RESULTS AND DISCUSSION

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I. Effect of Plant Spacing on Growth Parameters at Different Growth Stages of Sugarbeet:

A. Growth analysis:

1. Plant height (cm):

Combined analysis of the two seasons shows that plant spacing did not affect significantly plant height at 100,121 and 163 days after sowing , whereas it was significant after 142 days from sowing. As shown in Table (3), plant height comes to its maximum height at plant spacing of 25 cm between hills, whereas it comes to its minimum height at 10 cm between hills. The differences between the two treatments was significant. In general, plant height was not significantly affected by plant spacing at 100, 121 and 163 days after sowing.

Table (3): Plant height as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	26.29	31.00	39.79 c	47.62
15	26.81	32.62	41.63 bc	48.47
20	26.60	34.28	42.78 ab	47.42
25	28.60	34.60	43.12 a	46.60
F-test	N.S	N.S	*	N.S

2. Root length (cm):

The effect of plant spacing on root length is shown in Table (4). Data showed that root length of sugarbeet was insignificantly affected by plant spacing at 100 , 121 and 142 days from sowing, whereas it was significant at 163 days after sowing, as shown in Table (4). Root length of sugarbeet plant reached its maximum value at 25 cm between hills, whereas it reached its minimum value at 10 cm between hills. The difference between the two treatments was significant. On the other hand, the differences of root length between 10 and 15 cm as well as between 20 and 25 cm between hills were not significant as shown in Table (4). In this regard, Obead (1980) reported that, increasing the distance between rows up to 60 cm significantly increased the root length.

Table (4): Root length as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	22.20	26.11	31.51	37.80 b
15	22.68	26.89	31.28	32.52 b
20	22.82	27.00	35.69	34.82 a
25	23.81	27.49	33.41	34.89 a
F-test	N.S	N.S	N.S	*

3. Root diameter:

Data in Table (5) showed that root diameter was significantly affected by plant spacing at all growth stages except the first one (100 days after sowing). The highest diameter of root was found after 163 days from sowing with 25 cm plant spacing as shown in Table (5).

In general, increasing plant spacing from 10 to 20 cm significantly increased root diameter of sugarbeet at 121, 142 and 163 days after sowing. It could be seen from Table (5) that the differences of root diameter between 10, 15 and 20, 25 cm between hills were not significant at both 121 and 142 days after sowing. On the other hand, the differences between 15, 20 and 25 cm between hills were not significant at 163 days after sowing. In this respect, Obead (1980) showed that beet root diameter increased with increasing distance in inter-row spaces.

Table (5): Root diameter as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	3.62	4.30 b	5.09 b	7.30 c
15	3.87	4.87 b	5.62 b	7.69 b
20	4.32	5.31 ab	6.01 ab	8.05 ab
25	4.80	6.02 a	6.80 a	8.82 a
F-test	N.S	*	*	*

4. Fresh weight of blades/plant (g):

Data presented in Table (6) indicated that fresh weight of blades/plant was significantly increased as plant spacing increased from 10 to 25 cm at stages of growh. Total fresh weight of blades reached its maximum weight at 25 cm between plants, whereas it reached its minimum weight at 10 cm between plants at all stages of growth.

Total fresh weight of blades increased consistently as the distance between plants increased. The highest fresh weight of blades was found at the fourth stage of growth with 25 cm plant spacing (307.60 g/plant). These results confirmed those of Basha (1984) who reported that the blades fresh weight consistently increased by decreasing the plant population from 56 to 33.6 thousand plants/fad.

Table (6): Fresh weight of blades per plant as affected by plant spacing at different growth stages (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	85.7 b	124.4 d	172.7 c	223.8 c
15	106.9 b	150.8 c	208.5 b	252.8 bc
20	114.4 a	160.7 bc	220.1 a	282.0 b
25	119.3 a	175.6 a	234.8 a	307.6 a
F-test	*	*	*	*

5. Fresh weight of petioles/plant (g):

Table (7) revealed that the fresh weight of petioles/plant was significantly affected by plant spacing at all growth stages. Increasing distance from 10 to 25 cm increased fresh weight of petioles. At 25 cm plant spacing, the highest fresh weight of petioles was found. Increasing plant spacing from 20 to 25 cm did not affect fresh weight of petioles at 100 and 121 days after sowing. On the other hand, the differences were significant between 10 and 15 cm at 100, 121 and 142 days after sowing. The differences of fresh weight of petioles between 10 and 15 cm was not significant at 163 days after sowing. However, it is observed from Table (7) that there was a consistent increase in fresh weight of petioles as the plant spacing increase in all growth stages. The fresh weight of petioles/plant ranged between 89.6 and 414.7 g/plant throughout growth stages. These results agree with those reported by Basha (1984) and Assey *et al.*(1992 a). They showed that the fresh weight of petioles/plant increased with decreasing plant population in unit area.

Table (7): Fresh weight of petioles per plant as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	60.6 c	103.3 c	174.3 c	313.0 c
15	72.2 b	135.4 b	210.4 b	335.9 c
20	83.0 a	157.3 a	225.0 b	362.5 b
25	89.6 a	166.1 a	241.1 a	414.7 a
F-test	*	*	*	*

6. Fresh weight of leaves/plant (g):

Widening distance between plants resulted in a marked increase in leaves fresh weight/plant (Table 8). This was true for all growth stages. It could be shown from Table (8) that plant spacing of 20 and 25 cm did not affect significantly fresh weight of leaves at 100, 121 and 142 days after sowing , whereas it was significant between 10 and 15 cm between plants. It is clear from data in Table (8) that there was a consistent increase in fresh weight of leaves as plant spacing increase in all growth stages.

These results are similar to those obtained by Basha (1984) and Nour El-Din *et al.*(1993) who showed that the fresh weight of leaves/plant significantly increased with decreasing plant density/fad.

Table (8): Fresh weight of leaves per plant as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing 100	121	142	163
10	151.1 c	229.6 c	332.2 c	513.1 c
15	184.0 b	288.1 b	394.6 b	565.5 bc
20	202.7 a	319.7 a	429.8 a	621.3 b
25	214.1 a	343.6 a	451.5 a	699.0 a
F-test	*	**	*	*

7. Fresh weight of root/plant (g):

Root fresh weight was significantly affected by plant spacing and this was true for all growth stages (Table 9). The differences in fresh weight of root were significantly between 20 and 25 cm at 100 and 121 days after sowing,whereas they were not significant between the two spaces at 142 and 163 days after sowing. However, it could be shown from Table (9) that a consistent increase was observed as plant spacing increase. The highest value of the fresh weight of root/plant was recorded at 25 cm plant spacing. In this respect, Ramadan (1986) and Nour El-Din *et al.*(1993) reported that increasing plant population decreased fresh weight of sugarbeet root/plant.

Table (9): Fresh weight of root per plant as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	87.1 c	152.6 d	363.5 c	572.8 c
15	108.7 b	187.8 c	374.8 bc	624.7 b
20	113.2 b	218.4 b	400.2 ab	654.3 ab
25	122.7 a	241.2 a	423.7 a	683.0 a
F-test	*	**	*	*

8. Total fresh weight of plant (g):

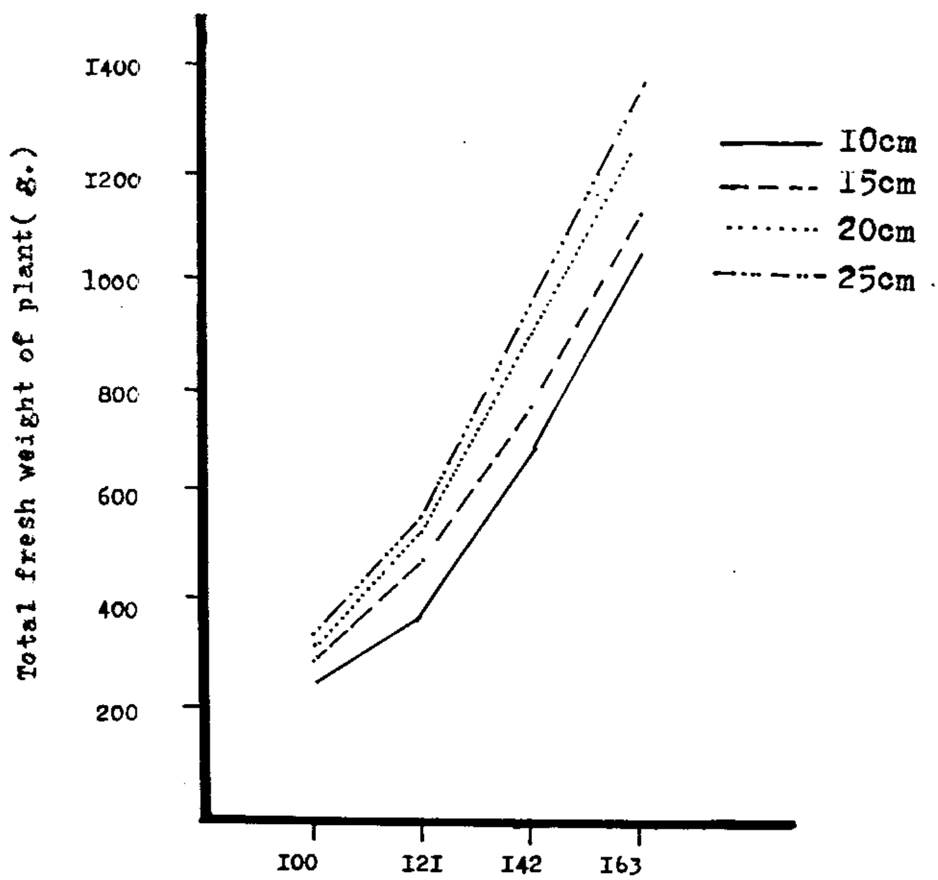
The effect of plant spacing on fresh weight of sugarbeet plant is shown in Table (10) and Fig.(1).

The data indicated that total weight of plant was significantly affected by plant spacing at all growth stages. Increasing distance between plants from 10 to 25 cm significantly increased fresh weight of plant. It could be shown from Table (10) that the differences in total fresh weight of plant between 20 and 25 cm at 100 and 163 days after sowing were not significant, whereas the differences in total fresh weight were significant between all plant spacing at 121 and 142 days after sowing. It increased to its maximum value with 25 cm between plants, whereas it reached its minimum value with 10 cm between plants at 121 and 142 days after sowing. The highest weight (1382 g) was observed at the fourth growth stage (163 days after sowing) with 25 cm plant spacing (Fig.1). Such effect may be due to inter-plant competition for light, soil moisture and nutrition accompanying dense sowing which may be reflected in decreasing fresh weight of plant.

These results agree with those reported by El-Gedawi (1979),Basha (1984),El-Shafei (1991) and Nour El-Din *et al.* (1993) who found that fresh weight of sugarbeet plant increased with decreasing plant population.

Table (10): Total fresh weight per plant as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing 100	121	142	163
10	240.6 b	382.2 d	695.5 d	1069.1 c
15	292.7 b	475.8 c	769.5 c	1131.6 bc
20	327.8 a	538.1 b	925.2 b	1275.6 ab
25	336.8 a	579.7 a	969.9 a	1382.0 a
F-test	*	*	*	*



Days after sowing

Fig.(1): Total fresh weight of plant as affected by plant spacing at different growth stages.

9. Dry weight of blades/plant (g):

The results in Table (11) revealed that blades dry weight was insignificantly affected by plant spacing only at 121 days after sowing, whereas it was significant at the other plant spacing. The differences in dry weight of blades were significant between 10 and 15 cm at 100 , 142 and 163 days after sowing. The differences between 15 and 25 cm between hills were significant as well. It could be stated that a consistent increase in dry weight of blades was observed as plant spacing increase at all growth stages as shown in Table (11). The highest dry weight of blades was found at the fourth stage of growth (163 days after sowing) with the 25 cm plant spacing (28.15 g/plant). It could be concluded that the accumulation of dry weight in the blades increased with increasing plant spacing as reported by Assey et al.(1992 a). On the other hand, Gobarh (1993) reported that blades dry weight was not affected by plant spacing.

Table (11): Dry weight of blades per plant (g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	7.15 c	10.45	15.55 c	21.33 d
15	8.65 b	12.45	17.70 b	23.75 c
20	9.40 ab	13.10	19.40 a	26.10 b
25	10.25 a	13.61	19.81 a	28.15 a
F-test	*	N.S	*	*

10. Dry weight of petioles/plant (g):

Dry weight of petioles/plant increased with increasing plant spacing (Table 12). Significant differences among plant spacing at all growth stages were found. Dry weight of petioles increased significantly between all plant spacing at 100 and 121 days after sowing. Regarding to 142 days after sowing, it could be shown from Table (12) that the difference between 20 and 25 cm plant spacing was not significant as well as between 10 , 15 and 20 cm at 163 days after sowing. It looks to be true that increasing plant spacing from 10 up to 25 cm caused a consistent increase in dry weight of petioles/plant. This is to be expected since decreasing plant spacing was positively correlated with inter specific competition. On the other hand, such effect may reflect the increase in photosynthetic area accompanying lower plant density , which resulted in more dry weight in tops as reported by Hills (1973). Basha (1984) , Assey *et al.*(1992 a) and Gobarh (1993).

Table (12): Dry weight of petioles per plant (g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	4.59 d	8.10 d	11.68 c	22.25 d
15	6.46 c	10.27 c	15.81 b	23.35 cd
20	7.32 b	11.33 b	17.12 a	24.10 bc
25	8.25 a	12.75 a	17.75 a	26.51 a
F-test	*	*	**	*

11. Dry weight of leaves/plant (g):

The results in Table (13) revealed that plant spacing insignificantly affected dry weight of leaves/plant at 100 days after sowing, whereas it was significant at 121, 142 and 163 days after sowing. Generally, widening distance between sugarbeet plants up to 25 cm resulted in increasing leaves dry weight as shown in Table (13). Highly significant difference was calculated at 163 days after sowing and the highest value of the dry weight of leaves was 54.36 g/plant at 25 cm plant spacing.

These results agree with those reported by Zalat (1986) and Assey *et al.*(1992 a) who showed that dry weight of leaves/plant was significantly increased as plant population decreased/fad.

Table (13): Dry weight of leaves per plant (g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	11.71	18.54 c	27.28 c	44.00 c
15	15.11	22.71 b	33.48 b	47.14 b
20	16.73	24.44 ab	36.52 a	48.78 b
25	18.47	26.36 a	37.54 a	54.36 a
F-test	N.S	*	*	**

12. Dry weight of root/plant (g):

The effect of plant spacing on dry weight of root/plant is shown in Table (14). Data showed that plant distance insignificantly affected dry weight of root after 142 days from sowing. However, at 100, 121 and 163 day stages, dry weight of root was significantly increased as plant distance increased up to 25 cm. It could be shown from Table (14) that dry weight of root/plant was significantly higher at 25 cm plant spacing than that at 15 and 20 cm plant spacing at 100 days after sowing. Plant spacing of 10 cm decreased significantly dry weight of root/plant than that of 15 , 20 and 25 cm plant spacing. Similar results were obtained at 163 days after sowing. It could be concluded that dry weight of root/plant increased consistently as plant spacing increased up to 25 cm at all growth stages. Similar results were reported by Basha (1984), Hanna *et al.*(1988) and Assey *et al.*(1992 a) who stated that dry weight production of beet roots increased as row spacing increased from 35 to 70 cm as well as hill spacing from 10 to 30 cm. Also, Nour El-Din *et al.*(1993) found that dry weight of root decreased accompanying to the increase in plant density.

Table (14): Dry weight of root per plant (g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	17.28 c	26.96 c	57.20	98.95 c
15	21.03 b	31.89 b	57.55	105.94 b
20	21.98 b	36.28 a	60.20	109.84 b
25	25.18 a	37.14 a	65.36	121.25 a
F-test	*	*	N.S	**

13. Total dry weight of plant (g):

The effect of plant spacing on total dry weight of plant is shown in Table (15) and Fig.(2). The results showed that total dry weight of plant was significantly increased with increasing plant spacing up to 25 cm. This increase was recorded at all growth stages. There was highly significant difference in dry weight of plant among plant spacing at the fourth stage of growth (163 days after sowing). In general, it could be stated that dry weight of plant increased consistently as plant spacing increased up to 25 cm for all growth stages. These results may be due to inter-plant competition for light, soil moisture and nutrition accompanying dense sowing which was reflected in lower plant fresh weight as mentioned before. These findings agree with those obtained by Hills (1973), Kamel *et al.* (1981), Pulkrabek (1985), Hanna *et al.*(1988) and Gobarh (1993) who found that dry matter accumulation in beet plants increased with the increase in plant spacing.

