RESULTS AND DISCUSSION

A. Effects of Nitrogen Fertilizer Level:

A.1: Growth Characters and Yield Components as Influenced by N- Fertilizer Level at Different Growth Stages:

1- Number of leaves per plant:

Results in Table (4) indicate the effect of the 5 different N levels on number of leaves per plant at 160, 185 and 210 days from planting in 1994/95 and 1995/96 growing seasons. The results showed that in both seasons, the increase in N level significantly increased functioning leaves number /plant. The highest leaves number was recorded at the highest N level i.e 100 kg N/fad.

In 1994/95 season, raising N level from zero to 100 kg N/fad induced significant increases in leaves number of 44.23, 46.83 and 54.98% at 160, 185 and 210 days from planting, respectively.

In 1995/96 season, the corresponding increases in leaves number were 49.01, 50.88 and 72.19%, respectively at the three growth stages. It was evident that a gradual increase in leaves number was observed with every increment in N level in both seasons. The increase in leaves number /plant due to the increase in applied N is mainly a result of the role of N in encouraging the vegetative growth and in prolonging the vegetative stages in sugar beet plants. Consequently, more functioning leaves were recorded with plants supplied by higher N levels.

Table (4): Effect of N fertilizer level on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	N Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Number of leaves/plant	0	18.305	22.569	24.791	20.236	29.070	31.361
	25	21.029	28.833	30.139	23.431	33.750	37.347
	50	22.792	31.180	32.861	25.819	36.014	42.999
	75	24.958	31.194	35.236	27.777	39.596	47.138
	100	26.402	33.139	38.418	30.153	43.861	54.000
L.S.D 5%		1.351	2.323	1.701	1.701	0.716	1.205
Leaf length (cm)	0	7.778	8.430	8.375	11.694	10.236	9.583
	25	10.669	11.903	9.361	13.819	12.208	11.138
	50	12.653	13.333	10.986	15.209	12.958	12.236
	75	15.042	14.597	11.541	16.555	14.125	13.305
	100	17.583	16.597	13.500	18.861	15.666	14.958
L.S.D 5%		0.834	0.617	0.892	0.596	0.309	0.258
Leaf width (cm)	0	5.457	5.624	5.088	7.597	6.597	6.291
	25	7.277	8.013	5.973	8.972	7750	7.445
	50	8.736	9.319	6.622	9.736	8.666	8.292
	75	10.014	9.903	7.194	10.431	9.208	9.320
	100	11.681	10.945	7.861	11.417	10.125	10.403
L.S.D 5%		0.743	0.643	0.339	0.265	0.202	0.193
Top fresh weight/plant (g)	0	45.667	45.819	38.694	140.250	168.972	199.292
	25	120.569	122.167	55.764	228.972	271.000	242.723
	50	164.180	178.195	74.667	304.680	336.820	286.333
	75	235.653	218.778	90.070	373.097	408.431	346.986
	100	297.903	254.472	117.555	498.597	530.736	456.375
L.S.D 5%		21.508	18.097	4.399	12.197	11.852	17.175

Similar results were also reported by EL-Geddawy (1979) and EL-Bashbishy (1982) who found that the increase in N application markedly increased number of leaves per sugar beet plant.

2- Leaf length:

Results in Table (4) showed that in both seasons as well as at different growth stages the increase in N level significantly increased leaf length. All increases in leaf length resulting from the increase in N level reached the significant level.

In 1994/95 season, raising N level from zero to 100 Kg N/fad significantly increased leaf length by 126.06 , 96.88 and 61.19% at 160, 185 and 210 days from planting, respectively. The corresponding increases in 1995/96 season in leaf length were 61.29, 53.05 and 56.09% at the three growth stages, respectively . It is evident from Table (4) that leaf length was greater in the second season compared with first one, probably due to the earlier planting of sugar beet in the second season. The effect of N on leaf length is mainly due to the prominent role of N on plant growth as a result of enhancing cell division and encouraging assimilation rate.

Similar results were also obtained by Prasad and Singh (1983) who found also that the increase in N application rate significantly increased LAI in sugar beet.

3- Leaf width:

Leaf width responded markedly to the increase in N level at all growth stages and in both seasons as well (Table 4). Increasing N level from zero to 25, 50, 75 and 100 kg N/fad significantly and consistently increased leaf width at 160, 185 and 210 days from planting.

In 1994/95 season, applying 100 kg N/fad induced a significant increase in leaf width over the check treatment by 114.06, 94.61 and 54.50% at 160, 185 and 210 days from planting, respectively. These increases were 50.28, 53.48 and 65.36% at the three respective growth stages, in the second season. The results showed also that the response of leaf width to N fertilizer was higher in the first season compared with the second one. That may be due to the different climatic conditions prevailing in that season and also due to the difference in sowing date. The present results reveal a clear argument for the major role of N as the most important nutrient element for sugar beet plants. The greater width resulted mainly from the increase in cell size and cell number by a good supply of N.

The present results are in agreement with those obtained by Prasad and Singh (1983) who found also that the increase in N application level significantly increased LAI in sugar beet.

4- Top fresh weight per plant :

Results in Table (4) show the effect of N fertilizer level on top fresh weight at 160, 185 and 210 days from planting. It is evident that marked and significant increases in top fresh weight per plant were observed with every increase in N level in both seasons as well as at the three growth stages.

In 1994/ 95 season, increasing N level from zero to 100 Kg N/fad significantly increased top fresh weight/ plant by 552.34, 455.39 and 203.81%, at 160, 185 and 210 days, respectively.

