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EFFECT OF NITROGEN AND SPACING ON GROWTH OF FODDER BEET (*Beta vulgaris* L.var.Crassa) CULTIVARS UNDER SUDAN CONDITIONS

Khogali M E[1*], Ibrahim Y M[2], El Hag M G[3]
[1]Department of Animal Production, Faculty of Science and Technology of Animal Production, Sudan University of Science and Technology, Khartoum North (Kuku), Sudan (www.sustech.edu)
[2]Department of Field Crops Sciences, Faculty of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan (www.sustech.edu)
[3] Department of Animal Production, Faculty of Agriculture, Al Zaeem Al Azhary University
*Email: muna_eltayeb@yahoo.com

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ABSTRACT
This study was conducted at the Farm of the College of Agricultural Studies (Shambat), Sudan University of Science and Technology, during 2007/08 – 2008/09 winter seasons to investigate the effects of nitrogen fertilization and plant spacing on growth of three fodder beet cultivars (Voroshenger, Anisa and Polyproductiva) using a factorial Randomized Complete Block Design (RCBD) arranged in split -split plots. Nitrogen treatments at a rate of 0, 40, 80 and 120 kg N/ha were applied eleven days from planting. The plant spacing were 15, 20 and 25 cm between holes. Nitrogen application significantly ($p<0.05$) increased root diameter, shoot length in both seasons and plant height in the second season; and plant height highly significantly ($p<0.01$) in the first season. Nitrogen had no significant effects on number of leaves and root length. Wider spacing significantly ($p<0.05$) increased number of leaves, root diameter in the first season. Spacing had no significant effects on root length, shoot length and plant height. Cultivars exhibited highly significant ($p<0.01$) differences in number of leaves, root diameter, root length and plant height in both seasons. Cultivars exerted a significant ($p<0.05$) effect on shoot length in the first season. Application of 80 kg N/ha and sowing at 25cm apart (N_2S_3) increased root length highly significantly ($p<0.01$) and plant height significantly ($p<0.05$) in the first season. Nitrogen and cultivars interaction resulted in significant($p<0.05$) increase in leaves number attained by Voroshenger and Polyproductiva cultivars under 80 kg/N/ha (N_2V_1 and N_2V_3) in the first and second season, respectively.
KEYWORDS: Nitrogen, Spacing, Growth, Fodder beet and Cultivars

INTRODUCTION

The production of forage crops is very important for livestock production. Animal production in the Sudan depends mainly on natural range which is affected by rain fluctuations and low quality grasses. This necessitates the introduction of irrigated forage crops in the irrigated schemes and in farms around cities like Khartoum. Moreover; the estimated livestock number was 140 million heads [1].

In the fodder plants, the economical yield is the biological yield, so the growing conditions must be optimum and carefully determined to obtain better growth and hence higher biomass yield.

Nitrogen is a vital element for plant growth as it is a component of protein and chlorophyll. It is thus, essential for photosynthesis and growth. Nitrogen is needed in greater amount than other elements and it is often the most limiting factor in crop production. Hence, application of fertilizer nitrogen results in higher biomass yield[2]. Often the only mineral fertilizer added is straight nitrogen[3].

The above and below growth parts (leaves and roots) are used to feed the animals but, the main fodder is tuberous roots[4]. Therefore the optimum population which produces maximum leaves and roots growth and hence productivity must be carefully determined.

Fodder beet tops and roots are succulent, palatable, and easily digestible and liked by most livestock[5]. Its tubers are nutritious, could be a good source of carbohydrates and very rich in starch (NFE= 81% of DM)[6] .

The growth and productivity of fodder beet vary between cultivars, beet parts and growing conditions[7].

Fodder beet is a good forage especially during the critical period of forage shortage such as early summer and late winter season in the Sudan and other countries. The objectives of this study were to investigate the effects of nitrogen application and plant spacing on the growth of fodder beet cultivars under Sudan conditions.