Table (15): Total dry weight of plant (g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	28.99 c	45.50 c	84.48 d	142.05 c
15	36.14 ab	54.60 b	91.03 c	153.08 b
20	38.71 b	60.72 a	96.72 b	158.62 b
25	43.65 a	63.50 a	102.90 a	175.61 a
F-test	*	*	*	**

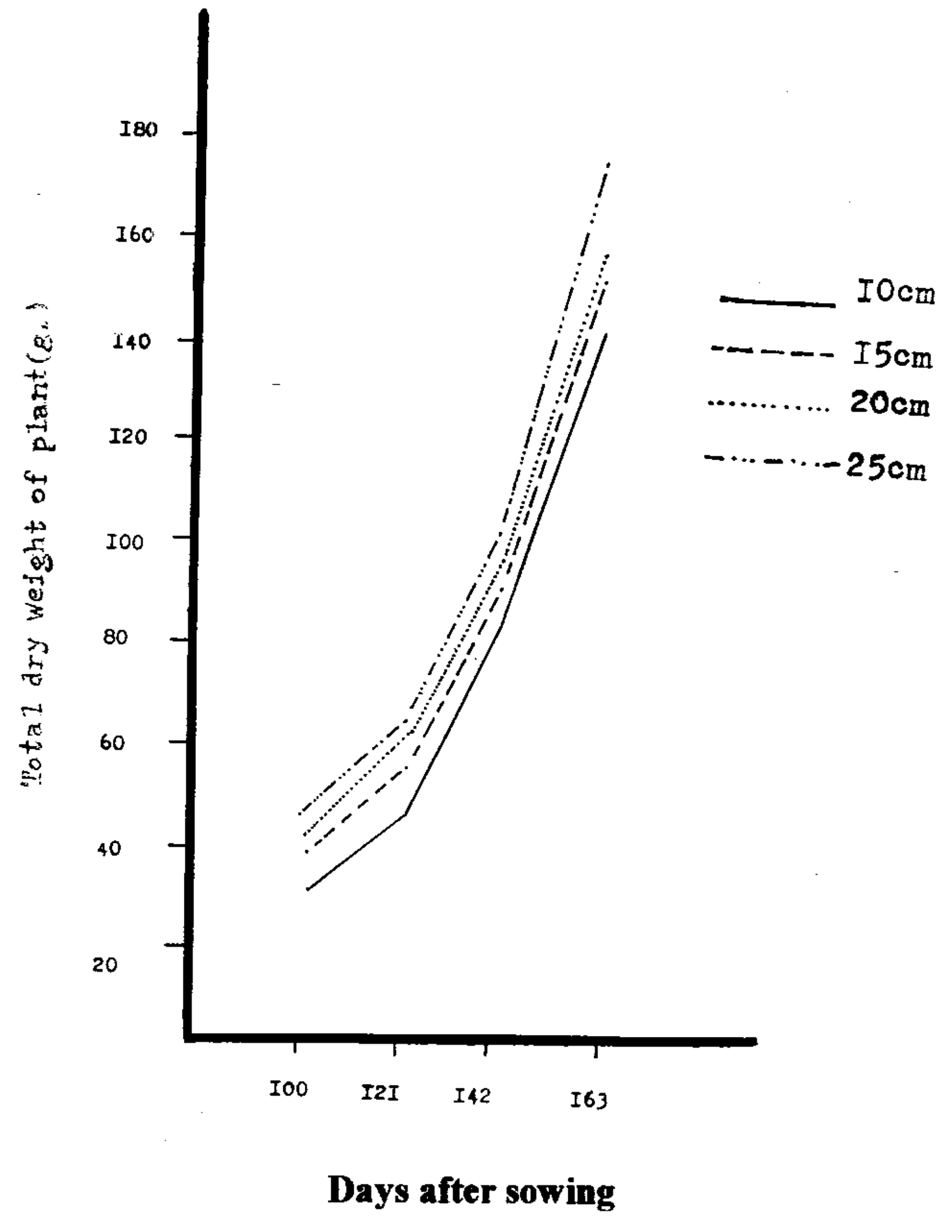


Fig.(2): Dry weight of plant as affected by plant spacing at different growth stages.

14. Leaf area/plant (cm^2):

The data in Table (16) indicated that leaf area/plant (LA) was significantly affected by plant spacing at all growth stages. In general, increasing plant spacing from 10 to 25 cm increased LA. The highest measuring of LA was 5583.3 cm^2 at 25 cm plant spacing with 163 days of age. Such effect may be due to inter-plant competition for light,soil moisture and nutrition accompanying dense sowing, which was reflected in lower size and weight of blades as mentioned before. This finding agree with those obtained by Basha (1984) who found that LA increased with the increase in plant spacing.

Table (16): Leaf area / plant (cm^2) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	1287.8 c	2049.8 c	2935.7 b	4519.4 b
15	1723.5 b	2357.3 b	3602.5 a	4407.7 b
20	1759.4 b	2672.9 a	3692.6 a	5363.9 a
25	1954.0 a	2748.0 a	3780.0 a	5585.3 a
F-test	*	**	*	*

B. Growth attributes:

1. Leaf area index (LAI):

Leaf area index (LAI) was affected by plant spacing at all growth stages (Table 17). The results showed that LAI significantly decreased with increasing distance between hills from 10 to 25 cm. On the other hand , LAI increased as plant age increased. The highest LAI was obtained at 10 cm plant spacing , whereas the lowest one was obtained at 25 cm plant spacing at all growth stages, as shown in Table (17). Similar results were reported by Moraghan (1972) , Aly (1985) , Kamel *et al.*(1989) , El-Shafei (1991) , Gobarh (1993) and Nour El-Din *et al.*(1993). On the other hand, Mahmoud *et al.*(1990 a) found that a significant increase in LAI was observed with increasing distance between rows up to 60 cm.

Table (17): Leaf area index (LAI) as affected by plant spacing at different growth stages (combined analysis 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	2.63 a	4.10 a	5.87 a	8.04 a
15	2.09 bc	3.42 a	4.80 b	5.66 b
20	1.66 bc	2.68 b	3.90 c	5.35 bc
25	1.44 c	2.33 b	3.02 c	4.47 c
F-test	*	**	*	*

2. Leaf area ratio (cm^2 / g):

The results in Table (18) revealed that leaf area ratio (LAR) was not affected by plant spacing till 142 days after sowing. However, after 163 days, increasing plant spacing from 10 to 25 cm significantly increased LAR. At this growth stage, LAR increased from 31.31 to 37.75 cm^2/g with both 10 and 25 cm plant spacing, respectively. The difference in LAR between 10 and 15 cm plant spacing was not significant, whereas LAR increased significantly at 25 cm plant spacing than that of 20 cm plant spacing.

Table (18): Leaf area ratio (cm^2 / g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Days after sowing			
	100	121	142	163
10	53.56	49.52	37.05	13.31 c
15	53.80	48.92	40.71	31.85 c
20	51.85	48.47	39.99	35.75 b
25	50.80	45.18	38.26	37.75 a
F-test	N.S	N.S	N.S	*

3. Leaf weight ratio (LWR):

Data in Table (19) indicated that leaf weight ratio (LWR) was not affected by plant spacing when was recorded after 121 and 163 days after sowing. Moreover, at the growth stages of 100 and 142 days, there were significant differences. Data showed that increasing distance between hills from 10 to 20cm significantly increased LWR. The highest LWR value was 0.64 at 100 days stage with 20 cm plant spacing. Also, it could be shown from Table (19) that the ratio of leaf weight decreased with the progress at maturity for all plant spacings.

However, Obead (1980) and Basha (1984) showed that varying hill spacings from 10 to 30 cm of sugarbeet did not affect LWR.

Table (19): Leaf weight ratio (LWR) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	0.46 c	0.39	0.33 b	0.32
15	0.48 b	0.40	0.37 a	0.32
20	0.64 a	0.39	0.38 a	0.33
25	0.49 b	0.39	0.37 a	0.32
F-test	*	N.S	*	N.S

4. Specific leaf area (cm^2/g):

The effect of plant spacing on specific leaf area (SLA) is shown in Table (20). Data indicated that SLA was not affected by plant spacing when was recorded after 100, 121 and 142 days after sowing. However, at 163 days growth stage the data showed a significant difference in SLA by plant spacing. Increasing plant spacing from 10 to 20 cm significantly increased SLA.

Also, the results indicated that the highest values of SLA was recorded at stage of 121 days. Generally, the 20 cm plant spacing gave the greatest values at all growth stages.

Table (20): Specific leaf area (cm^2 / g) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing			
(cm)	100	121	142	163
10	108.36	118.37	107.21	92.80 c
15	98.97	112.75	105.35	94.02 bc
20	99.97	120.71	109.32	103.18 a
25	96.29	110.00	105.75	100.77 ab
F-test	N.S	N.S	N.S	*

5. Crop growth rate (mg/day):

Crop growth rate (CGR) was always affected by plant spacing at all growth periods (Table 21). Increasing plant spacing from 10 to 25 cm significantly increased CGR at all growth periods. Such effect may be due to the decrease of number of plants per unit area which consequently decreased inter-plant competition for growth elements and increased dry weight per plant as mentioned before (Table 15). It is worth to mention that CGR increased as the growing season progressed up to 163 days after sowing. The highest increase in CGR was recorded at 142-163 days after sowing. These findings are in agreement with those obtained by Assey et al.(1992 a) who reported that increasing distance between rows from 35 to 55 cm as well as within rows from 15 to 25 cm increased CGR determined as g/ plant/ day. On the other hand , Castillo Garcia and Lopez Bellido (1986) found that CGR increased by increasing plant density from 80,000 to 100,000 plants/ha. Also, Gobarh (1993) found that increasing plant spacing from 15 to 20 cm decreased CGR at all growth periods.

Table (21): Crop growth rate (mg/day) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing		
(cm)	100 - 121	121 - 142	163 - 163
10	786.19 b	1656.19 b	2784.29 b
15	879.05 b	1696.76 b	2944.76 b
20	948.10 ab	1714.29 ab	2957.62 b
25	1045.24 a	1876.19 a	3462.38 a
F-test	*	*	**

6. Net assimilation rate (mg/cm^2/day):

The results concerning net assimilation rate (NAR) recorded for three periods with three weeks intervals were significantly decreased as plant spacing increased up to 20 cm at all growth periods (Table 22) , therefore, it slightly increased with 25 cm plant spacing . The highest value of NAR was recorded at 142-163 days after sowing.

In this respect , Aly (1985) , Kamel *et al.*(1989) , Mahmoud *et al.*(1990 a), El-Shafei (1991) and Gobarh (1993) found that NAR was not significantly affected by varying plant spacing.

Table (22): Net assimilation rate (mg/cm^2/day) (NAR) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing		
(cm)	100 - 121	121 - 142	163 - 163
10	0.58 a	0.72 a	0.82 a
15	0.49 ab	0.62 b	0.73 b
20	0.43 b	0.50 c	0.59 c
25	0.43 b	0.59 bc	0.68 bc
F-test	*	*	*

7. Relative growth rate (mg/g/day):

Relative growth rate (RGR) was significantly affected by plant spacing at 100 - 121 and 121 - 142 days growth periods (Table 23), while the results showed that plant spacing did not affect RGR at 142-163 days period. However, there was a tendency for this trait to decrease as plant spacing increased up to 20 cm. RGR decreased with the progress of plant age (Table 23). In this regard, Mahmoud *et al.*(1990 a) reported that a gradual decrease was noticed in RGR as plant spacing increased. On the other hand, Gobarh (1993) found that RGR was not significantly affected by varying plant density.

Table (23): Relative growth rate (mg / g / day) as affected by plant spacing at different growth stages (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing	Days after sowing		
(cm)	100 - 121	121 - 142	163 - 163
10	30.66 b	27.74 a	22.87
15	28.57 b	24.47 b	22.00
20	28.43 b	24.20 b	22.80
25	33.06 a	25.64 b	22.06
F-test	*	*	N.S

Generally, it looks to be true that plant spacing affected significantly most of growth characters, i.e. root diameter, fresh and dry weight of sugarbeet plant and its organs leaf area, CGR, NAR and RGR. It could be concluded that most of these traits increased significantly as plant spacing increased from 10 up to 25 cm between hills at most of growth stages. This is to be expected since high population of plants per unit area at 10 cm plant spacing caused high inter specific competition for the essential requirements of growth such as light, water and nutrients.

II. Effect of Nitrogen Levels on Growth Parameters at Different Growth Stages of sugarbeet:

A. Growth analysis:

1. Plant height (cm):

Concerning plant height , the effect of nitrogen application on this trait is shown in Table (24). Plant height was not significantly affected by nitrogen application at 121 days after sowing. However, plant height increased significantly by increasing nitrogen level up to 90 kg / fad at 100 , 142 and 163 days growth stages. In addition , it could be shown that plant height increased considerably and consistently as nitrogen level increased up to 90 kg/fad. This results was true for the four growth stages as shown in Table (24). The highest values of plant height at 163 days after sowing (52.29 and 52.32 cm) were obtained with application of 75 or 90 kg N / fad , respectively. The same results were obtained by Basha (1984), who reported that plant height increased by increasing nitrogen levels.

Table (24):Plant height (cm) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	22.11 c	28.59	34.47 c	39.10 d
45	24.80 c	30.71	35.98 c	44.89 c
60	28.13 b	33.18	41.21 b	49.21 b
75	29.87 b	36.20	43.29 ab	52.29 ab
90	31.90 a	38.38	45.40 a	52.32 a
F-test	**	N.S	*	*

2. Root length (cm):

The results in Table (25) clearly indicated that root length of sugarbeet was insignificantly affected by nitrogen application at 100, 121 and 163 days after sowing , While at the growth stage of 142 days after sowing it was significant. In general, root length increased with increasing nitrogen levels. The highest measuring for length was 33.88 cm by adding 90 kg N/fad at 163 days after sowing. Similar results were obtained by Ramadan (1986), Table *et al.*(1986), Obead (1986) and Sorour *et al.*(1992) who found that the increase in nitrogen level significantly increased root length of sugarbeet plant.

Table (25):Root length (cm) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	21.58	25.79	29.30 c	32.40
45	22.22	26.68	30.77 b	32.78
60	23.50	27.00	30.23 bc	33.32
75	23.62	27.11	31.10 ab	33.81
90	23.51	25.80	31.50 a	33.88
F-test	N.S	N.S	*	N.S

3. Root diameter (cm):

The data in Table (26) show clearly that root diameter was increased significantly by increasing nitrogen level at all growth stages. The root diameter at 60 kg N/fad was significantly lower that at 90 kg N/fad. There was no significant differences between the two highest levels (75 and 90 kg N/fad) of applied nitrogen throughout the growing stages. The diameter of root ranged from 4.93 to 8.59 cm with the 90 kg N/fad along the stages of growth. The increase in diameter with increasing nitrogen level was also obtained by Ramadan (1986), Table *et al.*(1986), Obead (1986), Sorour *et al.*. (1992) and Assey et al.(1992 a).

Table (26): Root diameter (cm) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	3.61 c	5.00 b	5.90 d	7.40 c
45	3.92 c	5.29 b	6.69 c	7.58 c
60	4.32 b	5.31 b	7.05 bc	8.12 b
75	4.48 ab	6.00 a	7.31 ab	8.42 ab
90	4.93 a	6.40 a	7.81 a	8.59 a
F-test	*	*	**	*

4. Fresh weight of blades/plant (g):

Fresh weight of blades / plant (Table 27) was significantly increased as nitrogen level increased up to 90 kg/fad. Thus, reflecting the important role of nitrogen in building up the photosynthetic area of beet plants. Generally, both 75 and 90 kg/fad nitrogen fertilization levels had similar effect on fresh weight of blades at all growth stages and the difference between the two levels was not significant. The lowest fresh weight of blades/plant was obtained at zero level of nitrogen, whereas it reached its maximum weight at 90 kg N/fad, and this result was true for all growth stages. The increase percentages of fresh weight of blades were 30.35, 45.87, 31.07 and 36.46% by applying 90 kg N/fad as compared with zero level after 100,121, 142 and 163 days after sowing, respectively. In this respect, Basha (1984) reported that significant increase in fresh weight of blades/plant due to nitrogen fertilization up to 60 kg/fad.