In 1995/96 season, the corresponding increases at the three respective stages were 255.51, 214.10 and 129.00%. It is clear that the effect of N on top fresh weight was more clear at earlier growth stages. Also increases in the first season were more evident than in the second one due to the different environmental conditions and as a result of the difference in planting date. The present results are expected since the increase in N level markedly increased leaf length, leaf width and number of leaves/ plant as indicated with the previous traits. The results cleared the role of N on vegetative growth of sugar beet plants where the increases in top fresh weight reached five folds of the check treatment.

The results herein are in agreement with those obtained by EL-Geddawy (1979), Prasad and Singh (1983) and Nour El-Din *et al.* (1992) who found that N application significantly increased leaves weight per sugar beet plant.

5- Root length:

Results in Table (5) show clearly that the increase in N level significantly increased root length of sugar beet at the three growth stages as well as in both seasons.

In 1994/95 season, raising the N level from zero to 100 Kg N/fad significantly increased root length by 54.96, 59.35 and 54.37% at 160, 185 and 210 days from planting, respectively.

Similarly, in 1995/96 season, the corresponding increases reached 41.06, 34.70 and 26.47% at the respective growth stages. The results showed also that root length recorded higher values in the second season due to the earlier planting. Also, the effect of N on root length was more evident in the first season than in the

Table (5): Effect of N fertilizer level on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	N Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Root length (cm)	0	17.208	19.236	21.278	20.096	22.055	28.805
	25	20.805	22.111	23.236	22.861	24.236	31.110
	50	22.223	25.612	25.473	24.319	26.333	32.834
	75	23.111	27.042	28.695	25.861	27.570	34.223
	100	26.666	30.652	32.847	28.347	29.709	36.430
L.S.D 5%		1.419	0.947	1.034	0.440	0.440	0.350
Root diameter (cm)	0	4.459	6.500	7.293	7.570	8.736	9.542
	25	5.334	7.334	8.416	8.639	10.111	10.723
	50	5.791	8.041	9.528	9.500	10.847	11.542
	75	6.252	8.451	10.431	9.917	11.445	12.333
	100	7.278	9.320	11.278	10.765	12.194	13.638
L.S.D 5%		0.404	0.320	0.182	0.280	0.242	0.241
Root weight (gm)	0	87.556	146.000	377.500	343.389	543.347	1039.375
	25	167.263	285.375	496.792	457.333	707.723	1185.792
	50	219.707	349.374	609.375	553.624	797.583	1242.347
	75	274.222	414.389	721.458	633.888	935.458	1379.986
	100	341.6.6	505.847	882.500	770.944	1089.805	1488.083
L.S.D 5%		22.722	37.323	30.723	12.516	29.038	66.302
Root size (cm3)	0	89.180	146.166	367.292	332.153	523.750	959.792
	25	171.041	283.721	480.417	435.347	671.389	1065.833
	50	212.375	341.805	584.653	530.625	745.445	1131.805
	75	282.541	401.403	696.555	612.153	881.320	1212.570
	100	364.027	483.541	837.083	736.736	1001.458	1349.322
L.S.D 5%		29.076	35.773	33.302	14.019	25.130	31.987
Root : top ratio/ plant	0	2.014	3.340	9.965	2.520	3.252	5.412
	25	1.437	2.369	9.171	2.038	2.609	5.086
	50	1.387	1.965	8.324	1.820	2.375	4.712
	75	1.170	1.913	8.160	1.712	2.299	4.154
	100	1.155	1.975	7.545	1.565	2.080	3.442
L.S.D 5%		0.214	0.260	0.519	0.130	0.122	0.165

second one. It is worthy to note that every increase in N level significantly increased root length at the three growth stages and in both seasons as well. For example, raising N level from zero to 25, 50, 75 and 100 kg N/ fad in 1994/95 season significantly increased root length at 210 days from planting by 9.20, 19.72, 34.86 and 54.37%, respectively.

In 1995/96 season, the corresponding increases were 8.00, 13.99, 18.81 and 26.47% at 210 days, respectively. It is clear that every increment in N level induced a significant increase in root length. The present result is a clear evidence for the prominent role of N on the growth of sugar beet roots. The result is expected since N increased growth and number of leaves contributing to a marked increase in sugar beet root length.

The present results are in full agreement with those obtained by EL-Bashbishy (1982) and Sharif and Eghbal (1994) who found that the increase in N fertilizer level markedly increased root length of sugar beet.

6- Root diameter:

Root diameter responded to N level in a similar manner as root length (Table 5). The results cleared that root diameter in both seasons as well as at the three growth stages significantly increased as the N level increased. The significant increase in root diameter was observed with every increment in N level at all growth periods.

In 1994/95 season, raising N level from zero to 100 kg N/fad significantly increased root diameter by 63.22, 43.38 and 54.64% at 160, 185 and 210 days, respectively.

In 1995/96 season, the corresponding increases due to application of the highest N level were 42.21, 39.58 and 42.93% at the three different growth stages. The present results are expected since N increased top growth, leaves number, leaves weight and root length. The contribution of N as the major nutritive element for sugar beet growth is clearly illustrated.

Similar results were also obtained by EL-Bashbishy (1982), Basha (1984) and Sharif and Eghbal (1994) who found the increasing N fertilizer level markedly increased root diameter of sugar beet. On the other hand, Assey *et al.*(1992) found that there was no relevance between root diameter and N level throughout the growing season of sugar beet.

7- Root fresh weight per plant:

Results in Table (5) indicated that increasing N level significantly increased root fresh weight at the three growth stages as well as in both seasons.

In 1994/95 season, increasing N level from zero to 25, 50, 75 and 100 kg/fad significantly increased root fresh weight by 31.60, 61.42, 91.11 and 133.77%, respectively at 210 days from planting.