MATERIALS AND METHODS

A field experiment was conducted in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat Khartoum North (latitude 15 º 40′ N, longitude is 32 º 32′ E, during two winter seasons (2007-08 and 2008-09). The climate of the locality is tropical semi-arid with low relative humidity. The soil of the experimental site is clay loam with low nitrogen content (0.05%) and ph of 7.9.

The land was ploughed, harrowed twice, leveled and ridged at 70 cm apart. The experimental design was randomized complete block arranged in split-split plots with four replicates. Four nitrogen fertilization levels were applied to the main plots (81 m^2), three spacing were used as sub-plots (27 m^2) and three cultivars were sown on the sub-plots (9 m^2) in four rows each (3.21 m in length and 0.70 m in width).

The seeds of the three tested fodder beet cultivars (Voroshenger, Anisa and polyproductiva) were imported from Egypt. Fodder beet cultivars were sown at a rate of 4.6 kg/ha on November 30 and 31 in the first and second season, respectively. Seeds were planted on top of the shoulder of the ridge in a row 70 cm apart (3 seeds per hole).

Nitrogen fertilization in the form of urea (46 % N), was applied once before the third irrigation (11 days from planting) at a rate of 0 (N0) as control, 40 (N1), 80 (N2), and 120 (N3) kg N/ha. Triple superphosphate (46% P_2O_5) was added pre-planting at a rate of 100 kg/fed. as agronomic practice. Three spacing between holes: 15 cm (S1), 20 cm (S2) and 25 cm (S3) were used.

The frequency of irrigation was every 7-10 days intervals depending on the temperature, relative humidity and soil moisture conditions. Hand thinning to one plant per hole and resowing by the removed seedlings were done simultaneously

after 5-6 weeks from planting during both seasons. Manual weeding by a hand implement"Nagama" was done, after 5 weeks from planting in the two seasons.

At harvest (3 – 3.5 months from sowing) when plants showed signs of maturity which is indicated by leaf yellowing and partial drying of the lower leaves, three plants from the inner two ridges of each plot were randomly hand-pulled to determine number of leaves, root diameter, root length, shoot length and plant height .Data were analyzed as split-split plot design by the analysis of variance[8] using MSTAT[9]. Means were separated using the Duncan Multiple Range Test (D.M.R.T) and Least Significant Difference (LSD) procedures at 5% level.

RESULTS

Increasing nitrogen fertilization insignificantly increased leaves number (Table 1).Number of leaves increased markedly with wider spacing in the two seasons and the effect was significant in the first season (Table 1). In both years, Voroshenger and Polyproductiva had significantly more leaves than Anisa (Table 1).Number of leaves/plant was significantly affected by the interaction effect between nitrogen X cultivars in the first season (Table 3). The highest number of leaves was obtained by Voroshenger (CV_1) fertilized by (N_2) 80 Kg N/ha.

Increasing nitrogen fertilizer doses significantly increased root diameter in both seasons (table 1), and the greater diameter was obtained under N2 (80 Kg N/ha).In both seasons, root diameter of cultivar Anisa was highly significantly wider than that of Voroshenger and Polyproductiva (Table 1).

Wider spacing resulted in greater root diameter with a significant effect in the first season when S_3 (25 cm) was similar to S2 (20cm) and significantly differed from S1 while the latter spacing were not significantly different (Table 1).

Neither nitrogen fertilization nor spacing had significant effects on root length during the two seasons (table 1). However, both Voroshenger and Polyproductiva cultivars highly significantly surpassed Anisa in root length by 10.3, 9.4 and 12.3, 13.4% in both seasons, respectively (table 1).

A highly significant interaction effect between nitrogen and spacing on root length in the first season was observed, when the longest root was achieved by adding N_2 (80 Kg N/ha) and sowing at (S_3) (25 cm between holes) (table 2).