Table (27): Fresh weight of blades per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	89.3 c	119.9 d	160.6 c	207.1 d
45	103.3 b	139.2 c	165.6 c	217.8 cd
60	110.1 ab	158.1 b	185.6 b	237.1 b
75	114.0 a	172.3 a	203.1 a	255.1 a
90	116.4 a	174.9 a	210.5 a	282.6 a
F-test	*	*	**	*

5. Fresh weight of petioles/plant (g):

Data presented in Table (28) indicated that fresh weight of petioles/plant increased due to adding nitrogen. The increase was more evident at the latter growth stages, i.e. after 142 and 163 days. Adding nitrogen fertilizer to sugarbeet plants caused a significant effect on fresh weight of petioles/plant. At 142 days after sowing, there was a significant increase in fresh weight of petioles between all nitrogen levels except between 60 and 75 kg N/fad. The same result was obtained at 163 days after sowing. The increase percentages of fresh weight of petioles at 142 days after sowing were 24.85, 50.69, 59,99 and 79.63% for 45, 60, 75 and 90 kg N/fad as compared with zero level, respectively. The increase percentages after 163 days were 23.81, 42.26, 53.35 and 67.84% for the same respective nitrogen levels. The highest increase was recorded at 163 days stage with application of 90 kg N/fad. Similar findings were reported by Basha (1984).

Table (28): Fresh weight of petioles per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	48.7 c	73.8 e	151.7 d	259.6 d
45	66.5 c	104.2 d	189.4 c	321.4 c
60	85.5 b	121.5 cd	228.6 b	369.3 b
75	93.4 ab	176.6 b	242.7 b	398.1 b
90	106.1 a	227.5 a	272.5 a	435.7 a
F-test	*	*	**	**

6. Fresh weight of leaves/plant (g):

The average of fresh weight of leaves/plant significantly increased as nitrogen level increased up to 90 kg/fad at all growth stages (as shown in Table 29). Fresh weight of leaves/plant increased to its maximum weight at 90 kg N/fad at all growth stages. Fresh weight of leaves increased significantly by 22.68, 25.67, 13.81 and 15.63% by adding 45 kg N/fad as compared with zero level at 100, 121, 142 and 163 days after sowing, respectively. The increase percentages were 61.88, 107.80, 54.68 and 54.02% by adding 90 kg N/fad as compared with zero level for the same respective growth stages. This finding was in agreement with that obtained by Nour El-Din *et al.*(1993) who found that fresh weight of leaves/plant was significantly increased with increasing nitrogen level up to 60 kg/fad.

Table (29): Fresh weight of leaves per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	138.0 d	193.6 d	312.2 d	466.3 d
45	169.3 c	243.3 c	355.3 c	539.2 c
60	195.8 b	279.5 c	414.2 b	606.4 b
75	206.9 ab	348.9 b	445.7 ab	653.2 b
90	223.4 a	402.3 a	482.9 a	718.2 a
F-test	*	*	**	**

7. Fresh weight of root/plant (g):

Concerning fresh weight of root, the effect of nitrogen fertilization on this trait is shown in Table (30). The fresh weight of root /plant was not significantly affected by nitrogen fertilization at the 1^{st} and 3^{rd} growth stages (at 100 and 142 days after sowing). However, the data indicated that significant increases due to nitrogen application in fresh weight of root was recorded after 121 and 163 days after sowing. Fresh weight of root recorded the lowest weight at zero level with significant difference with all nitrogen levels at 121 and 163 days after sowing. On the other hand, sugarbeet root reached its maximum weight by adding 90 kg N/fad at the same growth stages. The difference of root fresh weight was significant between all nitrogen levels as compared with 90 kg N/fad. Similar results were reported by El-Geddawi (1979), Hassanein (1979), Ramadan (1986) and Nour El-Din *et al.*(1993). They found that fresh weight of beet root was significantly increased with increasing nitrogen fertilization.

Table (30): Fresh weight of root per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	79.7	157.9 c	342.5	467.7 d
45	95.4	190.0 b	359.1	602.5 c
60	112.2	201.2 b	410.0	644.9 bc
75	120.2	209.1 b	412.6	679.7 b
90	132.0	241.8 a	448.3	739.6 a
F-test	N.S	*	N.S	*

8. Total fresh weight of plant (g):

Data in Table(31) indicated that nitrogen fertilization increased significantly the total fresh weight of plant at all growth stages,except at the first growth stage (at 100 days after sowing). The highest level of nitrogen (90 kg N/fad) produced the highest fresh weight of plant at all growth stages as shown in Table (31) and Fig.(3). It should be noted that differences of applied nitrogen on total fresh weight of sugarbeet plant were not significant between 45 and 60 kg N/fad at 121 stage as well as between 0 and 45; 45 and 60; 60 and 75; and 75 and 90 kg N/fad after 163 days after sowing. On the other hand, the differences between all nitrogen levels were significant at 142 days after sowing. The increase percent was 9.10, 22.83, 31.10 and 62.55% for 45, 60, 75 and 90 kg N/fad as compared with zero level, respectively. This effect of nitrogen on enhancing the growth of sugarbeet plant was expected and clears the essential role of nitrogen in growth of beet plant. These results agree with those obtained by El-Geddawi (1979), Hassanein (1979), El-Shafei (1991) and Nour El-Din *et al.*(1993).

Table (31): Total fresh weight per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	217.8	351.6 d	654.7 e	984.0 d
45	264.7	433.3 c	714.3 d	1141.6 cd
60	307.9	480.9 c	804.2 c	1251.3 bc
75	322.8	558.0 b	858.3 b	1367.0 ab
90	419.1	644.1 a	1064.2 a	1457.8 a
F-test	N.S	*	**	*

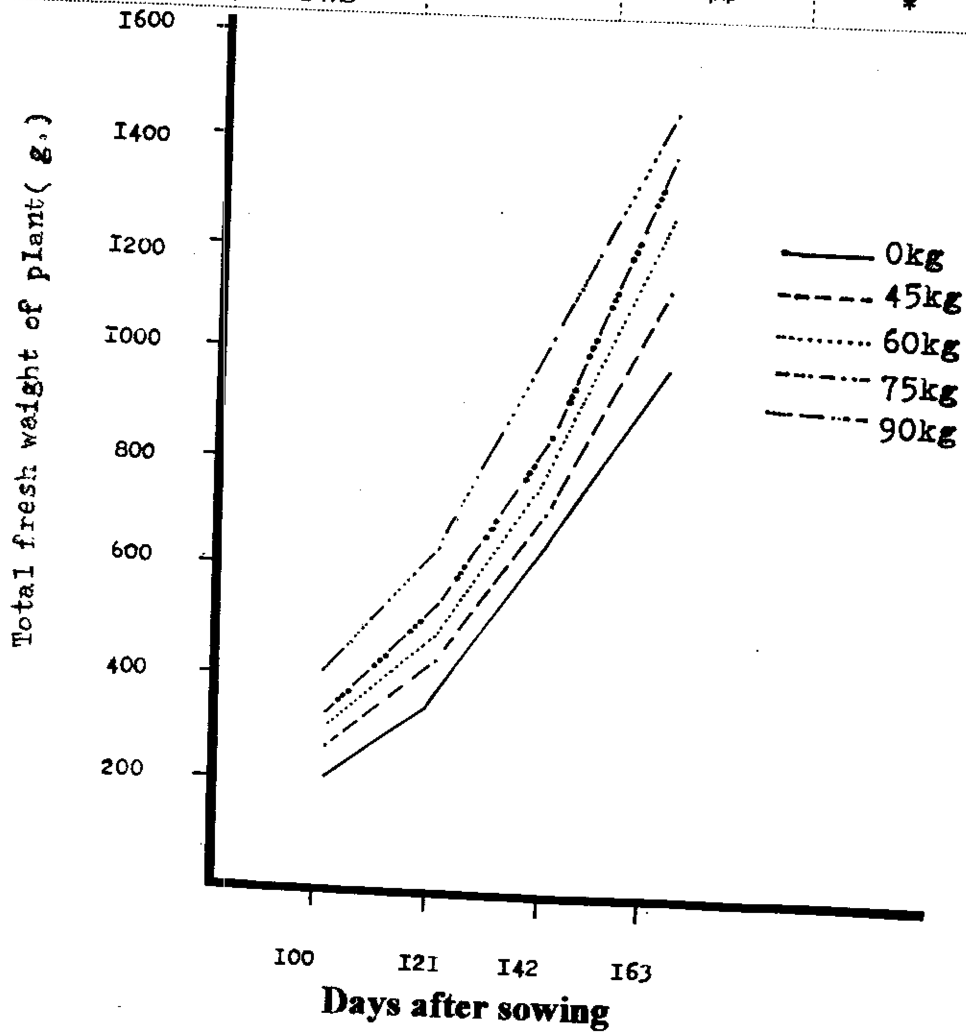


Fig.(3): Fresh weight of sugarbeet plant as affected by nitrogen fertilization

9. Dry weight of blades/plant (g):

The data in Table (32) indicated that nitrogen level had a significant effect on dry weight of blades at all growth stages. It could be shown from Table (32) that dry weight of blades/plant reached its maximum weight at the level of 90 kg N/fad at all growth stages with a significant difference as compared with 45 , 45 , 75 and 60 kg N/fad at 100, 121, 142 and 163 days after sowing,respectively. The increase in dry weight percentages were 18.14, 15.97, 5.45 and 8.65% at the same respective levels and growth stages. Thus, reflecting the important role of nitrogen in building up the photosynthetic area of plant. These results confirmed those of Follett *et al.*(1970) who reported that the higher nitrogen level resulted a higher proportion of dry material accumulation in the top of sugarbeet plants than in the roots. Also, Gobarh (1993) found that blades dry weight percentage was significantly increased as nitrogen level increased up to 100 kg/fad at all growth stages.

Table (32): Dry weight of blades per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	7.67 c	11.00 b	14.92 d	19.41 c
45	8.38 bc	11.71 b	20.21 a	19.41 c
60	9.19 ab	12.72 a	18.17 c	22.30 b
75	9.53 a	13.28 a	19.80 b	23.93 a
90	9.90 a	13.58 a	20.88 a	24.23 a
F-test	*	*	*	*

10. Dry weight of petioles/plant (g):

Table (33) showed that the effect of nitrogen fertilizer on petioles dry weight was also similar to that of their fresh petioles. fresh weight previously mentioned in Table (28). Dry weight of petioles increased to its maximum weight by applying 90 kg N/fad with a significant difference with all nitrogen levels except the level of 75 kg N/fad at 100 days after sowing. The increase percent was 134.80 , 90.93 and 48.68% at 121 , 142 and 163 days after sowing. respectively. The highest petioles dry weight (28.22 g/plant) was found with application of 90 kg N/fad at the last growth stage. These results confirmed those of Obead (1988) , El-Shafei (1991) , Assey *et al.*(1992 a) and Gobarh (1993).

Table (33): Dry weight of petioles per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	4.45 d	5.92 e	10.36 d	18.98 d
45	5.77 c	7.53 d	13.41 c	22.16 c
60	7.01 b	9.36 c	14.72 bc	24.76 b
75	7.47 ab	12.20 b	15.95 b	25.98 b
90	8.32 a	13.90 a	19.78 a	28.22 a
F-test	**	*	*	*

11. Dry weight of leaves/plant (g):

The results in Table (34) revealed that nitrogen fertilization significantly affected the dry weight of leaves/plant at all growth stages except at the first growth stage (after 100 days from sowing). Dry weight of leaves/plant significantly increased due to nitrogen application up to 90 kg/fad. Thus reflecting the important role of nitrogen in building up the photosynthetic area of beet plants. The findings of El-Geddawi (1979) and Assey *et al.*(992 a) reported that nitrogen fertilization increased significantly dry weight of leaves of sugarbeet plants.

Table (34): Dry weight of leaves per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	12.15	16.90 d	25.25 c	38.47 d
45	14.10	19.50 c	28.62 c	41.57 c
60	16.17	24.05 b	32.84 b	47.08 b
75	16.96	25.25 a	35.80 b	50.27 a
90	18.16	27.17 a	40.25 a	52.92 a
F-test	N.S	*	*	*

12. Dry weight of root/plant (g):

The results of nitrogen application effect on dry weight of root/plant (Table 35) was only insignificant when recorded at stage of 121 days after sowing. However, at 100, 142 and 163 days after sowing, dry weight of root was significant. Dry weight of root reached its maximum value at 90 kg N/fad. The increase percentage was 57.22, 32.73 and 64.44% at 90 kg N/fad as compared with zero level at 100 , 142 and 163 days after sowing, respectively. These results agree with those obtained by Basha (1984) , Obead (1988) , El-Shafei (1991), Assey *et al.*(1992 a) and Gobarh (1993).

Table (35): Dry weight of root per plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	13.79 a	30.50	52.68 d	79.24 d
45	15.59 c	31.55	57.04 c	106.61 c
60	18.13 b	32.19	59.01 c	113.74 b
75	19.40 b	34.33	61.59 b	127.27 a
90	21.68 a	36.94	69.92 a	130.30 a
F-test	*	N.S	*	*

13. Total dry weight of plant (g):

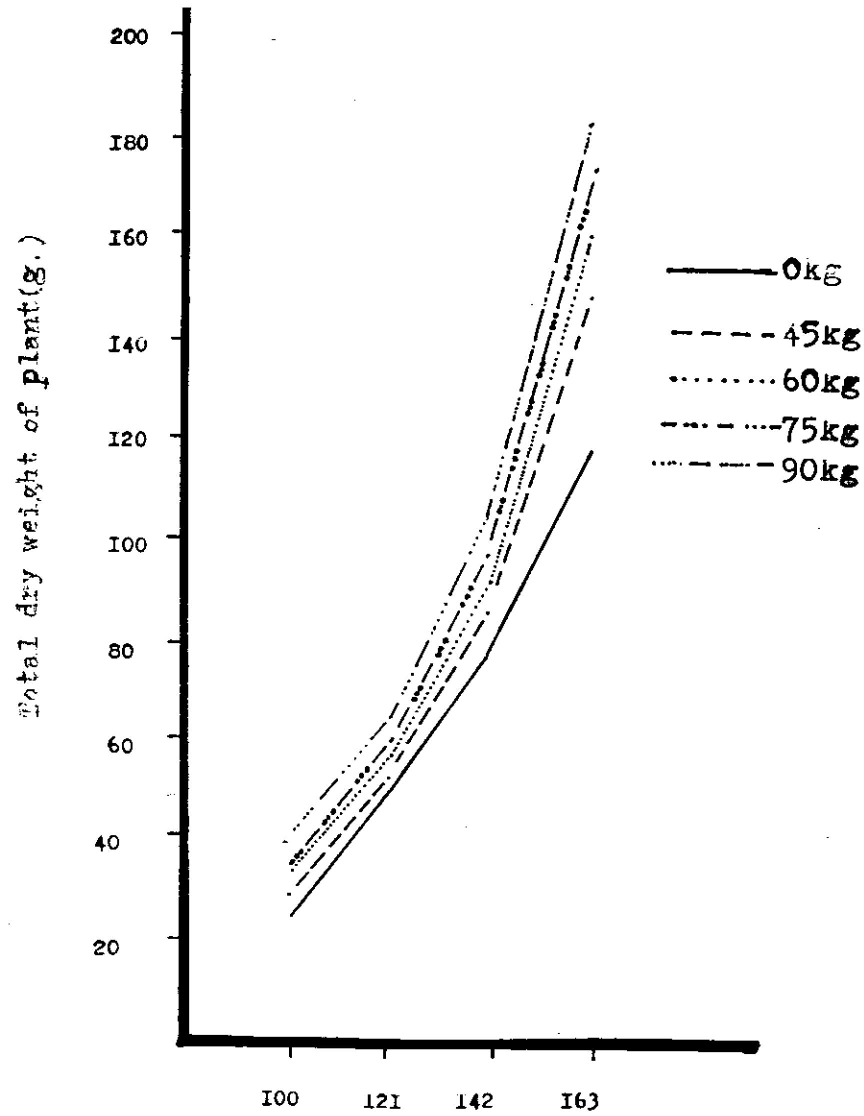
Table (36) showed the effect of nitrogen fertilization on total dry weight/plant at different growth stages.