In 1995/96 season, the same N levels increased significantly root fresh weight by 14.09, 19.53, 32.77 and 43.17%, respectively at 210 days from planting. All increases induced by each increment in N level reached the level of significance. The results also revealed that in 1994/95 season raising N level from zero to 100 kg/fad increased root fresh weight by 290.19, 240.40 and 133.77% at 160, 185 and 210 days from planting, respectively. The corresponding increases in 1995/96 season were 124.51, 100.57

and 43.17% at the respective growth stages. The present results are mainly due to the effect of N on root growth and are closely related with this effect on root size.

The results obtained herein are in full agreement with those reported by Follet *et al.* (1970), Halvorson and Hartman (1975), Prasad and Singh (1984) and Assey *et al.* (1992) who found that the increase in N application rate significantly increased root weight per plant and the dry matter accumulation in sugar beet plants.

8- Root size:

Results in Table (5) showed clearly that the increase in N level significantly increased root size at the different growth stages as well as in both seasons of experimentation. It was also evident that each increment in N level induced a significant increase in root size at all growth stages, indicating the vital role of N on root growth.

In 1994/95 season, increasing N level from zero to 25,50,75 and 100 kg/ fad significantly increased root size at 210 days from planting by 30.80, 59.18, 89.65 and 127.91%, respectively.

In 1995/96 season, the corresponding increases in N level were 11.05, 17.92, 26.34 and 40.58% for the respective N levels. The results also showed that raising N level from zero to 100 kg/fad increased root size in 1994/95 seasons by 308.19, 230.82 and 127.91% at 160, 185 and 210 days from planting, respectively. The corresponding increases in 1995/96 season were 121.81, 91.21 and 40.58% at the respective growth stages. The present results are quite expected since N significantly increased root length and root width at all growth stages. The results indicate the prominent role of N as the most important nutritive element for sugar beet.

The results are a good evidence for the contribution of N as the major nutritive element needed by sugar beet plants to achieve the highest weight and size of root.

The results herein are in full agreement with those reported by EL-Geddawy (1979), EL-Bashbishy (1982) and Basha (1984) who found that the increase in N application level considerably increased root size of sugar beet.

9- Root : top ratio:

Resulted in Table (5) revealed that the increase in N level significantly reduced root/top ratio at all growth stages as well as in both seasons of experimentation. The highest root/top ratio was recorded at the check treatment at all stages of growth.

In 1994/95 season, raising N level from zero to 100 kg/fad reduced root/top ratio by 42.65, 40.87 and 24.28% at 160, 185 and 210 days from planting, respectively.

In 1995/96 season, the highest N level significantly reduced root/top ratio by 37.90, 36.04 and 36.40%, at the three respective growth stages. The present results indicate that the increase in N application has a greater impact on the vegetative organs of sugar beet plants than the root system.

The results herein are in good agreement with those obtained by Follet *et al.* (1970) who found that the increase in N application caused a higher proportion of dry matter accumulation in top than in the root. Also, Hassanein (1979) showed that the increase in N level markedly reduced root: top ratio in sugar beet.

A. II: Root, Top and Sugar Yields as Influenced by N Fertilizer Level:

1- Root yield per faddan:

Results presented in Table (6) showed clearly that root yield of sugar beet significantly increased with every increment in N level in both seasons of experimentation.

In 1994/95 season, applying N at 25, 50, 75 and 100 kg/fad significantly increased root yield by 31.21, 62.70, 93.67 and 123.76%, respectively compared with the check treatment.

In 1995/96 season, the respective N levels significantly increased root yield by 29.03, 53.54, 64.28 and 88.88%, respectively. All increases induced by every increment in N level reached the level of significance. It is worthy to note that the response of root yield to N was more evident in the first season compared with the second one. This may be due to the differences in climatic conditions prevailing in the growing season and also due to the difference in planting date. The increase in root yield is a direct result of the positive effects of N on root length, root diameter, root weight and root size as well as to the effects of N on leaves number/plant, leaf length, leaf width and top fresh weight/plant. The present results indicate clearly the role of N as a vital important nutrient element for sugar beet. The results showed also that in both season, a level of 100kg N/fad seems to by the economical rate required by sugar beet under the conditions of the experiment. It is clear from Table (6) that raising N level from 75 to 100 kg/fad increased root yield by 3.133 and 3.467 t/fad in the first and second season, respectively. These marked increases reveal

Table (6): Effect of N fertilizer level on root, top and sugar yields and the related characters of sugar beet in 1994/95 and 1995/96 seasons.

N	Root yield (ton/fad)		Top yield (ton/fad)		Biological yield (ton /fad)		Harvest Index (%)		Sugar yield (ton/fad)	
kg/fad	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96
0	10.413	17.683	1.400	3.017	11.813	20.713	88.034	85.398	1.638	3.025
25	13.663	22.817	1.642	3.867	15.304	26.683	89.280	85.573	2.257	4.020
50	16.942	27.150	1.804	5.075	18.746	32.308	90.362	84.329	2.905	4.930
75	20.167	29.933	2.083	6.382	22.250	36.325	90.693	82.542	3.551	5.531
100	23.300	33.400	2.450	7.308	25.750	40.708	90.575	82.168	3.899	5.923
L.S.D 5%	1.076	0.651	0.201	0.408	1.185	0.917	0.176	0.175	0.175	0.114

the effect of a higher N supply for sugar beet as far as root yield is concerned. It is worth noting that the N total content of the experimental soil indicates that the vital nutritive element was only 0.11% in the upper layer (0.30 cm) in both seasons and 0.09% in the first season and 0.08% in the second season in the lower layer (Table 1-b). This low content of total N is a clear agreement of the high response of sugar beet plants to the applied N.