Shoot length increased significantly with increasing nitrogen fertilization. The greatest shoot length were obtained under N_3 (120 Kg N/ha) and N_2 (80 Kg N/ha) (Table 1).

Table 1: Effects of nitrogen fertilization, spacing and cultivars on growth of fodder beet for 2007-08 and 2008-09

	Treatments	Number of leaves (No.)		Root diameter (cm)		Root length (cm)		Shoot length (cm)		Plant height (cm)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Nitrogen	N0	27.33 a	29.65 a	23.70 b	28.08 b	38.21 a	40.50 a	46.62 c	47.66 b	84.83 c	88.16 b
	N1	29.17 a	29.24 a	25.45 ab	28.67 ab	37.72 a	40.60 a	47.98 bc	48.09 b	85.70 b	88.69 ab
	N2	32.25 a	30.67 a	27.21 a	32.11 a	38.48 a	41.69 a	49.84 ab	54.05 a	88.33 ab	95.75 ab
	N3	29.81 a	30.85 a	27.01 a	30.87 ab	40.29	42.66	51.29 a	53.19 a	91.58 a	95.85 a
F-test		NS	NS	*	*	NS	NS	*	*	**	*
SE ±		2.58	1.55	0.95	1.11	0.68	1.06	0.91	1.59	1.04	2.42
Spacing	S1	26.59 b	29.91 a	24.58 b	29.06 a	38.33 a	40.89 a	48.88 a	50.21 a	87.21 a	91.10 a
	S2	28.49 ab	30.90 a	25.63 ab	29.92 a	37.97 a	41.26 a	48.94 a	51.19 a	86.92 a	92.45 a
	S3	33.86 a	29.51 a	27.33 a	30.81 a	39.73 a	41.94 a	48.97 a	50.84 a	88.70 a	92.78 a
F-test		*	NS	*	NS	NS	NS	NS	NS	NS	NS
SE ±		1.95	0.99	0.85	0.68	0.62	0.77	0.75	0.74	0.95	1.20
Cultivars	CV1	33.34 a	32.42 a	24.96 b	28.94 b	40.17 a	42.92 a	49.67 a	51.23 a	89.84 a	94.15 a
	CV2	24.74 b	25.57 b	27.93 a	32.29 a	36.05 b	37.66 b	47.32 b	50.24 a	83.37 b	87.90 b
	CV3	30.85 a	32.32 a	24.64 b	28.56 b	39.81 a	43.51 a	49.81 a	50.77 a	89.62 a	94.28 a
F-test		**	**	**	**	**	**	*	NS	**	**
SE ±		0.90	0.92	0.51	0.46	0.62	0.63	0.68	0.67	1.01	1.05

NS: Not significant *: Significant (5%) **: Highly Significant (1%)
Means within each column followed by the same letters are not significantly different at (5%) level according to DMRT.
Nitrogen fertilization: N0 (Control) N1 (40 kg, N/ha) N2 (80 kg, N/ha) N3 (120 kg, N/ha)
Spacing: S1 (15 cm) S2 (20 cm) S3 (25 cm)
Cultivars: CV1 (Voroshenger) CV2 (Anisa) CV3 (Polyproductiva)

Table 2: Effects of nitrogen X spacing interactions for growth of fodder beet for 2007-08 and 2008-09