Nitrogen fertilization affected total dry weight/plant at all growth stages as shown in Table (36) and Fig.(4). Total dry weight increased to its maximum weight by adding 90 kg N/fad at all growth stages. The differences between 90 kg N/fad were significant as compared with any of the nitrogen fertilizer level. The increase percentage of total dry weight at the level of 90 kg N/fad amounted to 53.59, 28.22, 36.24 and 55.65% as compared with zero level of nitrogen at 100, 121, 142 and 163 days after sowing, respectively. The highest value of dry weight (183.22 g/plant) was recorded with application of 90 kg N/fad at growth stage of 163 days after sowing. This increase reflects the increase in photosynthetic area accomulating heavy nitrogen application which resulted in more metabolites and consequently increased dry weight of plant.

These results confirmed those of Follett (1970) , Halvorson and Hartman (1975) , Prasad and Singh (1983) , Kamel *et al.*(1984) , Pulkrabek (1985) , Zalat (1985) , Obead (1988) , Mahmoud *et al.* (1990 a) , Assey *et al.* (1992 a), Sorour et al.(1992) and Gobarh (1993). On the other hand, Izsaki (1984) reported that dry matter accumulation was not affected by nitrogen level.

Table (36): Total dry weight of plant (g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	25.94 c	50.00 c	77.93 e	117.71 2
45	29.69 c	51.05 c	85.66 d	148.18 d
60	33.80 b	56.24 b	91.85 c	160.82 c
75	35.37 b	59.58 b	97.39 b	171.54 b
90	39.84 a	64.11 a	106.17 a	183.22 a
F-test	*	**	*	*



Days after sowing

Fig.(4): Dry weight of sugarbeet plants as affected by nitrogen fertilization.

14. Leaf area/plant (cm^2):

Nitrogen fertilization affected leaf area/plant at all growth stages as shown in Table (37). The differences in leaf area were significant between 75 and 90 kg N/fad at all growth stages, whereas the differences in leaf area/plant between zero and 45 kg N/fad were insignificant at 100 and 121 days after sowing. The increase percentages at 90 kg N/fad were 10.67,22.71, 10.20 and 5.88% as compared with 75 kg N/fad at 100, 121, 142 and 163 days after sowing, respectively. The highest value of leaf area (6566.9 cm^2/plant) was recorded with application of 90 kg N/fad at growth stage of 163 days after sowing. Thus reflecting the important role of nitrogen in building up the photosynthetic area of plants as mentioned before (see Tables 27 and 32).

These results confirmed those of Basha (1984) who reported that applying nitrogen fertilizer up to 90 kg/fad increased linearly leaf area/plant of sugarbeet.

Table (37): Leaf area per plant (cm^2) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	1540.2 c	2385.1 d	3433.5 e	4031.7 e
45	1782.6 c	2642.2 d	3820.3 d	5009.2 d
60	2104.5 b	3065.5 c	4386.3 c	5462.4 c
75	2369.3 b	3549.2 b	4775.3 b	6202.2 b
90	2622.2 a	4355.2 a	5262.4 a	6566.9 a
F-test	*	*	*	*

B. Growth attributes:

The growth attributes LAI,LAR,LWR,SLA,CGR,NAR and RGR as affected by nitrogen fertilization are presented in Tables (38-44).

1. Leaf area index (LAI):

Data in Table (38) revealed that variation in nitrogen levels resulted in significant differences in leaf area index (LAI) at three growth stages, i.e. 121, 142 and 163 days after sowing. However, at the first growth stage, 100 days after sowing, LAI was not affected by nitrogen levels. In general, LAI was significantly increased as nitrogen level increased up to 90 kg/fad. These results are due to the positive effect of nitrogen on leaf area as mentioned before. Similar results are obtained by Follett *et al.*(1970) , Kamel *et al.*(1979 a) , Hassanein (1979) , Mohamed *et al.*(1979) , Carter and Traveller (1981) , Basha (1984) , Obead (1988) , Mahmoud *et al.*(1990 a) , Sorour *et al.*(1992), Gobarh (1993) and Nour El-Din *et al.*(1993).

Table (38): Leaf area index (LAI) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	1.62	2.58 c	3.60 b	4.77 c
45	1.77	3.52 b	3.98 b	5.27 bc
60	2.07	3.16 bc	4.56 a	5.47 bc
75	2.16	3.92 ab	4.94 ab	6.19 ab
90	2.49	4.28 a	5.37 a	6.82 a
F-test	N.S	*	*	*

2. Leaf area ratio (LAR):

The leaf area ratio (LAR) was significantly affected by nitrogen fertilization when recorded at 100 and 121 days after sowing (Table 39). However, at both stages 142 and 163 days from sowing the effect of nitrogen fertilization on LAR was statistically insignificant. At 100 and 121 days after sowing, leaf area ratio increased significantly as a result of adding 60 kg N/fad when compared with zero level. However, at the same growth stages the differences in LAR between 75 and 90 kg N/fad did not reach the 5% level of significance. The highest value of LAR (56.3) was recorded with application of 90 kg N/fad at 100 days after sowing.

Table (39): Leaf area ratio (LAR) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	48.57 c	43.04 c	34.52	29.69
45	48.94 c	44.75 c	35.51	30.02
60	52.15 b	48.69 b	38.83	29.92
75	55.41 a	50.65 ab	40.37	30.73
90	56.30 a	52.84 a	40.57	31.76
F-test	*	*	N.S	N.S

3. Leaf weight ratio (LWR):

Table (40) revealed that leaf weight ratio (LWR) was always affected by nitrogen fertilization when was recorded at all growth stages. The highest ratio of leaf weight varied with nitrogen level applied. LWR reached its maximum value by adding 75, 75, 60 and 75 kg N/fad at 100, 121, 142 and 163 days after sowing,respectively. This increment did not differ significantly with 90,75 and 0 kg N/fad at 100, 142 and 163 days after sowing, respectively.

Table (40): Leaf weight ratio (LWR) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level	Days after sowing			
(kg/fad)	100	121	142	163
0	0.47 b	0.40 c	0.34 d	0.33 a
45	0.48 bc	0.42 b	0.32 c	0.29 b
60	0.45 c	0.42 b	0.38 a	0.29 b
75	0.51 a	0.44 a	0.37 ab	0.34 a
90	0.49 ab	0.42 b	0.36 b	0.30 c
F-test	*	**	**	*

4. Specific leaf area (cm2/g):

Specific leaf area (SLA) calculated at 100 days after sowing exhibited insignificantly differences due to nitrogen level. Therefore, significant differences between nitrogen levels at 121, 142 and 163 days after sowing as shown in Table (41). It could be concluded that SLA reached its maximum value by applying 90 kg N/fad at all growth stages. The differences in SLA between 90 and 60 kg N/fad were not significant at 142 and 163 days after sowing. The same result was obtained between zero and 45 kg N/fad at 121 and 142 days after sowing. These results coincide with El-Shafei (1991) and Nour El-Din *et al.*(1993) who found that increasing nitrogen fertilza-tion up to 75 kg/fad increased SLA.

Table (41): Specific leaf area (cm^2/g) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level (kg/fad)	Days after sowing			
	100	121	142	163
0	101.36	111.65 c	101.84 b	82.79 c
45	98.71	111.13 c	105.98 b	92.99 b
60	97.29	119.98 b	106.80 ab	99.15 a
75	99.30	114.20 c	111.15 a	99.32 a
90	107.25	129.67 a	115.97 a	100.40 a
F-test	N.S	*	*	*

5. Crop growth rate (mg/day):

The data in Table (42) indicated that nitrogen level had a significant effect on crop growth rate (CGR) at all growth periods. CGR decreased significantly by adding 45 kg N/fad and differed significantly with all nitrogen levels at the first growth period (100-121 days). At the second growth period (121-142 days), CGR increased significantly at 90 kg N/fad with a significant difference with 0,45 and 60 kg N/fad. However, the same trend was obtained at the third growth stage period (142-163 days). It could be concluded that CGR comes to its maximum value at 90 kg N/fad at the three growth periods. Such effect of nitrogen might have resulted from increasing photosynthetic area which consequently increased dry weight/plant as mentioned before. These results are in harmony with those found by Kamel *et al.*(1984),Obead (1988), Sayed *et al.*(1988), Sorour *et al.*(1992) and Gobarh (1993).

Table (42): Crop growth rate (mg/day)) as affected by nitrogen fertilization at different growth periods. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Nitrogen level (kg/fad)	Days after sowing		
	100 - 121	121 - 142	142 - 163
0	1145.71 a	1330.00 c	1894.29 d
45	1017.14 b	1639.05 b	2977.14 c
60	1068.57 a	1695.71 b	3284.29 b
75	1152.86 a	1800.48 ab	3530.95 ab
90	1155.71 a	2002.86 a	3669.05 a
F-test	*	**	*

6. Net assimilation rate (NAR) (mg/cm²/day):

The results in Table (43) indicated that net assimilation rate (NAR) was significantly affected by nitrogen fertilization at all growth periods. In general, it could be concluded that NAR was significantly decreased as nitrogen level increased up to 75 kg/fad. NAR progressively increased as plant advanced towards maturity and reached a maximum at 163 days after sowing. The decrease in NAR due to increasing nitrogen level was reported by Mahmoud *et al.* (1990 a). On the other hand, Emara (1990), El-Shafei (1991), Sorour *et al.*(1992) and Gobarh (1993) found that NAR was significantly increased by increasing nitrogen up to 120 kg/fad. While, Ramadan (1986) reported that NAR was increased markedly by increasing nitrogen level up to 60 kg/fad but excess nitrogen over this level decreased it.

Table (43): Net assimilation rate (mg / cm² / day)) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing		
	100 - 121	121 - 142	142 - 163
0	0.54 a	0.64 a	0.74 a
45	0.49 b	0.63 a	0.74 a
60	0.46 bc	0.58 b	0.71 b
75	0.43 c	0.53 c	0.68 c
90	0.50 a	0.62 ab	0.64 d
F-test	*	*	*

7. Relative growth rate (mg/g/day):

The data presented in Table (44) revealed that nitrogen fertilizer significantly affected relative growth rate (RGR) when was recorded at the second and third periods, i.e. 121-142 and 142-163 days after sowing, respectively. RGR, in general, was significantly increased by increasing nitrogen level up to 75 kg/fad, but excess nitrogen over this level decreased it. Also , RGR increased till the second growth period, then decreased at the last one. Thus, reflecting dry weight response to nitrogen fertilization as mentioned previously. It is worth mentioning that RGR progressively increased as plants advanced towards maturity and reached a maximum at 121-142 days after sowing,thereafter it decreased due to senescence of older leaves. The increase in RGR due to increasing nitrogen levels was reported by Ramadan (1986), Obead (1988), Emara (1990), El-Khatib (1991). While Mahmoud *et al.*(1990 a) reported that RGR decreased by increasing nitrogen levels. On the other hand, Sayed *et al.*(1988) and Sorour *et al.*(1992) found that RGR was not significantly affected by nitrogen levels.

Table (44): Relative growth rate (mg/g/day) as affected by nitrogen fertilization at different growth stages. (combined analysis of 1992/93 and 1993/94 seasons).

Nitrogen level (kg/fad)	Days after sowing		
	100 - 121	121 - 142	142 - 163
0	19.40	24.44 c	18.90 c
45	20.92	25.37 bc	23.59 b
60	24.84	26.94 ab	23.88 b
75	24.19	28.23 a	24.43 a
90	25.15	28.30 c	22.30 b
F-test	N.S	*	*

III. Effect of the Interaction between Plant Spacing and Nitrogen Levels:

The effect of the interaction between plant spacing and nitrogen levels on plant height,root length,fresh weight of plant, fresh weight of blades/plant, fresh weight of leaves/plant, dry weight of plant, dry weight of leaves/plant, dry weight of root/plant, leaf area /plant, leaf area ratio, leaf weight ratio, crop growth rate and relative growth rate was not significant, consequently the data were excluded. However, root diameter, fresh weight of petioles/plant, fresh weight of root/plant, dry weight of blades/plant, dry weight of petioles/plant, leaf area index, specific leaf area and net assimilation rate were affected significantly by the interaction between plant spacing and nitrogen levels.

1. Root diameter:

The results of root diameter recorded at 142 days stage as affected by the interaction of plant spacing with nitrogen fertilization are shown in Table (45).

Nitrogen fertilizer level of 90 kg/fad increased root diameter under all plant spacing as shown in Table (45). Root diameter reached to its maximum value by adding 90 kg N/fad and under all plant spacing, whereas it reached its minimum value at zero treatment and under all plant spacings.

Table (45): The interaction effect between plant spacing and nitrogen fertilization on root diameter of sugarbeet recorded at 142 days after sowing. (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	C 5.77 b	BC 5.89 c	ABC 6.35 b	AB 6.76 a	A 7.21 b
15	C 5.06 c	B 6.49 bc	AB 6.97 b	A 7.36 a	A 7.40 b
20	B 5.96 b	A 7.09 ab	A 7.03 ab	A 7.21 a	A 7.69 b
25	C 6.63 a	BC 7.29 a	B 7.85 a	B 7.61 a	A 8.98 a

On the other hand, root diameter to its maximum value at plant spacing of 25 cm under all nitrogen fertilizer levels, whereas its minimum value recorded at plant spacing of 10 cm between plants under all nitrogen levels. It should be noted that plant spacing did not affect root diameter under nitrogen level of 75 kg/fad.

2. Fresh weight of petioles/plant:

The effect of interaction between plant spacing and nitrogen fertilization on fresh weight of petioles/plant recorded at 121 days after sowing in the combined analysis is presented in Table (46).

In general , it can be concluded that fresh weight of petioles under the different plant spacing used responsed to nitrogen up to 90 kg/fad. It reached its maximum weight at 90 kg N/fad.

Table (46): Fresh weight of petioles / plant (g) of sugarbeet recorded at 121 days after sowing as influenced by the interaction between plant spacing and nitrogen fertilization. (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	D 58.7 c	CD 78.7 c	C 90.7 c	B 128.9 c	A 161.3 d
15	D 40.8 c	C 110.8 b	BC 122.8 b	A 161.1 bc	A 193.6 c
20	D 123.2 a	D 123.2 a	CD 153.4 a	B 193.5 b	A 236.8 b
25	C 104.2 b	C 104.2 b	C 119.1 b	B 223.0 a	A 320.3 a

On the other hand, its minimum value was obtained under zero level of nitrogen. This was true under all plant spacings.

With regard to the effect of plant spacing under nitrogen levels, it could be shown from Table (46) that plant spacing affected significantly fresh weight of petioles under all nitrogen fertilizer levels.

Fresh weight of petioles reached its maximum weight at plant spacing of 20 cm under zero , 45 and 60 kg N/fad , whereas the maximum value was recorded at 25 cm plant spacing under 75 and 90 kg N/fad. The highest fresh weight of petioles was obtained from planting at 25 cm hill spacing with application of 90 kg N / fad.

While, the lowest value resulted from planting at 15 cm plant spacing with zero kg N/fad. This is true over all plant spacings as well as nitrogen levels.

3. Fresh weight of root/plant:

The results of fresh weight of root at 121 days stage as influenced by interaction of plant spacing and nitrogen fertilization are presented in Table (47).

Regarding plant spacing, it is clear from Table (47) that the longest plant spacing of 25 cm was the highest in fresh weight of

Table (47): The interaction effect between plant spacing and nitrogen fertilization on root fresh weight per sugarbeet plant (g) recorded at 121 days after sowing. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	C 120.1 c	B 141.4 d	B 157.1 c	B 159.9 c	A 202.6 c
15	C 161.0 b	BC 171.1 c	B 178.8 c	AB 188.1 b	A 212.2 c
20	C 169.3 b	B 200.6 b	B 212.8 b	B 209.1 b	A 249.6 b
25	D 213.4 a	C 246.7 a	BC 255.9 a	B 279.2 a	A 302.8 a

roots, while the short plant spacing of 10 cm was the lowest under all nitrogen levels. In general, the fresh weight consistenly increased by increasing nitrogen level up to 90 kg/fad under all plant spacings.