The results concluded here are in full agreement with those reported by Ali (1978), Johnson *et al.* (1978), Hassanein (1979), Kamel *et al.* (1979), Abd El-Ghaffar *et al.*(1981b)., Chochola (1981), Tanaka *et al.* (1984), Assey *et al.* (1985), Feyerabend (1985), Gaber *et al.* (1986), Kamel *et al.*(1989), Vlassak *et al.*(1991), Jazsczolt (1992), Edris *et al.* (1992), Sharif and Eghbal (1994), Toor and Bains (1994), Lauer (1995) and Gezgin *et al.* (1996) who found that the increase in N application rate significantly increased root yield of sugar beet. On the other hand, in very few and exceptional cases, root yield of sugar beet was not significantly increased due to applying N fertilizer (Bajci and Tomankova, 1991). Also Kamel *et al.* (1989) reported that N increased root yield when applied till 60 Kg N/fad, but the increase in N level to 90 Kg/fad slightly reduced root yield.

2- Top yield per faddan:

The results in Table (6) revealed clearly the marked effect of N application on the fresh top yield of sugar beet. The increase in N application level significantly increased top yield in both seasons of experimentation.

In 1994/95 season, increasing N level from zero to 25, 50, 75 and 100 Kg/fad significantly increased top yield by 17.29, 28.86, 48.79 and 75.00%, respectively compared with control. The corresponding increases in 1995/96 season were 28.17, 68.21, 111.53 and 142.23%, for the respective N level. It is worth mentioning that the top yield in the second season exceeded that of the first season due to the earlier planting in the second season. This marked difference in top yield indicates clearly the positive effect of early planting for sugar beet. The present result is a good manifestation for the vital role of N on number of leaves/ plant, leaf length, leaf width, top weight/plant and consequently top yield/fad. It could be concluded that root and top yield of sugar beet are greatly associated and both yields were linearly increased with the increase in N supply.

Similar results were also obtained by Abd El-Ghaffar *et al.* (1981b), Gaber *et al.* (1986), Morghan (1987), Mahmoud *et al.* (1990), Wisniewski and Sadowski (1991), Gutmanski and Nowakowski (1994) and Sharif and Eghbal (1994) who found that top yield of sugar beet markedly increased as the N fertilizer level increased.

<u>3- Biological yield per faddan:</u>

The results presented in Table (6) showed that biological yield of sugar beet responded to N level similarly as observed with root and top yields.

In 1994/95 season, raising N level from zero to 25, 50, 75 and 100 Kg/fad significantly increased biological yield by 29.55, 58.69, 88.35 and 117.98%, respectively.

In 1995/96 season, the corresponding increases for the same N level were 28.82, 55.96, 75.37 and 96.53%, respectively. The present results are expected since N application showed positive effects on both root and top yields of sugar beet. It could be concluded that biological yield of sugar beet increased linearly with the increase in N level. The N level of 100 Kg/fad seems to be the economic rate of N under the condition of the experiments.

The results obtained here coincide with those obtained by Jaszczolt (1992) and Rozbicki and Kalinowska-zdun (1993) who reported that the biological yield of sugar beet was markedly increased with the increase in N level.

4- Harvest index:

Harvest index of sugar beet per faddan as influenced by N fertilizer rate is presented in Table (6). The results revealed that harvest index responded differently from one season to the other.

In 1994/95 season, the increase in N level increased in general harvest index till 75 kg N/fad. The further increase in N level to 100 Kg/fad slightly and insignificantly reduced harvest index. The highest harvest index was recorded with 75 kg N/fad, being 90.693.

In 1995/96 season, another trend was observed where the first N application rate slightly increased harvest index. On the other hand, further increments in N level, i.e. 50, 75 and 100 Kg/fad significantly reduced harvest index by 1.25, 3.34 and 3.78% compared with cheek treatment, respectively. It could be concluded that the effect of N on harvest index showed no specific trend from one season to another and even was fluctuating from one N rate to another. Further investigation of the effect of N level on harvest index is needed to find out the exact role of N on this trait.

The results obtained by Wojcik (1990) indicated that harvest index of sugar beet was reduced due to the increase in N application level.

5- Sugar yield per faddan:

The effect of N on sugar yield is quite evident and was closely associated with the effect of N on root yield. The results presented in Table (6) indicated a linear increase in sugar yield with the increase in N level in both seasons of experimentation.

In 1994/95 season, applying N at 25, 50, 75 and 100 Kg/fad significantly increased sugar yield by 37.79, 77.35, 116.79 and 138.03%, respectively compared with the check treatment.

In 1995/96 season, the corresponding increases due to applying the same N levels were 32.89, 62.98, 82.84 and 95.80%, respectively. The increase in sugar yield due to applying N is highly demonstrated. A rate of 100Kg N/fad seems to be the economic level in Sakha region which is considered the sugar beet main growing area. Also, the chemical analysis of the soil indicated a low content of total N% in both seasons in both soil and sub-soil layers (Table 1-b). The results showed clearly that the early planting in the second season (October, 7) had a definite positive effect on root and sugar yields compared with the later planting date of the first season (November, 9). It is worthy to note here that the increase in sugar yield induced by the increase in N supply is mainly due to the increase in root yield and not a result of N effect on sucrose percentage, which will be discussed later in the present study.