Treatments		Number of leaves (No.)		Root diameter (cm)		Shoot length (cm)		Root length (cm)		Plant height (cm)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
N0	S1	24.58 a	29.61a	21.09 a	26.60 a	45.46 a	47.06 a	35.64 d	39.48 a	81.10d	86.54 a
	S2	26.78 a	29.39 a	24.23 a	28.99 a	46.53 a	46.90 a	39.86abc	41.11 a	86.38abcd	88.01 a
	S3	30.64 a	29.94 a	25.79 a	28.63 a	47.87 a	49.02 a	39.13abcd	40.91 a	86.99abcd	89.92 a
N1	S1	26.17 a	30.61 a	24.41 a	28.49 a	48.55 a	49.16 a	40.03abc	41.95 a	88.58abc	91.11 a
	S2	29.17 a	30.06 a	25.91 a	28.79 a	47.88 a	48.28 a	36.49cd	40.02 a	84.37cd	88.30 a
	S3	32.18 a	27.06 a	26.04 a	28.73 a	47.53 a	46.83 a	36.63cd	39.83 a	84.15cd	86.66 a
N2	S1	27.45 a	30.91 a	25.25 a	31.14 a	48.96 a	52.87 a	37.58bcd	40.95 a	86.54abcd	93.82 a
	S2	28.93 a	33.42 a	26.31 a	31.70 a	50.46 a	56.14 a	35.58d	41.16 a	86.03bcd	97.29 a
	S3	40.38 a	27.70 a	30.07 a	33.49 a	50.12 a	53.15 a	42.29a	42.98 a	92.41a	96.13 a
N3	S1	28.14 a	28.50 a	27.56 a	30.02 a	52.57 a	51.74 a	40.05abc	41.19 a	92.62a	92.93 a
	S2	29.08 a	30.72 a	26.08 a	30.19 a	50.91 a	53.45 a	39.97abc	42.76 a	90.88ab	96.20 a
	S3	32.23 a	33.33 a	27.40 a	32.39 a	50.38 a	54.38 a	40.87ab	44.04 a	91.25ab	98.42 a
F-test		NS	NS	NS	NS	NS	NS	**	NS	*	NS
SE ±		3.9	1.97	1.69	1.36	1.50	1.48	1.23	1.55	1.90	2.40

NS: Not significant *: Significant (5%) **: Highly Significant (1%)
Means within each column followed by the same letters are not significantly different at (5%) level according to DMRT.
Nitrogen fertilization: N0 (Control) N1 (40 kg, N/ha) N2 (80 kg, N/ha) N3 (120 kg, N/ha)
Spacing: S1 (15 cm) S2 (20 cm) S3 (25 cm)

Table 3: Effects of nitrogen X cultivar interactions on growth of fodder beet for 2007-08 and 2008-09

Treatments		Number of leaves (No.)		Root diameter (cm)		Root length (cm)		Shoot length (cm)		Plant height (cm)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
N0	CV1	30.33 bcd	33.50 a	22.48 a	28.60 a	40.66 a	42.46 a	47.98 a	49.49 a	88.64 a	91.95 a
	CV2	23.74 e	23.83 a	25.74 a	29.40 a	34.85 a	35.84 a	45.11 a	46.02 a	79.96 a	81.86 a
	CV3	27.93 cde	31.61 a	22.89 a	26.23 a	39.12 a	43.19 a	46.76 a	47.47 a	85.88 a	90.66 a
N1	CV1	32.23 bc	31.33 a	25.13 a	26.66 a	40.27 a	42.00 a	47.79 a	47.84 a	88.06 a	89.83 a
	CV2	24.53 e	25.75 a	27.50 a	31.87 a	35.60 a	37.44 a	47.44 a	48.52 a	83.04 a	85.96 a
	CV3	30.75 bcd	30.64 a	23.73 a	27.48 a	37.28 a	42.36 a	48.72 a	47.92 a	86.00 a	90.28 a
N2	CV1	40.07 a	30.97 a	27.03 a	30.59 a	38.70 a	42.76 a	50.21 a	54.88 a	88.91 a	97.64 a
	CV2	25.99 de	27.80 a	28.48 a	34.47 a	35.80 a	39.09 a	48.73 a	52.47 a	84.53 a	91.55 a
	CV3	30.70 bcd	33.25 a	26.13 a	31.27 a	40.95 a	43.24 a	50.59 a	54.81 a	91.54 a	98.05 a
N3	CV1	30.72 bcd	33.89 a	25.19 a	29.90 a	41.03 a	44.47 a	52.70 a	52.72 a	93.73 a	97.19 a
	CV2	24.70 e	24.89 a	30.02 a	33.42 a	37.95 a	38.26 a	47.99 a	53.96 a	85.94 a	92.22 a
	CV3	34.03 b	33.78 a	25.83 a	29.28 a	41.90 a	45.25 a	53.17 a	52.90 a	95.07 a	98.15 a
F-test		*	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE ±		1.81	1.84	1.01	0.92	1.24	1.25	1.35	1.33	2.02	2.10