Also, the results indicated that under the different four plant spacings used root fresh weight was not changed when comparing between 60 and 75 kg N/fad. But, there was significant difference between 75 and 90 kg N/fad except under 15 cm plant spacing. The lowest fresh weight of root was obtained from planting at 10 cm hill spacing and zero level of nitrogen, while the highest value resulted from plant spacing at 25 cm with 90 kg N/fad. This result is true under all nitrogen levels as well as all plant spacings.

4. Dry weight of blades/plant (g):

The results of blades dry weight recorded at 100 days stage as affected by the interaction of plant spacing with nitrogen rates are shown in Table (48).

With regard to nitrogen levels , it is clear from Table (48) that dry weight of blades increased significantly at 75 kg N/fad and 10cm plant spacing,whereas the differences were significant at 90 kg N/fad and 15, 20 and 25 cm plant spacing. On the other hand, plant spacing affected significantly dry weight of blades under all nitrogen levels. Table (48) clears that the maximum dry weight of blades recorded at 20 cm plant spacing and 0, 45 and 60 kg N/fad with significant difference as compared with 15 and 10 cm plant spacing.

Table (48): Effect of plant spacing and nitrogen fertilization interaction on dry weight of blades per plant (g) of sugarbeet recorded at 100 days after sowing. (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	B 7.31 c	B 7.19 c	B 7.46 c	A 7.90 d	B 7.40 d
15	BC 9.01 b	C 8.54 b	B 9.61 b	BC 9.40 c	A 10.76 c
20	C 9.64 a	BC 10.44 a	AB 10.86 a	BC 10.00 bc	A 11.14 bc
25	C 6.54 d	B 10.14 a	B 10.86 a	A 12.70 a	A 12.15 a

On the other hand, dry weight of blades reached its maximum by plant spacing of 25 cm and 75 and 90 kg N/fad. Over all plant spacing and nitrogen levels, the highest blades dry weight was obtained from planting at 25 cm hill spacing with application of 75 kg N/fad, while the lowest value resulted from planting at 10 cm plant spacing with 45 kg N/fad.

5. Dry weight of petioles/plant (g):

The effect of interaction between plant spacing and nitrogen fertilization on dry weight of petioles/plant was statistically significant at 100 days stage. Dry weight of petioles/plant as affected by that interaction at 100 days from sowing is shown in Table (49).

Table (49): The interaction effect between plant spacing and nitrogen fertilization on dry weight of petioles (g) per sugarbeet plant recorded at 100 days after sowing. (combined analysis of 1992 / 93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	C 3.76 b	C 3.79 c	B 4.78 c	A 5.37 c	A 5.40 a
15	D 3.96 b	C 5.26 b	B 6.92 b	B 6.87 b	A 8.72 b
20	D 4.19 b	C 6.86 a	B 8.17 a	BC 7.47 b	A 9.10 b
25	C 5.49 a	BC 7.16 a	B 8.17 a	A 10.17 a	A 10.11 a

Under 75 and 90 kg nitrogen fertilization, the effect of plant spacing on sugarbeet root was more pronounced. Since it was always increased due to any increase in plant spacing. It could be concluded that under the different plant spacings used,sugarbeet dry weight was not changed when comparing between 75 and 90 kg N/fad at 10 and 25 cm distance between hills. Under 15 and 20 cm distance between hills, increasing nitrogen fertilization increased root dry weight. The highest petioles dry weight was obtained from planting at 25 cm hill spacing with application of 75 kg N/fad, while the lowest value resulted from planting at 10 cm hill spacing with zero kg N/fad.

6. Leaf area index (LAI):

Plant spacing x nitrogen levels interaction exhibited significant effects on LAI at 142 days after sowing. The results of LAI recorded at 142 days after sowing as influenced by that interaction are presented in Table (50). It is of interest to state that LAI was clearly affected by plant spacing under all nitrogen levels used. Under 45 kg N/fad , a consistent significant increase was found due to increasing plant spacing from 10 to 25 cm, whereas under 60 kg N/fad, there was no significant effect between both 10 and 15 cm plant spacings. But for plants fertilized with 75 or 90 kg N, there was insignificant difference between both the 15 and 25 cm plant spacings.

Table (50): Effect of plant spacing and nitrogen fertilization on leaf area index (LAI) of sugarbeet recorded at 142 days after sowing. (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	C 2.83 c	C 3.38 d	B 4.09 c	AB 4.40 c	A 4.80 c
15	B 3.73 b	B 3.78 c	B 4.29 c	AB 5.00 b	A 5.39 b
20	C 3.73 b	BC 4.00 b	AB 4.79 b	A 5.10 ab	A 5.39 b
25	C 4.33 a	BC 4.78 a	AB 5.19 a	AB 5.30 a	A 5.82 a

For all plant spacings (10, 15, 20 and 25 cm) there was insignificant difference between unfertilized plants and those fertilized with 45 kg N/fad or between adding 75 and 90 kg N/fad. For the plant spacing of 15 cm, LAI did not respond to nitrogen up to 75 kg N/fad.

Over all nitrogen levels and plant spacings, it could be shown that the highest LAI resulted from the application of 90 kg N/fad at 25 cm distance between hills, while the lowest value was obtained at 10 cm distance between hills and zero level of nitrogen

7. Specific leaf area (SLA):

The results of SLA determined at 163 days stage as influenced by the interaction between plant spacing and nitrogen fertilization are shown in Table (51). Under 60, 75 and 90 kg N/fad, increasing plant spacing from 10 to 20 cm significantly increased SLA. However, plants received 45 kg N were not affected concerning SLA due to plant spacing. Over all nitrogen rates and plant spacing, it could be shown that the highest SLA was resulted from 20 cm plant spacing with application of 90 kg N/fad, while the lowest value was obtained from 10 cm plant spacing with zero nitrogen level.

Table (51): The interaction effect between plant spacing and nitrogen fertilization on specific leaf area (SLA) of sugarbeet plant recorded at 163 days after sowing. (combined analysis of 1992 / 93 and 1993 / 94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	C 76.00 c	BC 91.01 a	A 96.91 b	A 97.22 b	B 88.60 c
15	C 78.00 c	B 92.48 a	A 99.06 ab	A 98.72 ab	A 102.04 b
20	B 93.30 a	B 94.38 a	AB 100.31 a	A 102.02 a	A 107.44 a
25	C 84.30 b	B 94.08 a	AB 100.31 a	AB 99.32 ab	A 103.56 ab

8. Net assimilation rate (NAR):

The results of NAR recorded at growth period of 121-142 days as influenced by the interaction between plant spacing and nitrogen fertilization are presented in Table (52).

Plant spacing x nitrogen levels interaction exhibited significant effects on NAR at 121-142 growth period after sowing. In general, NAR significantly decreased as plant spacing and/or nitrogen level increased up to 45 and 90 kg N/fad. Over all nitrogen rates and plant spacing, it could be shown that the highest value of NAR was obtained from planting at 10 cm hill spacing with application of 45 kg N/fad, while the lowest was at 20 cm plant spacing with 60 kg N/fad.

Table (52): The interaction effect between plant spacing and nitrogen fertilization on net assimilation rate (NAR) of sugarbeet plant recorded at growth period of 121-142 days after sowing. (combined analysis of 1992/93 and 1993/94 seasons).

Plant spacing (cm)	Nitrogen fertilization (kg N / fad)				
	0	45	60	75	90
10	B 0.73 a	A 0.85 a	CD 0.62 a	D 0.60 a	A 0.80 a
15	A 0.74 a	AB 0.66 b	B 0.56 b	C 0.43 b	A 0.72 a
20	A 0.61 b	B 0.55 c	C 0.32 b	B 0.52 c	B 0.50 b
25	B 0.46 c	B 0.46 c	A 0.83 a	B 0.57 c	B 0.46 b

IV. Yield and Yield Attributes:

A. Effect of plant spacing:

1. Root yield (tons/fad):

Data presented in Table (53) and Fig.(5) indicated that increasing distance between hills from 10 up to 20cm increased significantly root yield/fad in both seasons and their combined analysis. On the other hand, increasing the distance between hills from 20 to 25 cm caused insignificant increase in root yield/fad, in the combined analysis. Also, there was no significant difference among hill spacings of 10 and 15 cm in both seasons and their combined. The increase percentages in root yield/fad of sugarbeet were 4.90, 13.59 and 19.97% in the combined analysis, when seeds were sown at 15, 20 and 25 cm apart between hills, respectively, as compared with planting at 10 cm apart between hills. This increase in root yield in tons/fad by planting at 25 cm apart between hills is due to the increase in root length, root diameter and root weight.

The present results are in harmony with those obtained by Minx (1984), Taha (1985), Hanna *et al.*(1988), Kamel *et al.*(1989), Mahmoud *et al.* (1990 b). Assey *et al.*(1992 b) and Gobarh (1993).

On the other hand, some investigators found that yield of sugarbeet was not significantly affected by varying plant spacing (Aly, 1985 ; Table *et al.*, 1986 and El-Shafei, 1991).

Table (53): The effect of plant spacing on root yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	24.22 c	22.10 c	23.16 b
15	25.36 c	22.74 bc	24.63 b
20	28.23 b	24.11 b	26.67 a
25	30.12 a	26.21 a	28.17 a
F-test	*	*	*

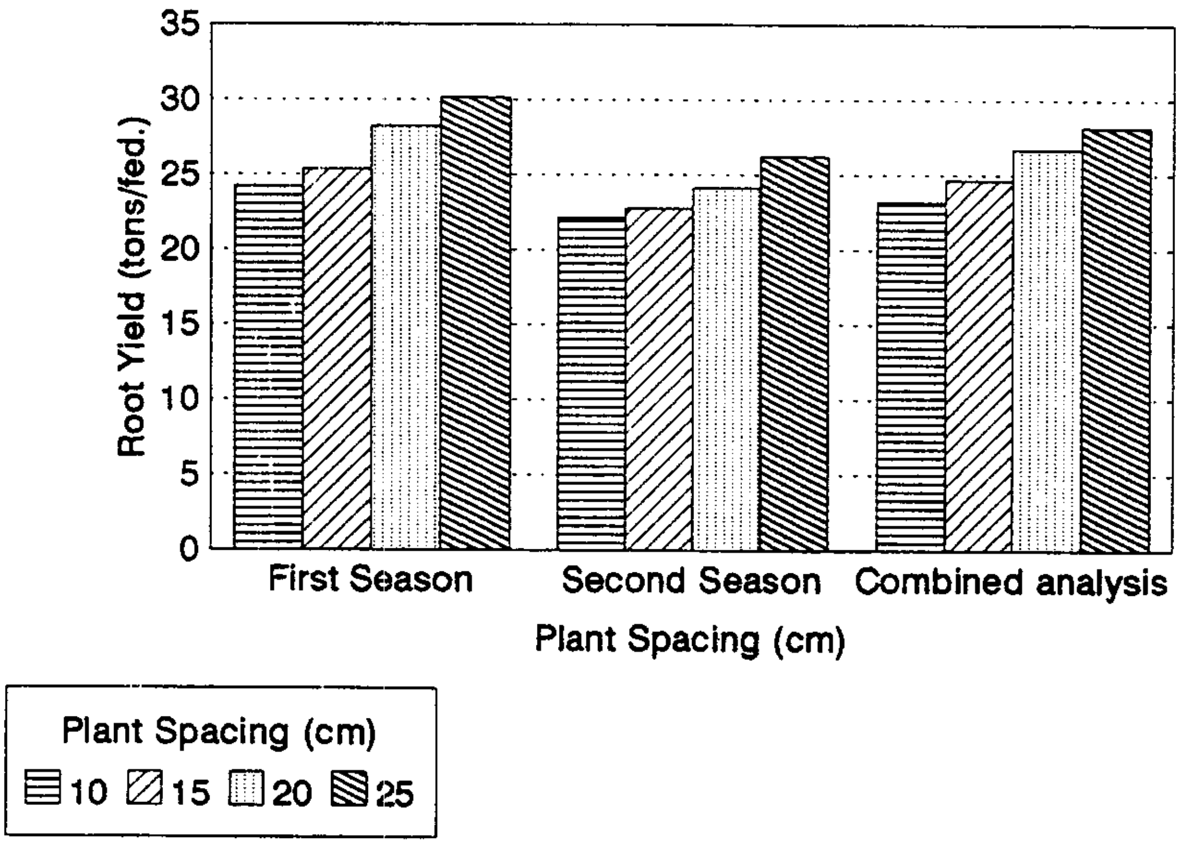


Fig.(5): The effect of plant spacing on root yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

2. Top yield (tons/fad):

Data presented in Table (54) and Fig.(6) revealed that top yield/fad was not affected by plant spacing in the first season, but in the second season, as well as the combined analysis, top yield significantly increased due to increasing plant spacing from 10 to 25 cm. As shown in the combined there was an increase reached about 26.41, 40.60 and 52.91%, when seeds were sown at 15, 20 and 25 cm apart between hills, respectively, as compared with planting at 10 cm apart between hills. These results agree with those reported by Pulkrabke (1985) who mentioned that increasing distance between plants from 6 to 36 cm within rows 50 cm apart, increased top yield. While, Assey et al.(1992 b) using between row spacing viz, 35, 45 and 55 cm and hill spacing i.e. 15,20 and 25 cm, found that different plant spacings had no significant effect on top yield.

3. Gross sugar yield (tons/fad):

The results in Table (55) and Fig.(7) showed that,plant spacing significantly affected gross sugar yield in tons/fad in both seasons as well as in the combined analysis. In general, no significant effect was found by planting at 10 and 15 cm between hills in the two seasons as well as the combined. However, a significant increase in sugar yield in tons/fad was obtained by planting at 20 and 25 cm between hills. Higher gross sugar yield in tons/fad resulted from planting at 25 cm plant spacing, reflecting the better growth characteristics of sugarbeet plants in terms of higher dry weight per plant, increased size and weight of individual roots as well as root yield/fad.