The present results are in general agreement with those obtained by Morghan (1972), James *et al.* (1978), Halvorson and Hartman (1980), Prasad *et al.* (1985), Kamel *et al.*(1989), Gutmanski and Nowakowski (1994), Sharif and Eghbal (1994), Toor and Bains (1994) and Gezgin *et al.* (1996) who found that the increase in N level led to an increase in sugar yield. On the other hand, in very limited number of studies, it was reported that sugar yield was not significantly affected by N application (Vielemeyer *et al.* 1986; and Faber and Kryszkowska, 1990). Also in some exceptional cases, it was claimed that the increase in N level reduced sugar yield (Vlagaveshchenskaya and Mogindovid, 1986). Also, Kamel *et al.*(1989) reported that the highest sugar yield was recorded with a N level of 60 Kg/fad, and increasing N level to 90 Kg/fad slightly reduced sugar yield.

A. III: Quality Characters as Influenced by N Fertilizer Level:

The data of the quality characters obtained in 1994/95 season were statistically analyzed, but in 1995/96 season, the samples collected from the four replications were bulked into one sample to save some of the needed chemicals. Therefore, the results of 1995/96 season were not statistically analyzed.

1- Total soluble solids percentage:

Results presented in Table (7) showed that in 1994/95 season, increasing N level from zero to 50 Kg/fad significantly increased T.S.S.%. Further increase in N level up to 100 Kg/fad significantly reduced T.S.S% in roots. The result showed that excessive N had negative effects on T.S.S.%. The application of 0, 25, 50, 75 and

Table (7): Effect of N fertilizer level on the quality characters of sugar beet in 1994/95 and 1995/96 seasons.

N	1994/95							1995/96						
	T.S.S	Sucrose	Purity	Sugar recovery	Impurities%			T.S.S	Sucrose	Purity	Sugar recovery	Impurities%		
Kg/fad	%	%	%	%	α amino N	K	Na	%	%	%	%	α amino N	K	Na
0	20.083	16.708	83.321	13.520	0.174	1.710	0.297	20.100	17.30	86.867	14.97	0.263	1.339	0.114
25	20.417	17.307	83.375	14.264	0.176	1.696	0.253	20.417	17.82	86.000	15.13	0.272	1.335	0.115
50	20.625	17.613	82.729	14.739	0.179	1.599	0.306	21.292	18.42	85.883	15.46	0.274	1.314	0.122
75	19.708	17.775	81.833	14.704	0.184	1.640	0.289	20.858	18.47	85.766	15.24	0.279	1.313	0.127
100	18.792	16.995	81.233	14.045	00.188	1.818	0.319	19.250	17.83	85.583	14.79	0.294	1.397	0.151
L.S.D 5%	0.544	0.166	0.490	0.280	N.S	N.S	N.S	-	-	-	-	-	-	

100Kg N/ fad produced T.S.S% of 20.08, 20.42, 20.63, 19.71 and 18.79%, respectively in 1994/95 season.

In 1995/96 season, similar trend was observed where the application of 25 and 50 kg N/ fad markedly increased T.S.S.% over the control, but further increase of N up to 100 kg/fad reduced T.S.S% from 21.30% (for the 50 kg N/fad level) to 19.25%. In that season, N at 0, 25, 50, 75 and 100 Kg/fad recorded T.S.S% of 20.10, 20.42, 21.30, 20.86 and 19.25%, respectively. It could be concluded that N at 25 or 50 Kg/fad increased T.S.S% in both seasons, whereas raising N level up to 100 Kg/fad markedly reduced T.S.S% indicating a negative effect of excessive N application on this trait.

Similar results were also obtained by Nour and Fayed (1976) and Sharif and Eghbal (1994) who found that T.S.S.% was reduced as N application was increased to higher levels. On the other hand, Nour EL- Din *et al.*(1992) found that T.S.S.% in sugar beet roots was not considerably affected by the increase in N application.

2- Sucrose percentage:

The results presented in Table (7) showed that N application significantly increased sources percentage in 1994/95 season. In that season, the highest sucrose content was recorded at the 75 Kg/fad N level. No apparent difference was observed in succors% between 50 and 75 Kg N/fad levels. Increasing N level to 100 Kg/fad significantly reduced sucrose% compared with 25, 50, and 75 Kg N/fad level.

In 1995/96 season about the same trend of the results was observed and the highest sucrose% was recorded by applying 75 Kg N/fad, being 18.47%.

Similarly, raising N level to 100 Kg/ fad markedly reduced sucrose% compared with 25 and 50 Kg/fad levels. It could be concluded that N application at normal N levels (25, 50 and 75 kg/fad) markedly increased sucrose%, whereas excessive N application (100 Kg N/fad) reduced sucrose% compared with the lower levels. The results of sucrose% are similar to those of T.S.S.% where both traits were favorably affected by the normal N doses, since sucrose is the main component of the T.S.S.% in sugar beet juice.

The results obtained by Gaber (1970), Kamel *et al.* (1979), Abd El-Ghaffar (1981b), Gaber *et al.* (1986) and Nour EL-Din *et al.* (1992), indicated that there was no relevance between sucrose% and N application level in sugar beet. However, other investigators reported that N application reduced sucrose% in sugar beet (Hills and Ulrich, 1971; Johnsen *et al.,* 1978; O'Connor, 1983; Koch *et al.,* 1988; Vielemeyer *et al.,* 1986; Rozbicki and Kalinowski-Zdun, 1993; Sharif and Eghbal, 1994; Toor and Bains, 1994 and Lauer, 1995). The reduction in sucrose% in sugar beet roots was particularly observed with an excessive N application (Gaber, 1970; Kalio *et al.,* 1982; Buzas and Kudar, 1983 and Anderson and Peterson, 1988).

3- Purity percentage:

Results in Table (7) showed clearly that purity% gradually reduced as the N level increased in both seasons of experimentation.

In 1994/95 season, applying N at 50, 75 and 100 Kg/fad significantly reduced purity% compared with the check treatment.

