated with 50 % soil moisture of field capacity surpassed in net assimilation rate (NAR) at 145-175 DAPS compared to Voroshenger cultivar and the other water stress levels (Table 5). Such reduction in NAR in response to adequate soil moisture content may be attributed to the reduction in leaf area which resulted in increasing photosynthetic ability per every unit of leaf area [21].

Concerning to nitrogen fertilizer levels, NAR of Voroshenger and Rotta cultivars was decreased as nitrogen fertilizer levels increased, where, the maximum NAR values (0.070 & 0.074 g dm^{-2}/week) were obtained with applied of 143 kg Nha^{-1} at the third growth stage. The reduction in net assimilation rate of fodder beet plants in response to N fertilizer levels may be reflected to the progressive effect of this nutrient on leaf area by its role in building up and enlargement of cells which in turn the photosynthetic area. Similar results by Kandil *et al.* [22] on sugar beet and Warraich *et al.* [23].

Yield and Yield Attributes: Data in Table 6 illustrated that Rotta cultivar surpassed Voroshenger one in all yield attributes at harvesting time in combined analysis. Beets plants irrigated with 100% soil moisture of field capacity gave the highest top length (44.45 & 47.66 cm) and root diameter (51.03 & 55.56) for Voroshenger and Rotta cvs, respectively. However, the relative value between root length of stressed plants (50 & 75 % FC) and those non-stressed ones (100 % FC), which characterized in terms of root plasticity, treatment of 75 % gave the maximum root plasticity (1.136 & 1.141) for Voroshenger and Rotta cultivars, respectively. Furthermore, as water stress levels increased, root length increased significantly for both cultivars. These results indicate that fodder beet plants are capable to develop an extensive root system which enables them to extract water from deeper water soil layers, which in turn increased their adaptability to grow in inadequate soil moisture content and reflected on root plasticity improvement under water stress conditions. Suralta [24] reported that plasticity exhibited by root systems plays an important role under fluctuating soil-moisture stress, where drought and water-logged conditions occur repeatedly, which is typically experienced in rain-fed rice fields and water-saving cultivation environments [25]. Concerning to nitrogen fertilizer, increasing N levels from 143 up to 286 kg Nha^{-1} increased all yield attributes except root plasticity for both cultivars, while, adding more nitrogen fertilizer levels (357 kg Nha^{-1}) had non-significant increase in top and root length as well as root diameter. The positive

Table 5: Response of net assimilation rate (NAR, g dm-1/week) of fodder beet cultivars (Voroshenger & Rotta) to water stress and nitrogen fertilization levels at different growth periods in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Net assimilation rate (NAR, g dm^{-1}/week)							
FC %	55-85	85-115	115-145	145-175	55-85	85-115	115-145	145-175
50	0.023	0.024	0.047	0.016 a	0.026	0.026	0.067	0.017 a
75	0.023	0.024	0.056	0.011 b	0.025	0.024	0.066	0.013 b
100	0.022	0.023	0.058	0.010 c	0.025	0.025	0.068	0.012 c
Significant	N.S	N.S	N.S	**	N.S	N.S	N.S	**
N levels (kg Nha^{-1})								
143	0.063 a	0.030 a	0.070 a	0.016 a	0.067 a	0.034 a	0.074 a	0.019 a
214	0.038 c	0.020 c	0.067 b	0.015 ab	0.042 c	0.024 c	0.069 b	0.018ab
286	0.040 b	0.027 ab	0.066 c	0.013 c	0.044 b	0.031ab	0.071 c	0.016 c
357	0.033 c	0.025 b	0.061 d	0.11 d	0.038 c	0.029 b	0.065 d	0.13 d
Significant	**	*	**	**	**	*	**	**

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test

Table 6: Yield components characters of fodder beet cultivars (Voroshenger & Rotta) as affected by water stress and nitrogen fertilization levels in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Yield components characters							
FC %	Top length (cm)	Root length (cm)	Root diameter (cm)	Root plasticity	Top length (cm)	Root length (cm)	Root diameter (cm)	Root plasticity
50	40.89 c	38.45 a	47.99 c	1.116 c	42.66 c	40.45 c	49.99 c	1.118 c
75	43.31 b	37.61 b	49.44 b	1.136 b	45.31 b	38.61 b	50.44 b	1.141 b
100	44.45 a	35.45 c	51.03 a	1.126 a	47.45 a	37.45 a	55.56 a	1.127 a
Significant	**	**	**	**	**	**	**	**
N levels (kg Nha-1)								
143	36.33 c	31.11 c	42.41 c	1.104	39.42 c	33.16 c	45.61 c	1.106
214	39.72 b	33.17 b	46.29 b	1.113	42.79 b	36.77 b	50.09 b	1.116
286	41.66 a	36.29 a	49.82 a	1.125	45.69 a	40.89 a	52.85 a	1.127
357	45.17 a	39.14 a	51.01 a	1.123	46.07 a	41.44 a	53.08 a	1.125
Significant	**	**	**	N.S	**	**	**	N.S

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test.