Table (54): The effect of plant spacing on top yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	12.34	8.94 d	10.64 d
15	14.90	12.00 c	13.45 c
20	15.19	14.73 b	14.96 b
25	16.71	15.82 a	16.27 a
F-test	N.S	*	*

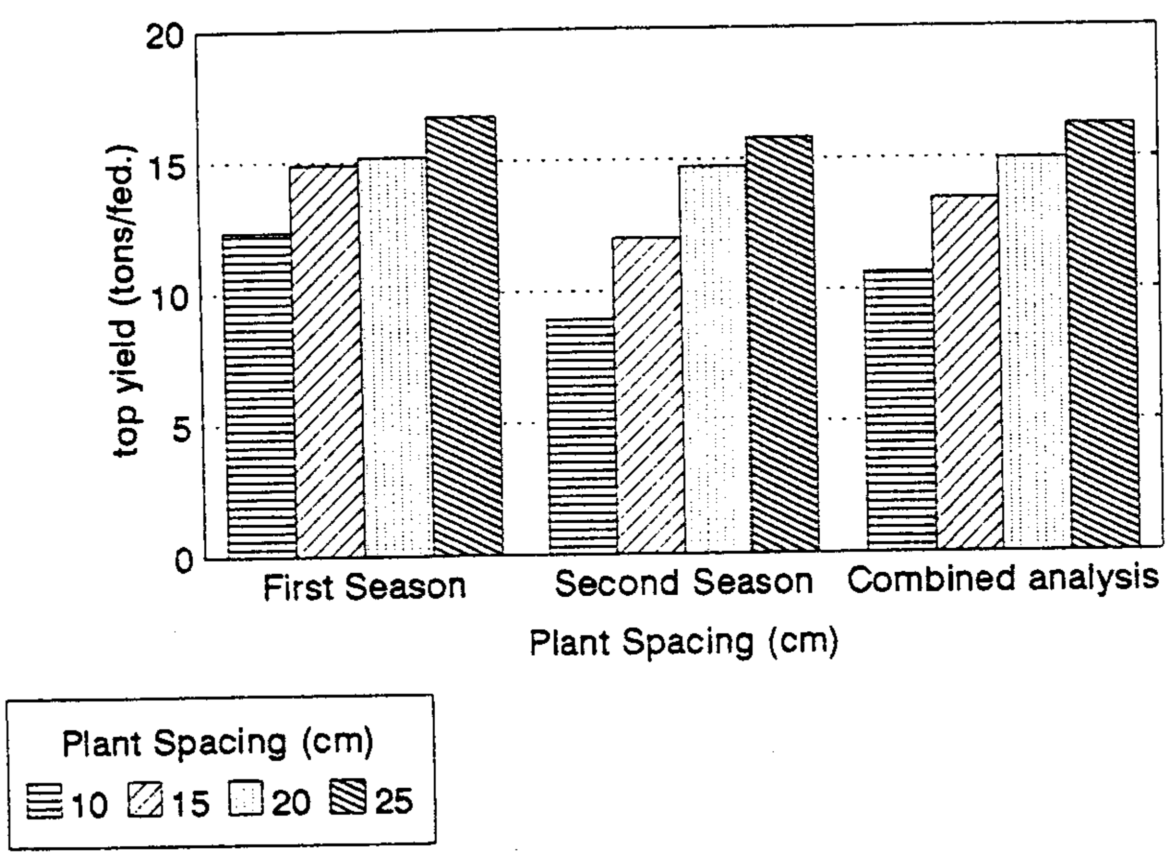


Fig.(6): The effect of plant spacing on top yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

Table (55): The effect of plant spacing on gross sugar yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	3.49 c	3.34 b	3.42 c
15	3.60 c	3.37 b	3.55 bc
20	3.81 b	3.36 b	3.66 b
25	4.01 a	3.60 a	3.81 a
F-test	*	*	*

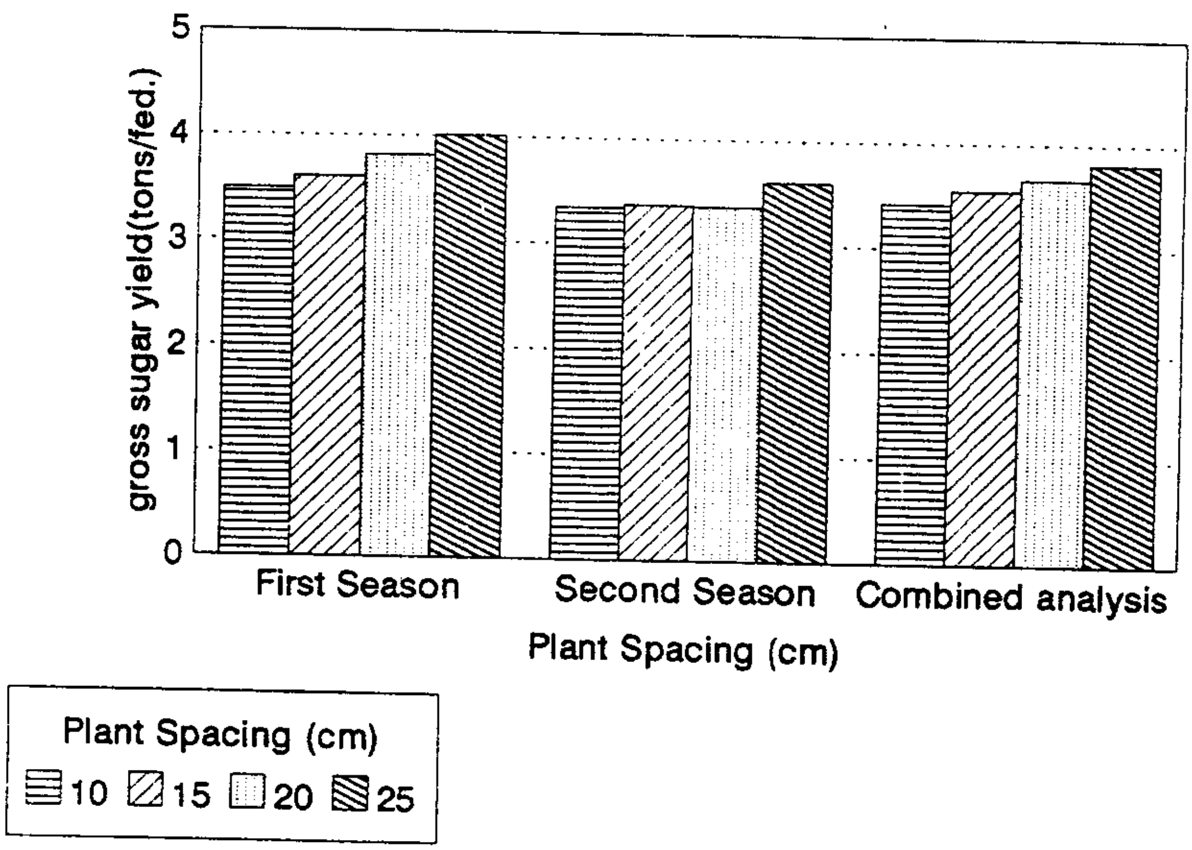


Fig.(7): The effect of plant spacing on gross sugar yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

On the other hand , the increase in plant population accompanying narrow spacing could not compensate for the reduction in dry weight, size and weight of individual roots as well as root yield per unit area. The present results are in harmony with those obtained by Mohamed (1986) , Kamel *et al.*(1989) , Mahmoud *et al.*(1990 b) and El-Khatib (1991).

4. Sugar production (kg/day/fad):

The data in Table (56) and Fig.(8) indicated that plant spacing significantly affected sugar production in kg/day/fad. This was true in both seasons as well as in the combined analysis. Increasing plant spacing from 10 to 25 cm markedly increased sugar production in kg/day/fad. The results of the first season showed no significant difference between the 10 and 15 cm plant spacings. However, as shown in the second season there was no significant differences between the different three plant spacings of 10, 15 and 20 cm. But in the combined analysis, any increase in plant spacing was always followed by a significant increase in sugar production in kg/day/fad. It means that the higher sugar production in kg/day/fad resulted from 25 cm apart between hills. These results were similar to those obtained by Basha (1984).

Table (56): The effect of plant spacing on sugar production (kg/day/fad) in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	17.45 c	16.70 b	17.08 d
15	18.00 c	16.85 b	17.75 c
20	19.05 b	16.80 b	18.30 b
25	20.05 a	18.00 a	19.05 a
F-test	**	**	*

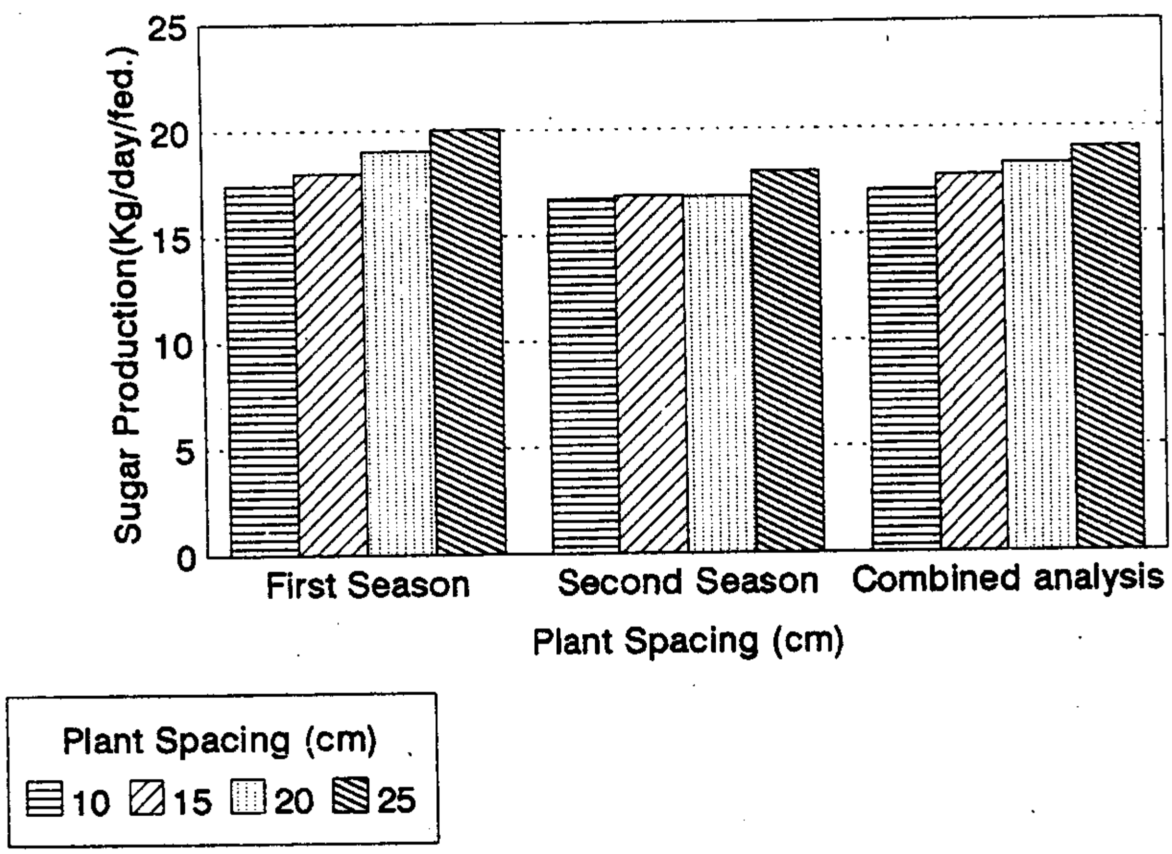


Fig.(8): The effect of plant spacing on sugar production (kg/day/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

B. Effect of nitrogen levels:

1. Root yield (tons/fad):

The results in Table (57) and Fig.(9) indicated that nitrogen fertilization level had a significant effect on root yield in both seasons as well as combined analysis. The data of the first season revealed no significant difference between plants received (45 and 60 kg/fad) or (75 and 90 kg/fad). Also,in the second season,there was no significant differences between plants received 60 and 75 kg N/fad. While in the combined analysis , nitrogen fertilization significantly increased the root yield, and any increase in nitrogen applied was followed by a respective increament in root yield (tons/fad). The combined analysis showed that,the increase in root yield of sugarbeet was about 37.67, 57.94, 76.29 and 92.06% due to adding 45, 60, 75 and 90 kg N/fad, respectively as compared with zero level. Such effect of nitrogen may be due to its role in improving beet growth, in terms of accumulation of more dry matter throughout the growing season as well as higher LA, LAI, CGR and RGR and improving size and weight of the individual root.

These results are similar to those reported by Prasad and Singh (1983), Taha (1985), Obead (1988), Emara (1990) , Mahmoud *et al.*(1990 b) , Assey *et al.*(1992 b) and Gobarh (1993).

Table (57): The effect of nitrogen fertilization on root yield (tons/fad) of sugarbeet in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Nitrogen level (kg/fad.)	First season 1992/93	Second season 1993/94	Combined analysis
0	18.22 c	15.02 d	16.62 e
45	24.53 b	21.22 c	22.88 d
60	26.30 b	26.20 b	26.25 c
75	30.44 a	28.25 b	29.35 b
90	31.70 a	32.13 a	31.92 a
F-test	*	*	*

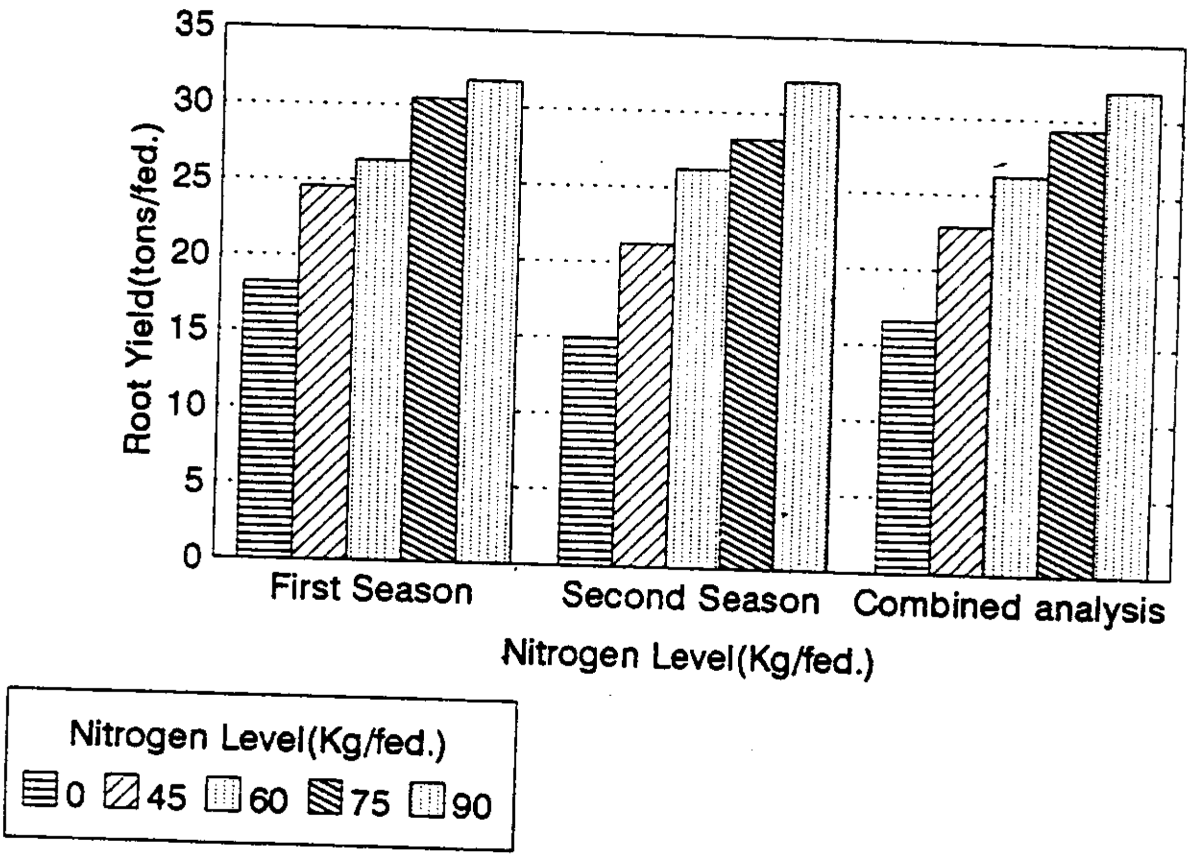


Fig.(9): The effect of nitrogen fertilization on root yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

2. Top yield (tons/fad):

Data presented in Table (58) and Fig.(10) revealed that top yield/fad responded to nitrogen fertilizer, and this was the fact in both seasons as well as the combined analysis. However, there was no significant differences between the levels (45 and 60 kg/fad) and (75 and 90 kg/fad) of nitrogen applied in the first season. But in the second season, as well as in the combined analysis, increase in nitrogen level was always followed by a significant increase in top yield. In the combined analysis, when sugarbeet plants were fertilized with 45, 60, 75 and 90 kg N/fad, top yield increased with about 25.48, 43.80, 78.04 and 98.29%, respectively as compared with zero level.Thus, reflecting the important role of nitrogen in building up the photosynthetic area of beet plants and consequently accumulation of more dry matter in the tops as mentioned before.

A positive association between the level of applied nitrogen and top yield has been reported by Follett *et al.*(1970) , Abd El-Ghaffar *et al.*(1981) , Basha (1984) , Taha (1985) , Obead (1988), Mahmoud *et al.*(1990 b) and Gobarh (1993). While , Aziz et al.(1977) found that nitrogen level up to 40 kg/donum increased top yield , thereafter top yield tended to decrease as nitrogen level increased. On the other hand, Anderson and Peterson (1988) reported that increasing nitrogen level up to 275 kg/ha had no effect on top yield.