In 1995/96 all N rates markedly reduced purity% of sugar beet juice. The reduction in purity% was linear with the increase in N level. In both seasons the lowest purity% was recorded at the highest N level (100 kg/fad) being 81.23 and 85.58% in the first and the second season, respectively. On the other hand, the highest purity% was 83.38% in 1994/95 season, and 86.87% in 1995/96 season which were recorded with 25 Kg and zero Kg N/fad levels in the first and the second season, receptively. It worth noting that purity% was higher in the second season compared with the first one due to the earlier planting in the second season.

Similar results were also reported by Follet *et al.* (1970), Hills and Ulrich (1971), Ali (1978), Kalio *et al.,* (1982), Buzas and Kudar (1983), Feyerabend (1985), Anderson and Peterson (1988), Mahmoud *et al.* (1990), and Sharif and Eghbal (1994) who found that the increase in N application level markedly reduced purity% in sugar beet.

4- Sugar recovery%:

The results presented in Table (7) indicated that applying N at lower or moderate rates (25, 50 and 75 kg N/fad) markedly increased sugar recovery% in both seasons. Excessive N application (100 kg/fad) markedly reduced sugar recovery%.

In 1994/95 season, a significant increase in sugar recovery% was recorded where N levels was applied at 25, 50 and 75 Kg/fad compared with the check treatment. Further increase in N from 75 to 100 significantly reduced sugar recovery%. The highest sugar recovery% in that season was 14.74% which was recorded with the N level of 50 Kg/fad.

In 1995/96 season, similar results were also obtained where an increase in sugar recovery% was observed at 25,50 and 75 Kg N/fad levels compared with the check treatment. Also, the highest sugar recovery% was recorded at 50 Kg N/fad, being 15.46%. It could be concluded that sugar recovery% followed the same pattern of response as that observed with sucrose and purity percentages.

The results obtained by Hills and Ulrich (1971) showed that too much N increased juice impurities and reducing sugar% and consequently limits refined sucrose production. Similar results were also reported by EL-Essawy (1996) who stated that the depressing effects of N on sucrose and purity% were compensated by higher root yield and finally increased sugar yield/ fad.

5- Alpha amino-nitrogen percentage:

The results presented in Table (7) indicated clearly that α-amino-N% was not significantly affected by N application.

In 1994/95 season, no significant differences in α-amino-N% were found and the differences were very slight. In both seasons, the highest α-amino N% was recorded at the highest N level (100 kg/fad), being 0.19 and 0.29% in the first and second season, respectively. On the other hand, the lowest value of α-amino-N% was that of the check treatment, being 0.17% and 0.26% in 1994/95 and 1995/96 season, respectively. It is worth noting that α-amino-N% was higher in the second season than in the first one, due to the differences in climatic conditions as a result of a marked difference in planting date. It could be concluded that the increase in N level slightly increased α-amino-N% in sugar beet juice.

Similar results were also obtained by Puente *et al.*(1982) and O'Connor (1983) who found that an increase in N supply was associated with an increase in alpha amino-N% sugar beet juice.

6- Potassium percentage:

The results presented in Table (7) showed that adding N at normal levels slightly reduced k% in sugar beet juice at harvest.

In 1994/95 season no significant effect was detected for N application on K% in juice. However, the highest K content in that season was 1.82% which was recorded at the highest N level (100 kg/fad) and the lowest K content was 1.60% which was recorded at 50Kg N/fad.

In 1995/96 season, the application of N reduced K% in juice and the lowest K content was obtained by applying 75 Kg and 50 Kg N/fad, being 1.313 and 1.314%, respectively compared with 1.34% which was recorded at the check treatment as well as at the highest N level. The results show no definite trend for the effect of N on K%. It could be concluded that no relevance could be detected between N application and K% in sugar beet juice under the conditions of the present investigation.

The results reported by Puente *et al.* (1982) and Rozbicki and Kalinowska-Zdun (1993) showed that N application increased K% in sugar beet root.

Table (8): Effect of P fertilizer level on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	P Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Number of leaves/plant	0	22.694	28.905	31.767	24.955	35.583	41.588
	15	22.772	29.861	32.811	26.011	37.334	43.550
L.S.D 5%		N.S	N.S	N.S	0.415	0.453	0.762
Leaf length (cm)	0	12.927	12.572	10.616	15.017	12.766	11.928
	15	12.533	13.172	10.889	15.439	13.311	12.561
L.S.D 5%		N.S	0.390	N.S	0.377	0.196	0.163
Leaf width (cm)	0	8.628	8.655	6.367	9.544	8.272	8.167
	15	8.639	8.866	6.726	9.717	8.667	8.534
L.S.D 5%		N.S	N.S	0.215	0.168	0.128	0.122
Top fresh weight/plant (g)	0	167.689	161.444	73.267	288.956	324.017	296.834
	15	177.899	166.328	77.433	329.283	362.366	315.850
L.S.D 5%		5.107	2.927	2.782	7.714	7.496	10.863

second season. The results indicated that in 1994/95 season, P application at 15 Kg P_2O_5/fad insignificantly increased leaves number over the control treatment by 0.34, 3.31 and 3.29% at 160, 185 and 210 days, respectively. These increases were far below the level of significance.