Table 7: Fresh and dry yield (t ha^{-1}) of fodder beet cultivars (Voroshenger & Rotta) as affected by water stress and nitrogen fertilization levels in combined analysis (2009/2010&2010/2011).

Cultivars	Voroshenger				Rotta			
	Fresh yield (t ha^{-1})		Dry yield (t ha^{-1})		Fresh yield (t ha^{-1})		Dry yield (t ha^{-1})	
FC %	Top	Root	Top	Root	Top	Root	Top	Root
50	6.011 c	53.13 c	2.065 c	8.65 c	7.006 b	57.46 c	2.590 c	9.46 c
75	6.221 b	59.44 b	2.556 b	10.45 b	7.016 b	63.45 b	2.959 b	12.87 b
100	6.611 a	68.21 a	2.883 a	16.66 a	7.905 a	72.66 a	3.057a	17.07a
Significant	**	**	**	**	**	**	**	**
N levels (kg Nha^{-1})								
143	5.739 c	56.36 c	2.112 d	10.11 d	6.737 c	58.32 c	2.306 d	10.65 d
214	6.096 b	62.75 b	2.233 c	10.86 c	7.092 b	65.72 b	2.426 c	11.59 c
286	6.649 a	70.92 a	3.651a	11.88 a	7.543 a	72.88 a	2.941 a	12.62 a
357	6.852 a	68.17 b	3.066 b	11.66 ab	7.648 a	71.13 a	2.897 b	11.89 bc
Significant	**	**	**	*	**	**	**	*

FC=Field capacity; *, ** and N.S indicate P<0.05, P< 0.01 and not significant, respectively. Means of each column have the same letter are not significantly different at 5% level using Duncan s Multiple range test.

response of fodder beet top and root to nitrogen fertilizer application may be refer to the greatest lack of this nutrient in the soil of such semi-arid region (11.85 ppm). Also, nitrogen fertilization enhanced plant capacity in protein synthesis and encouraging cell division, where, fodder beet responded positively to these building up roles of nitrogen. The positive response of root diameter and other yield attributes to increasing nitrogen levels supports the findings of Ismail [26], Ouda [27] on sugar beet cultivars and Khogali *et al.* [28] on fodder beet cultivars.

Superiority of Rotta cultivar in fresh and dry top and root yields was observed under semi-arid conditions which suffer from water deficit and low fertility levels when compared to Voroshenger one (Table 7).Top and root fresh yield of Rotta cv. surpassed Voroshenger cv. by 16.37 and 7.07%, respectively. Increasing water stress levels by delaying irrigating fodder beet plants till 50 % from soil field capacity decreased significantly fresh and dry top yield for both cultivars. This reduction in top yield as a result to non-abundance soil moisture in root zone may be refer to the reduction in top length, leaf area index and net assimilation rate (the above data).Increasing N levels from 143 up to 286 kg Nha^{-1} increased top fresh and dry yields from 5.739 and 2.112 to 6.649 and 3.651 t ha^{-1} for Voroshenger cv. respectively, while adding more nitrogen fertilizer levels (357 kg Nha^{-1}) had non-significant increase of them. These increment estimated by 11.96 and 27.54 % for Rotta cv. respectively. Similar trend was observed in root fresh and dry yields, where, applying 286 kg N ha^{-1} gave the maximum values (70.92 & 72.88 t ha^{-1}) and (11.88 & 12.62 t ha^{-1}) for Voroshenger and Rotta cultivars, respectively. The positive effect of nitrogen fertilization on fodder beet cultivars cleared that root yield augmentation was a consequence to positive response of root diameter, length and the increasing of metabolites efficiency from leaves to developing roots. Mehdikhani [29] characterized the correlation between rooting morphology and rooting metabolites is positive and strong in sugar beet.

CONCLUSION

It can be recommended from the obvious field trails that fodder beet Rotta cultivar could gave economic growth and forage yield as plants irrigated with 75% of soil water field capacity and fertilized by nitrogen fertilizer level of 286 kg Nha^{-1} under semi-arid conditions as North Sinai governorate and similar regions.

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