NS: Not significant *: Significant (5%) **: Highly Significant (1%)
Means within each column followed by the same letters are not significantly different at (5%) level according to DMRT.
Nitrogen fertilization: N0 (Control) N1 (40 kg, N/ha) N2 (80 kg, N/ha) N3 (120 kg, N/ha)
Cultivars: CV1 (Voroshenger) CV2 (Anisa) CV3 (Polyproductiva

Table 4: Effects of spacing X cultivars interactions on growth of fodder beet for 2007-08 and 2008-09

Treatments		Number of leaves (No.)		Root diameter (cm)		Root length (cm)		Shoot length (cm)		Plant height (cm)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
S1	CV1	28.71 a	32.52 a	23.56 a	27.33 a	39.74 a	42.17 a	49.39 a	50.13 a	89.14 a	92.30 a
	CV2	22.52 a	25.68 a	26.93 a	32.40 a	35.53 a	37.73 a	47.08 a	50.85 a	82.61 a	88.58 a
	CV3	28.53 a	31.52 a	23.24 a	27.45 a	39.71 a	42.76 a	50.18 a	49.66 a	89.89 a	92.42 a
S2	CV1	32.51 a	32.71 a	25.00 a	28.98 a	39.64 a	42.52 a	50.64 a	52.14 a	90.29 a	94.66 a
	CV2	23.89 a	27.06 a	28.23 a	32.32 a	35.39 a	37.17 a	46.83 a	50.33 a	82.23 a	87.50 a
	CV3	29.06 a	32.92 a	23.66 a	28.45 a	38.88 a	44.08 a	49.35 a	51.11 a	88.23 a	95.19 a
S3	CV1	38.79 a	32.04 a	26.31 a	30.51 a	41.11 a	44.07 a	48.98 a	51.43 a	90.08 a	95.50 a
	CV2	27.81 a	23.96 a	28.64 a	32.15 a	37.23 a	38.06 a	48.04 a	49.55 a	85.28 a	87.61 a
	CV3	34.96 a	32.52 a	27.02 a	29.78 a	40.84 a	43.68 a	49.90 a	51.56 a	90.74 a	95.24 a
F-test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE ±		1.57	1.60	0.88	0.80	1.07	1.08	1.17	1.15	1.75	1.81

NS: Not significant *: Significant (5%) **: Highly Significant (1%)
Means within each column followed by the same letters are not significantly different at (5%) level according to DMRT.
Spacing: S1 (15 cm) S2 (20 cm) S3 (25 cm)
Cultivars: CV1 (Voroshenger) CV2 (Anisa) CV3 (Polyproductiva)

Increasing spacing gradually increased shoot length but no significant differences were observed between the different spacing (Table 1). Voroshenger and Polyproductiva had significant greater shoot length than Anisa and the difference was significant in the first season (Table 1).

Increasing nitrogen fertilization increased plant height highly significantly in the first season and only significant in the second season (table 1). Adding N3 (120 Kg N/ha) gave significantly greater plant height over the control (N0). The results also indicated that closer spacing between holes tended to decrease plant height insignificantly (Table 1). Voroshenger and Polyproductiva gave the greatest plant height compared to Anisa cultivar and the difference was highly significant (Table 1).Plants fertilized by 120 Kg N/ha (N_3) and sown at 15 cm apart (S_1) attained significantly greater plant height in the first season (Table 2). Spacing and cultivars had no significant interaction effect on all growth attributes (Table 4).