In 1995/96 season, applying P at 15 Kg P_2O_5/fad significantly increased leaves number/plant by 4.23, 4.92 and 4.72%, at 160, 185 and 210 days from planting, respectively. The significant increases in the second season for the application of P may be due to early planting, allowing the growing plants to utilize the applied nutrients more efficiently than in the first season. It could be concluded that P application favorably affected functioning leaves number/plant of sugar beet throughout the growing season. The effect of P was more evident in the second season and reached the significant level. The favourable effect of P on leaves number/plant is mainly due to its important role in plant life. P is a constituent of nucleic acid, phytin and phospholipids and it is known to stimulate metabolic process which contribute to the increase in the metabolite amounts which is used in building new organs such as leaves in addition to root growth stimulation. The positive effects of P on the growth of sugar beet may be due to the stimulation of photosynthetic rate at higher P rates (Sucin and Sebok, 1979). In this connection, El-Essawy (1996) reported that P applied at 30 Kg P_2O_5/fad in combination with 120 Kg N+ 24 Kg K_2O/fad increased growth and yield attributes of sugar beet.

2- Leaf length:

Results in Table (8) indicated that P application increased leaf length at all growth stages and in both seasons of experimentation as well. It is evident that the effect of P on this trait was more clear in 1995/96 season than in 1994/95 season. The effect of P reached the level of significance at 185 days in the first season and at all stages in the second one.

In 1994/95, applying P at 15 Kg P_2O_5/fad significantly increased leaf length over the check treatment by 4.77% at 185 days from planting. On the other hand, no significant effect was detected for P application at 160 and 210 days in that season.

In 1995/96 season, P application at 15 Kg P_2O_5/fad significantly increased leaf length over the check treatment by 2.81, 4.43 and 5.31% at 160, 185 and 210 days, respectively. It could be concluded that P favourably affected leaf length, particularly in the second season probably due to earlier planting. The positive effect of P on sugar beet growth was also reported by El-Essawy (1996) who carried out field experiments at the same experimental site of the present investigation.

3- Leaf width:

The results presented in Table (8) showed also that applying P at 15 Kg P_2O_5/fad increased leaf width at all growth stages as well as in both seasons of experimentation. However, the increase in leaf width due to P application reached the level of significance at 210 days from planting in the first season and at the three sampling stages in the second one.

In 1994/95 season, applying P at 15 Kg P_2O_5/fad increased leaf width over the control treatment by 0.13, 2.44 and 5.64% at 160, 185 and 210 days, respectively.

In 1995/96 season, P application significantly increased leaf width by 1.81, 4.78 and 4.49% at the respective growth stages. It could be concluded that leaf width was favourably affected by P application particularly in the second season. This result is mainly due to the role of P on plant growth and agrees with those reported by El-Essawy (1996). Also, the chemical analysis of the experimental soil indicated a low content of available P in the soil, being 13.50 and 12.25 ppm in the first and second , respectively in the top soil layer and 10.20 and 9.50 ppm in the subsoil in the two successive seasons (Table 1-b).

4- Top fresh weight per plant:

The results in Table (8) indicated clearly that applying P fertilizer at 15 Kg P_2O_5/fad significantly increased top fresh weight/plant at the three sampling dates and in both seasons of experimentation as well.

In 1994/95 season, P application (15 Kg P_2O_5/fad) significantly increased leaves fresh weight/plant over the check treatment by 6.09, 3.03 and 5.69%, receptively at 160, 185 and 210 days from planting. The corresponding increases in 1995/96 season due to the application of the same P level were 13.96, 11.84 and 6.41%, respectively. It is worthy to note that the response of top fresh weight/plant to P application was greater in the second season than in the first one due to earlier planting and the differences in environmental conditions. The present results are expected since P application showed positive effects on number of leaves/plant, leaf length and leaf width. The positive effect of P on top fresh weight was also reported by El-Essawy (1996) particularly when P application was combined with N and K application.

5- Root length:

Results in Table (9) showed that P application increased root length. The effect of P was more evident in the second season and reached the significant level throughout the three sampling stages, whereas the significant effect was only recorded at 185 days from planting in the first season.

In 1994/95 season, the application of 15 Kg P_2O_5/fad significantly increased root length by 4.82% compared with the control treatment at 185 days.

In 1995/96 season, the same level of P induced significant increases in root length over the check treatment of 3.85, 2.11 and 2.01% at 160, 185 and 210 days, respectively. It could be concluded that P positively affected root length, particularly in the second season. This effect is mainly due to the role of P in stimulating root growth and photosynthetic processes as indicated by Sucin and Sebok (1979).

Similar results were also obtained by Hassanein (1992) who found that application of 45 Kg P_2O_5/fad significantly increased length of sugar beet root. Also El-Essawy (1996) showed that the highest root length was recorded with applying 120 Kg N + 30 Kg P_2O_5 + 24 Kg K_2O/fad in 1992/93 season and by applying 90 Kg N+ 45 Kg P_2O_5+ 24 Kg K_2O/fad in 1993/94 season.

Table (9): Effect of P fertilizer level on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	P Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Root length (cm)	0	21.911	24.344	26.611	23.838	25.711	32.355
	15	22.094	25.517	26.000	24.755	26.250	33.006
L.S.D 5%		N.S	0.599	N.S	0.278	0.278	0.221
Root diameter(cm)	0	5.795	7.934	9.222	9.150	10.511	11.295
	15	5.850	7.961	9.556	9.406	10.822	11.816
L.S.D 5%		N.S	N.S	0.115	0.177	0.153	0.152
Root weight (g)	0	210.189	327.150	601.833	532.183	784.811	1259.983
	15	225.961	353.244	633.217	571.488	844.755	1274.250
L.S.D 5%		14.371	23.605	19.431	7.916	18.365	N.S
Root size (cm^3)	0	213.400	316.927	575.666	511.750	741.000	1137.695
	15	234.266	345.727	610.733	547.056	791.944	1150.194
L.S.D 5%		18.389	22.625	21.062	8.866	15.893	N.S
Root : top ratio/plant	0	1.350	2.378	8.718	2.009	2.590	4.616
	15	1.515	2.246	8.548	1.853	2.456	4.507
L.S.D 5%		0.136	N.S	N.S	0.082	0.077	0.104

6- Root diameter:

The results reported in Table (9) showed that root diameter followed the same pattern of response to P as indicated by root length. The results revealed that P application at 15 Kg P_2O_5 /fad significantly increased root diameter over the check treatment by 3.62% at 210 days in the first season. In the second season, the increase in root diameter reached the significant level at the three sampling stages, being 2.80, 2.96 and 4.61% at 160, 185 and 210 days, respectively. It could be concluded that P favourably affected root diameter of sugar beet.