Table (58): The effect of nitrogen fertilization on top yield (tons/fad) of sugarbeet in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Nitrogen level (kg/fad.)	First season 1992/93	Second season 1993/94	Combined analysis
0	10.88 c	6.70 e	8.79 d
45	13.08 b	8.97 d	11.03 d
60	14.25 b	11.03 c	12.64 c
75	18.62 a	12.67 b	15.65 b
90	19.08 a	15.78 a	17.43 a
F-test	*	*	**

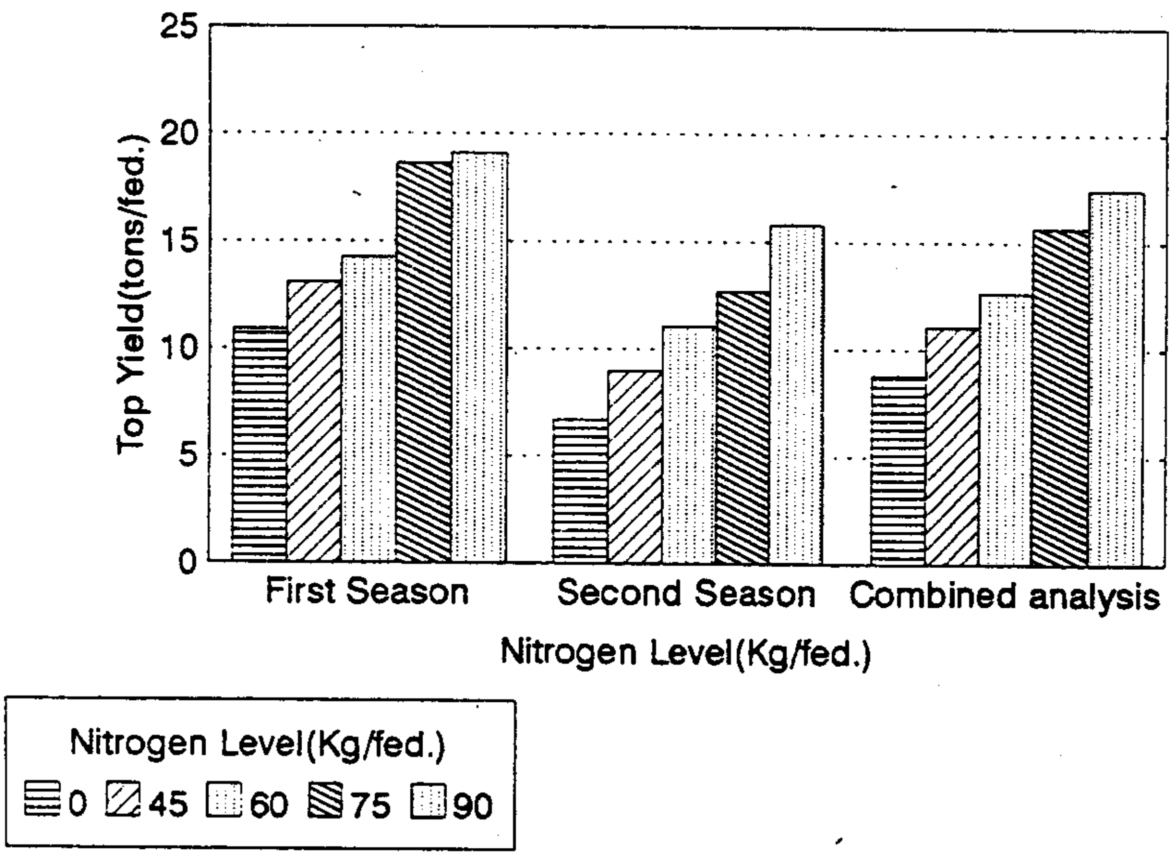


Fig.(10): The effect of nitrogen fertilization on top yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

3. Gross yield (tons/fad):

The effect of nitrogen fertilizer levels on gross sugar yield is shown in Table (59) and Fig.(11). Data showed that nitrogen fertilization significantly affected gross sugar yield/fad. This was true in both seasons as well as in the combined analysis. In general, the results of both seasons and their combined showed significant differences between plants received 45 and 60 kg N as well as between 45 kg N and non fertilized ones. However, there was no significant differences between the other different levels of nitrogen applied (60, 75 and 90 kg N/fad).

In short, increasing nitrogen level up to 60 kg/fad substantially improved gross sugar yield by 1.91 tons/fad in the combined analysis as compared with zero level. Thereafter, further application of nitrogen had no significant effect on sugar yield. Such effect may be due to improved sugarbeet growth, in terms of more dry matter accumulation, higher LAI, CGR, NAR as well as increased root size and weight accompanying higher nitrogen level. These results are, in general, agree with those reported by Bishr *et al.*(1973), El-Geddawi (1979), Carter and Traveller (1981), Taha (1985), Halvorson and Hartman (1988), Obead (1988), Kamel *et al.*(1989), Mahmoud *et al.* (1990 b), El-Shafei (1991) and Gobarh (1993). On the other hand, Herron et al.(1964), Follett et al.(1970) and O'Conner (1983) found that sugar yield was not significantly influenced by nitrogen fertilization level.

Table (59): The effect of nitrogen fertilization on gross sugar yield (tons/fad) of sugarbeet in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Nitrogen level (kg/fad.)	First season 1992/93	Second season 1993/94	Combined analysis
0	2.40 c	2.03 d	2.22 c
45	3.27 b	3.06 c	3.17 b
60	4.25 a	4.01 b	4.13 a
75	4.18 a	4.25 ab	4.22 a
90	4.22 a	4.62 a	4.42 a
F-test	**	*	*

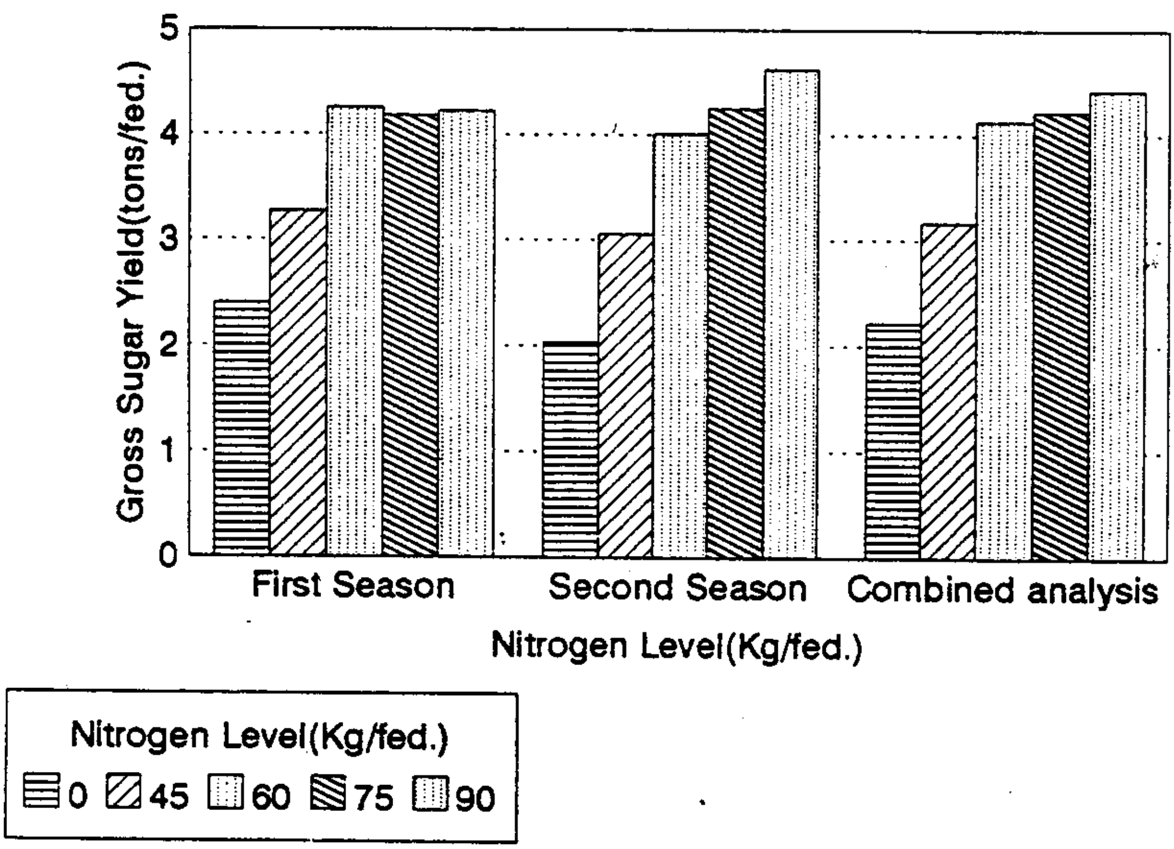


Fig.(11): The effect of nitrogen fertilization on gross sugar yield (tons/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

4. Sugar production (kg/day/fad):

The results in Table (60) and illustrated graphically in Fig.(12) indicate the effect of nitrogen fertilization on sugar production. The results indicated that sugar production in kg/day/fad was significantly affected by nitrogen fertilization. This was true as shown in Table (60) in both seasons as well as in the combined analysis. The results of the first season showed that a significant difference in sugar production between plants received 45 kg N/fad and nonfertilized ones. However, there was no significant differences between the other different levels of nitrogen applied (i.e. 60 , 75 and 90 kg N/fad). While in the second season, nitrogen significantly increased the sugar production and any increase in nitrogen applied was followed by a respective increment in sugar production (kg/day /fad).

As shown in the combined analysis there was no significant difference between 60 and 75 kg N/fad in this respect. Also, the increase in sugar production due to adding 45, 60, 75 and 90 kg N/fad reached about 42.79, 86.04, 90.90 and 99.10%, respectively as compared with zero level.

These results are generally in the same line with those obtained by Basha (1984) who found that increasing nitrogen fertilization from 30 to 90 kg/fad significant increased sugar production from 15 to 35%.

Table (60): The effect of nitrogen fertilization on sugar production (kg/day/fad) of sugarbeet in 1992/93 and 1993/94 seasons and combined analysis of two seasons.

Nitrogen level (kg/fad.)	First season 1992/93	Second season 1993/94	Combined analysis
0	12.00 c	10.15 e	11.10 d
45	16.35 b	15.30 d	15.85 c
60	21.25 a	20.05 c	20.65 b
75	20.90 a	21.25 b	21.10 b
90	21.10 a	23.10 a	22.10 a
F-test	*	**	*

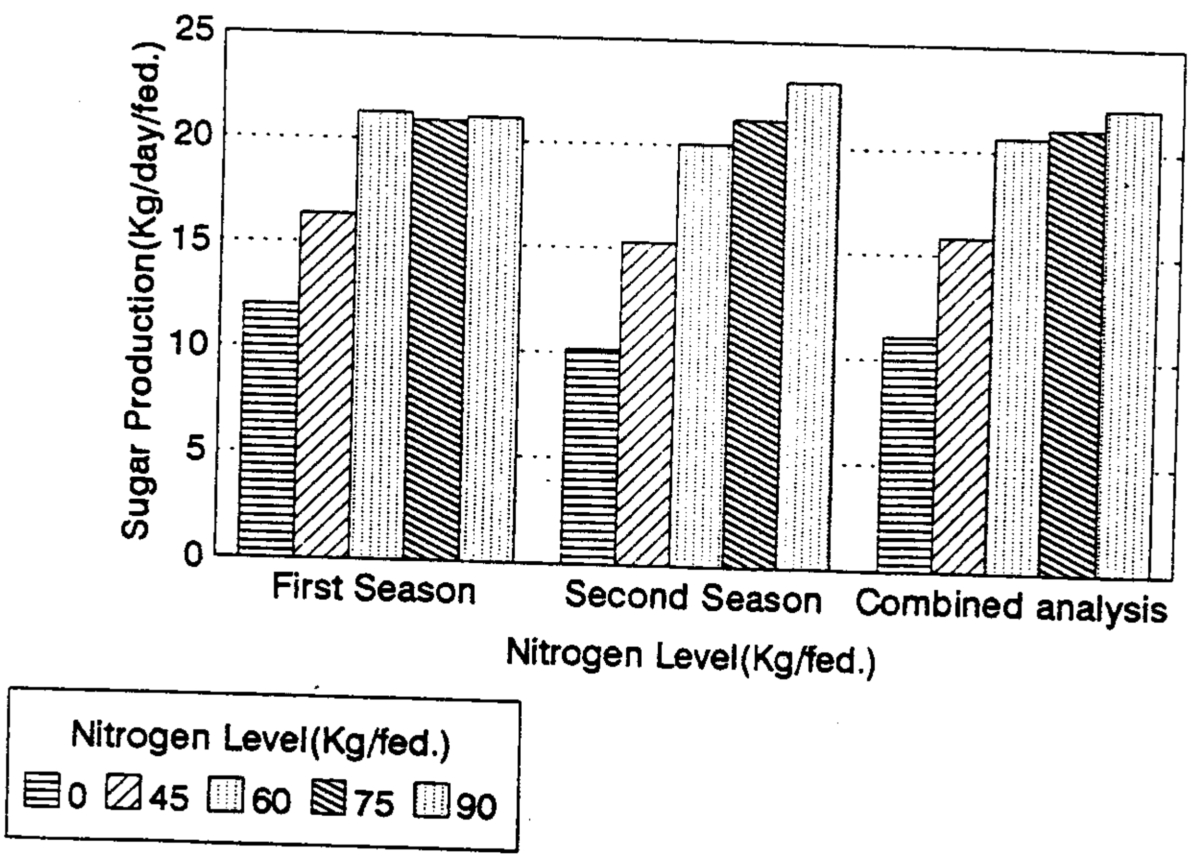


Fig.(12): The effect of nitrogen fertilization on sugar production (kg/day/fad) in 1992/93 and 1993/94 seasons and combined analysis of the two seasons.

C. Effect of the interaction between plant spacing and nitrogen levels:

The effect of the interaction between plant spacing and nitrogen levels on root yield, top yield, gross sugar yield and sugar production was not statistically significant. And this was the fact in both seasons as well as the combined analysis, consequently the data were excluded.

V. Root Characters:

A. Effect of plant spacing:

1. Root length (cm):

Data in Table (61) revealed that plant spacing affected the root length significantly in both seasons as well as their combined. There was a tendency toward increasing the root length by increasing plant spacing from 10 to 25 cm between hills. This increase in the root length was due to the increase in the accumulation of dry matter and the decrease in competition between roots on space, water and nutrients under wider spacing between hills. The differences between plant spacing 20 and 25 cm apart between hills in the first season, as well as between 10 and 15 cm apart between hills in both seasons, and the combined analysis was not significant. These findings are in agreement with those of Goodman (1966), Kamel *et al.*(1981), Taha (1985), El-Shafei (1991) and Gobarh (1993).

Table (61): The effect of plant spacing on root length at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	33.31 b	32.70 c	33.01 c
15	33.98 b	32.33 c	33.16 c
20	35.92 a	35.50 b	35.71 b
25	36.31 a	37.73 a	37.02 a
F-test	*	*	**

2. Root diameter (cm):

Concerning root diameter (cm), the effect of plant spacing on this trait is shown in Table (62).

In general, the results indicated that increasing plant spacing tended to increase root diameter in sugarbeet in both seasons as well as the combined. In the combined analysis of the two seasons, the increase in root diameter due to increasing plant spacing from 10 to 15,20 and 25 cm was 6.33,11.22 and 20.61%, respectively. This may be due to the increase in the accumulation of dry matter as a result of the increase in the RGR under sowing at wider space between hills, as shown in Table (19). In this connection , similar results were obtained by Hills (1973) , Table *et al.*(1986) , El-Shafei (1991) and Gobarh (1993). They found that root diameter was significantly increased by wider spacing.

Table (62): The effect of plant spacing on root diameter (cm) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	10.21 d	9.39 c	9.80 d
15	10.72 c	10.12 b	10.42 c
20	11.53 b	10.27 b	10.90 b
25	12.55 a	11.09 a	11.82 a
F-test	*	**	*

3. Root weight (g):

A gradual increase in root weight was obtained due to increasing plant spacing from 10 to 25 cm, and this was the fact in both seasons as well as in the combined analysis (Table 63). The differences between the four plant spacings used were significant. The decrease in root weight is accompanying dense sowing. Also, this decrease is due to the decrease in root length and root diameter as shown previously in Tables (61 and 62).

These results might be explained by the competition between plants for nutrients, water as well as light, as recorded by Kamel et al.(1981), Taha (1985), Mahmoud et al.(1990 b), El-Shafei (1991) and Gobarh (1993).

Table (63): The effect of plant spacing on root weight (g) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	794.00 d	625.41 d	709.71 d
15	881.80 c	873.62 c	877.71 c
20	1107.86 b	1043.00 b	1075.43 b
25	1250.00 a	1109.31 a	1179.66 a
F-test	*	*	**

B. Effect of nitrogen levels:

1. Root length (cm):

Data in Table (64) revealed that nitrogen rates exhibited significant effects on root length in both seasons and their combined analysis. Increasing nitrogen rates up to 90 kg/fad significantly increased root length. Such effect of nitrogen might have been due to the increase in dry matter accumulated in the roots as a result of higher LAI. RGR and NAR accompanying its application.