DISCUSSION

Nitrogen fertilization had no significant effect on number of leaves per plant which supports the result found by[10] working on Sugar beet in the Sudan. The increment in leaves number due to increase in spacing supports the findings of[11] and[12] in Roz-Saszinu fodder beet cultivar .The significant cultivar effect on number of leaves/plant during both seasons confirms the finding of [13] in three sugar beet cultivars. The highest leaves number recorded for Voroshenger under 80 kg N/ha due to the interactive effect between nitrogen and cultivars might have been due to the differences in N efficiency between cultivars.

The positive response of root diameter to increasing nitrogen levels supports the findings of[14,15] in Sugar beet cultivars,[16,17] and[18] in some fodder beet cultivars. The significant increase in root diameter of fodder beet resulted from wider spacing supports the results obtained by[19] in monovert fodder beet cultivar,[20] and[11] in some sugar beet cultivars. The wider spacing (35cm between hills) gave more space to roots to grow horizontally and its root diameter was bigger than in the lowest hill spacing (15cm) as reported by[12] working on fodder beet. The significant difference between the tested cultivars in root diameter confirms the finding of [15]. Root length was increased insignificantly and gradually as nitrogen rate was increased, and the same finding was reported by [21] working on two sugar beet cultivars .Plant spacing had no significant effect on root length. Analogous result was reported by [19] for monovert fodder beet cultivar.The cultivar differences in root length are in line with those results obtained by [22],[23],[17] and [24] .A significant interaction effect between nitrogen and spacing on root length was observed in the first season when the highest root length was recorded for sowing at 25cm under 80 kg N/ha (N_2 S_3). This result coincides with those reported by [14].

Shoot length increased significantly as nitrogen rates increased. Nitrogen increases vegetative growth and internodes length [25]. Shoot length was insignificantly increased with the increasing of planting spacing and the longest shoot was recorded for S_2 (20cm) in the second season. The difference between the three fodder beet cultivars under study could be due to the variation in the genetic make-up and their response to the environmental conditions. This result is in agreement with those reported by [22] and [23].

Plant height was significantly greater under higher nitrogen levels in both seasons. This could be attributed to the role of nitrogen in enhancing plant growth and internodes length [25]. Plant height was insignificantly increased with respect to increasing spacing. In the second season 25cm between holes produced the tallest plants. Similar finding was reported by [19]. Both Voroshenger and Polyproductiva attained significantly greater root length and shoot length compared to Anisa. These results may be behind the highly significant difference in plant height between the three studied cultivars where again the cultivars of Voroshenger and polyproductiva attained greater plant height than Anisa during both seasons. The combination of high nitrogen dose and close spacing (N3S1) and lower nitrogen dose and wider spacing (N2S3) gave the tallest plants .This may reflect the efficient utilization of nitrogen with respect to plant density and nitrogen dose (greater number of plants applied with high dose of nitrogen whereas fewer number supplied with lower dose).

CONCLUSIONS

Nitrogen fertilization improved growth of fodder beet, and had significant positive effects on root diameter, shoot length and plant height. Mostly, the highest growth was associated with 80 kg N/ha. So, it can be recommended to be the optimum dose under Shambat conditions. There was a trend for growth to increase at wider plant spacing of 25 cm. Both Voroshenger and Polyproductiva cultivars were superior over Anisa in growth parameters except for root diameter. Most interactions between nitrogen, spacing and cultivars were not significant for growth attributes.

The present results are, indicative of the potential success of fodder beet as a winter fodder crop in Sudan. Since climatic and agronomic factors can influence the performance and success of beet culture, hence, further trials are required to identify optimum agronomic practices especially sowing time, soil type, land preparation, fertilization, spacing and harvesting date.

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