These results confirmed those obtained by Kamel et al.(1979 b), Mahmoud (1979), Hanna *et al.*(1988), Sayed *et al.*(1988), Emara (1990) and Gobarh (1993).

Table (64): The effect of nitrogen fertilization on root length (cm) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	33.72 c	32.87 c	33.30 d
45	34.45 c	33.90 c	34.18 cd
60	36.01 b	34.11 b	35.06 bc
75	36.32 ab	35.14 b	35.73 ab
90	37.34 a	36.24 a	36.79 a
F-test	*	*	*

2. Root diameter (cm):

The results in Table (65) showed clearly that nitrogen fertilization significantly increased root diameter in both seasons as well as the combined analysis. The combined analysis indicated that adding 45, 60, 75 and 90 kg N/fad increased the root diameter with about 1.63,8.41,16.62 and 28.7%,respectively,as compared with zero level, with no significant differences between adding 45 kg N/fad and the control. Such effect of nitrogen may be due to the increase in dry matter accumulated in the root as a result of higher LA, RGR and NAR accompanying its application.

These findings are in agreement with those of Kamel *et al.*(1981), Taha (1985), El-Shafei (1991) and Gobarh (1993).

Table (65): The effect of nitrogen fertilization on root diameter (cm) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	10.68 c	10.02 c	10.35 d
45	10.93 c	10.11 c	10.52 d
60	11.03 c	11.40 b	11.22 c
75	12.50 b	11.64 b	12.07 b
90	13.90 a	12.73 a	13.32 a
F-test	*	*	*

3. Root weight (g):

Data presented in Table (66) revealed that nitrogen levels had a significant effect on root weight in both seasons as well as in the combined analysis. Each nitrogen increment was associated with a gradual increase in root weight. The combined analysis showed that, adding 45, 60, 75 and 90 kg N/fad increased the root weight with about 15.27, 28.58,39.16 and 46.92%, respectively as compared with zero level,with no significant difference between 75 and 90 kg N/fad. Such effect of nitrogen may reflect its role in improving sugarbeet growth in terms of LA, LAI, RGR, NAR and root dimensions (root length and root diameter) as discussed before.

Similar results were reported by Mahmoud (1979), Obead (1988), Kamel *et al.*(1989), Emara (1990), El-Khatib (1991) and Gobarh (1993).

Table (66): The effect of nitrogen fertilization on root weight (g) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	897.46 d	1001.32 c	949.39 d
45	1117.31 c	1072.50 c	1094.91 c
60	1230.22 b	1211.31 b	1220.77 b
75	1292.15 b	1350.11 a	1321.13 a
90	1419.37 a	1370.31 a	1394.84 a
F-test	*	*	*

C. Effect of the interaction between plant spacing and nitrogen level:

The effect of interaction between plant spacing and nitrogen level on root characters (root length, root diameter and root weight) was not statistically significant. And this was the fact in both seasons as well as the combined analysis, consequently the data were excluded.

VI. Yield quality:

A. Effect of plant spacing:

1. Total soluble solids (TSS %):

The results in Table (67) represent the effect of plant spacing on TSS% during the two growing seasons (1992/93 and 1993/94) and their combined analysis. The resuls indicated that the total soluble solids % in sugarbeet roots was significantly affected by increasing plant spacing in both seasons as well as in the combined analysis. In general, increasing plant spacing from 10 to 15 to 20 cm apart between hills caused a significant decrease in TSS% in the first and second seasons as well as combined analysis. Meanwhile, there was no significant difference between plant spacings of 20 and 25 cm in both seasons and their combined. This result was in general agree with that obtained by El-Shafei (1991) and El-Geddawi et al.(1992) who found that total soluble solids % increased by increasing plant population.

Table (67): The effect of plant spacing on total soluble solids (TSS) in the roots at harvest in 1992 / 93 and 1993 / 94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	17.18 a	18.05 a	17.62 a
15	16.92 b	17.36 b	17.14 b
20	16.44 c	16.83 c	16.64 c
25	16.35 c	16.71 c	16.53 c
F-test	*	**	*

2. Sucrose content percentage:

The effect of plant spacing on sucrose content percentage is shown in Table (68). The data showed that sucrose content was significantly affected by plant spacing and this was the fact in both seasons as well as in the combined analysis. In the first season, the results revealed that sucrose content was significantly decreased with increasing plant spacing between hills from 10 cm up to 20 cm apart. But there was no significant difference between hill spacing of 20 and 25 cm. Also , the results of the second season as well as the combined analysis showed no significant differences in sucrose content between plant spacing of 10 and 15 cm apart as well as between 20 and 25 cm apart. This result may be due to the decrease in sucrose content percentage in sugarbeet roots growing at wider space, as shown previously in Table (68). This result was in agreement with that obtained by Mohamed (1985), Ramadan (1986), El-Shafei (1991), El-Geddawi *et al.*(1992) and Gobarh (1993), who found that sucrose content increased as the plant spacing was increased.

Table (68): The effect of plant spacing on sucrose percentage in the roots at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	14.40 a	15.12 a	14.76 a
15	14.21 b	14.80 a	14.55 a
20	13.50 c	13.92 b	13.71 b
25	13.30 c	13.72 b	13.51 b
F-test	*	*	*

3. Apparent purity percentage:

The data in Table (69) revealed that apparent purity percentage was not significantly affected due to increasing plant spacing. This was clearly shown in both seasons and in the combined analysis.

In general, it could be stated that increasing plant spacing from 10 up to 15 cm between hills improved the purity percentage, while increasing the distance from 15 cm up to 25 cm caused decrease in purity percentage, in both seasons and their combined analysis, but without any significance as shown in Table (69). Such effect might have been due to inter-plant competition accompanying dense sowing which was reflected in small sized roots containing higher sucrose content as reported by Herron *et al.*(1964), Hills (1973), Smith *et al.* (1977) , O'Conner (1983) , Hanna *et al.*(1988) , Kamel *et al.*(1989) , Mahmoud *et al.*(1990 b) , El-Shafei (1991) and Gobarh (1993). On the other hand, Basha (1984), Aly (1985) and Assey *et al.*(1985) reported that varying plant density had no significant effect on purity percentage.

Table (69): The effect of plant spacing on apparent purity percentage in the roots of sugarbeet plant at harvest of in 1992/93and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	83.82	83.77	83.65
15	83.98	85.25	84.61
20	82.12	82.71	82.39
25	81.34	82.11	81.73
F-test	N.S	N.S	N.S

4. Impurities : Alpha-amino-nitrogen, potassium and sodium contents:

The data in Tables (70 , 71 and 72) revealed that , increasing plant spacing from 10 cm up to 25 cm between hills caused a significant increase in impurity components in termes of α-amino-N, K and Na. This is true in both seasons as well as combined analysis.

The results showed that the increase in α-amino-N content in the sugarbeet roots at both 15 and 20 cm spacing between hills in combined analysis was not significant as shown in Table (70). Also, the data indicated that the difference in values of K-content in the beet roots at both 10 and 15 cm spacings between hills in second season and the combined analysis was not significant as shown in Table (71). In this respect, the increase in the α-amino-N, K and Na contents ranged from 0.58 to 1.49, from 0.08 to 0.44 and from 0.16 to 0.38 milliequivalents, as compared with planting at 10 cm apart between hills. Such effect may reflect the reduction in root diameter and weight accompanying dense sowing.

The small sized roots are assumed to contain less impurities as reported by Morghan *et al.* (1973), Smith and Martin (1989), Yoshimura and Nomura (1989), El-Shafei (1991) and Gobarh (1993). On the other hand , Barocha *et al.* (1973) found that K and Na concentrations were reduced markedly and α-amino-N was reduced slightly as population density increased from 49.9 to 123.9 thousand plants/ha.

Table (70): The effect of plant spacing on alpha-amino-N content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	2.87 d	2.78 d	2.83 c
15	3.48 c	3.34 c	3.41 b
20	3.98 b	3.78 b	3.66 b
25	4.46 a	4.17 a	4.32 a
F-test	*	*	*

Table (71): The effect of plant spacing on potassium content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	3.72 d	3.75 c	3.74 c
15	3.81 c	3.82 c	3.82 c
20	3.95 b	3.93 b	3.94 b
25	4.15 a	4.20 a	4.18 a
F-test	*	*	*

Table (72): The effect of plant spacing on sodium content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Plant spacing (cm)	First season 1992/93	Second season 1993/94	Combined analysis
10	1.21 d	1.37 d	1.29 d
15	1.43 c	1.46 c	1.45 c
20	1.48 b	1.58 b	1.53 b
25	1.63 a	1.73 a	1.68 a
F-test	*	*	*

B. Effect of nitrogen level:

1. Total soluble solids (TSS) % :

Nitrogen levels exhibited a significant effect on TSS % in both seasons as well as in the combined analysis (Table 73). Generally, increasing nitrogen level up to 60 kg/fad significantly increased the TSS %,and any increase in nitrogen applied (from 60 to 90 kg N/fad) was followed by a respective decrease in TSS % . The results of the first season and the combined analysis indicated no significant difference between 45 and 90 kg N/fad. Also, there was no significant differences between 60 and 75 kg N/fad as well as between 45 and 90 kg N/fad in the second season.

The greatest TSS % (18.78, 18.05 and 18.42%) were obtained from sugarbeet plants received 60 kg N/fad in the first and second seasons and their combined analysis, respectively.

Table (73): The effect of nitrogen fertilization on toal soluble solids (TSS) in the roots at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	15.75 d	16.35 c	16.05 d
45	16.25 c	17.20 b	16.73 c
60	18.78 a	18.05 a	18.42 a
75	16.72 b	17.83 a	17.28 b
90	16.20 c	16.90 b	16.55 cd
F-test	**	*	*

On the other hand , the lowest ones (15.75, 16.35 and 16.05%) recorded at non-fertilized plants in both seasons and the combined analysis , respectively. In this respect , Parashar (1976) found that TSS% in juice contents of beet root was significantly reduced from 19.99 to 17.99% due to increasing nitrogen fertilization from 50 to 200 kg/ha.

2. Sucrose content:

The results in Table (74) showed that sucrose content was statistically affected by nitrogen levels, and this was the fact in both seasons as well as the combined analysis. It could be concluded that, in general, increasing nitrogen level up to 60 kg/fad increased sucrose content in the root. Whereas, increasing nitrogen from 60 to 90 kg/fad markedly decreased sucrose content as shown in Table (74). The data in the first season indicated that adding 45 or 90 kg N/fad did not affect sucrose percentage. But, adding 75 kg N/fad significantly decreased sucrose %. In the second season, the results showed no significant difference between 60 and 75 kg N/fad levels as well as between nitrogen levels of 45 and 90 kg/fad. Also, the combined analysis revealed that the difference between the nitrogen levels of 45 and 90 kg/fad was not significant.

These results are generally in the same line with those obtained by Dhakar (1976) who found that increasing nitrogen fertilization from 60 to 150 kg/ha decreased root sugar percent from 17.39 to 15.21% . Also , several investigators have reported that excessive nitrogen decreased sucrose content of beets. Among them Basha (1984), Kamel *et al.*(1984), Assey *et al.*(1985), Emara (1990), El-Khatib (1991) and Gobarh (1993).

On the contrary, Ryabchuk and Lyashmskii (1972) found that the increase of nitrogen level up to 120 kg/ha was accompanied with an increase in sucrose concentration. On the other hand, Bishr *et al.* (1973) and Kamel *et al.*(1989) found that lower nitrogen levels up to 45 kg/fad improved sucrose content. While , application of nitrogen levels up to 80 kg / fad (Draycott *et al.*, 1974) and 60 kg / fad (Mahmoud *et al.*,1990 b) had no significant effect on surose content in the beet roots.

Table (74): The effect of nitrogen fertilization on sucrose percentage in the roots at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	13.18 c	13.51 c	13.35 d
45	13.33 c	14.40 b	13.87 c
60	16.16 a	15.29 a	15.73 a
75	13.72 b	15.04 a	14.38 b
90	13.30 c	14.39 b	13.85 c
F-test	*	*	*

3. Apparent purity percentage:

The effect of nitrogen level on percentage of apparent purity is shown in Table (75). The results clearly showed that apparent purity percentage was not significantly affected due to adding nitrogen fertilizer up to 90 kg/fad. This was clearly shown in first season and in the combined analysis. Whereas, in the second season, the results revealed that nitrogen level exhibited a significant effect on purity percentage. Increasing nitrogen level from zero to 90 kg/fad significantly increased purity percentage from 82.63 to 85.15%. The data, also, showed no significant difference in purity percentage of beet root juice between nitrogen levels of 60 and 75 kg/fad.

Similar findings were reported by El-Shafei (1991) and El-Geddawi *et al.* (1992) who reported that purity significantly increased with increasing the level of nitrogen from 40 to 75 kg/fad. On the other hand, Basha (1984) and Assey *et al.*(1985 and 1992 b) found that purity percentage was not significantly affected by nitrogen levels.

Table (75): The effect of nitrogen fertilization on apparent purity percentage in the roots at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	83.68	82.63 d	83.18
45	82.03	83.72 c	82.90
60	86.05	84.71 b	85.40
75	82.06	84.35 b	83.22
90	82.10	85.15 a	83.69
F-test	N.S	*	N.S

4. Impurities: (Alpha-amino-nitrogen, potassium and sodium contents):

Results presented in Tables (76, 77 and 78) indicated that impurity components in terms of α-amino-N, K and Na were significantly affected by nitrogen levels. This was clearly shown in both seasons as well as in the combined analysis. Each nitrogen increment up to 90 kg/fad resulted in a significant increase in α-amino-N, K and Na contents in sugarbeet roots. The differences between nitrogen levels of 75 and 90 kg/fad in combined analysis (Table 76) and between both 60 and 75 kg N/fad in second season (able 77) were not significant.

In general, increasing nitrogen level from zero up to 90 kg/fad caused a significant increase in impurity components (α-amino-N, K and Na contents). Such increase ranged from 1.08 to 2.63, from 0.18 to 0.74 and from 0.22 to 0.60 milliequivalents for α-amino-N, K and Na, respectively.

The positive response of impurity components to increased levels of applied nitrogen was reported by Aziz *et al.* (1977) , Halvorson *et al.*(1978) , El-Geddawi (1979) , Carter and Traveller (1981), Izsaki (1984),Leigh *et al.*(1991), Strand and Javurcek (1991) and Gobarh (1993). On the other hand, Marlander (1988) reported that increasing nitrogen levels up to 200 kg/ha increased root Na and α-amino-N content and had no effect on K conent, while El-Shafei (1991) found that impurity components were not significantly affected by increasing N-rate up to 75 kg/fad.

Table (76): The effect of nitrogen fertilization on alpha-amino-N content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	3.62 d	3.42 e	3.52 d
45	4.75 c	4.45 d	4.60 c
60	5.55 b	5.00 c	5.28 b
75	6.11 a	5.65 b	5.88 a
90	6.17 a	6.13 a	6.15 a
F-test	*	*	**

Table (77): The effect of nitrogen fertilization on potassium content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	3.77 e	3.66 d	3.72 e
45	3.92 d	3.88 c	3.90 d
60	4.15 c	4.22 b	4.19 c
75	4.30 b	4.22 b	4.26 b
90	4.51 a	4.41 a	4.46 a
F-test	**	*	*

Table (78): The effect of nitrogen fertilization on sodium content in the roots (meq/100 g sugarbeet) at harvest in 1992/93 and 1993/94 seasons and the combined analysis of the two seasons.

Nitrogen level (kg/fad)	First season 1992/93	Second season 1993/94	Combined analysis
0	1.11 e	1.22 e	1.17 e
45	1.31 d	1.46 d	1.39 d
60	1.44 c	1.58 c	1.51 c
75	1.56 b	1.73 b	1.65 b
90	1.66 a	1.88 a	1.77 a
F-test	**	**	*

C. Effect of the interaction between plant spacing and nitrogen levels:

The effect of the interaction between plant spacing and nitrogen levels on total soluble solids, sucrose content, purity percentage and impurity (alpha-amino-nitrogen, potassium and sodium contents) was not statistically significant. And this was the fact in both the two seasons as well as combined analysis, consequently the data were excluded.