Similar results were also obtained by Hassanein (1992) and El-Essawy (1996).

7- Root fresh weight per plant:

The results presented in Table (9) indicated a significant effect for P application on root fresh weight/plant in both seasons of experimentation. In general, P application increased root fresh weight throughout the three growth stages and the increase was almost significant.

In 1994/95 season, applying P at 15 Kg P_2O_5 /fad increased root fresh weight over the control treatment by 7.50, 7.98 and 5.21% at 160, 185 and 210 days from planting, respectively. The corresponding increases in root fresh weight/plant in 1995/96 season were 7.39, 7.64 and 1.13% at the three respective sampling dates. It is worth mentioning that the difference in root fresh weight at 210 days in the second season was not significant. It could be concluded that P application encouraged root fresh weight due to its effects on root growth and photosynthetic activities in the plant.

Similar results were also reported by Hassanein (1992) who found that applying 45 Kg P_2O_5/fad increased root weight/plant. Also, El-Essawy (1996) found that the maximum root weight/ plant was recorded by applying 120 Kg N+ 45 Kg P_2O_5+ 48 Kg K_2O/fad in 1992/93 season, and by applying 120 Kg N+ 30 Kg P_2O_5 +24 Kg K_2O/fad in 1993/94 season, being 852.7 and 1143.3 g in the first and second season, respectively.

8- Root size:

The results presented in Table (9) revealed that P application increased, in general, root size of sugar beet roots and this increase was mostly significant.

In 1994/95 season, the application of 15 Kg P_2O_5/fad significantly increased root size by 9.78, 9.09 and 6.09% over the check treatment at 160, 185 and 210 days from planting, respectively.

In 1995/96 season, the corresponding increases were 6.90, 6.88 and 1.10 at the three respective sampling ages. The increase in root size at 210 days in the second season was below the level of significance. The present results are expected since P application induced an increase in root length and root size, and agree with those reported by Hassanein (1992) and El-Essawy (1996). The present result is logical since P positively affected length, width and weight of root, consequently root size should be increased.

9- Root : top ratio per plant:

Results in Table (9) showed that P application had a significant effect on root: top ratio particularly in the second season.

In the first season, no specific trend was detected for P application effect on root: top ratio. The results showed that in 1994/95 season P application significantly increased root/ top ratio at 160 days from planting, where an increase of 12.22% was recorded. On the other hand, an opposite trend was observed at 185 and 210 days where slight and insignificant reductions of 5.55 and 1.95% were recorded at 185 and 210 days from planting due to applying 15 Kg P_2O_5/fad.

In 1995/96 season, P application significantly reduced root: top ratio by 7.77, 5.17 and 2.36 at 160, 185 and 210 days from planting, respectively.

The present results showed that, in general, P application favoured leaf growth to achieve a higher percentage in the biological yield. Results reported by Schmehl and James (1971) indicated an increase in top growth resulting from P fertilization of deficient soils.

***B.II: Root, Top and Sugar Yields as Influenced by P Fertilizer Level*:**

1- Root yield per faddan:

Results presented in Table (10) showed that the application of 15 Kg P_2O_5/fad significantly increased root yield by 4.91 and 2.29% in 1994/95 and 1995/96 seasons, respectively compared with the check treatment. The increase in root yield/fad is mainly due to the positive effects of P on root weight and root size per plant as

Table (10): Effect of P fertilizer level on root, top and sugar yields and the related characters of sugar beet in 1994/95 and 1995/96 seasons.

P kg/fad	Root yield (ton/fad)		Top yield (ton/fad)		Biological yield (ton /fad)		Harvest Index (%)		Sugar yield (ton/fad)	
	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96
0	16.492	25.900	1.817	5.093	18.308	30.998	89.987	83.938	2.890	4.607
15	17.302	26.493	1.935	5.170	19.237	31.691	89.591	84.067	2.902	4.764
L.S.D 5%	0.681	0.412	N.S	N.S	0.749	0.580	N.S	N.S	N.S	0.072

previously discussed. The results indicate that P is one of the major essential plant nutrients needed for sugar beet production. It is also known that sugar beet has a high P requirement and is considered as a limiting factor for obtaining high yields.

Similar results were also reported by Nour and Fayed (1976), Gordeiro *et al.*(1984), Radenovic and Dobrodoliani (1988), Hassanein (1992), Tsvei and Sidorov (1992), and El-Essawy (1996) who reported significant response of root yield of sugar beet to different rates of the applied P. On the other hand, in some investigations no significant effect for P fertilization on root yield was obtained (Herron, *et al.*1964 and Jaszczolt, 1990).

2- Top yield per faddan:

The results presented in Table (10) showed that top yield/fad of sugar beet was not significantly affected by P application in both seasons of experimentation. However, the results indicated slight and insignificant increases in top yield due to applying 15 Kg P_2O_5/fad over the check treatment. The increase in top yield was 6.49 and 1.51% in the first and second season, receptively. These increases were below the level of significance.

The present results agree with those reported by Herron *et al.* (1964) who found that P application did not affect top yield of sugar beet, whereas Hassanein (1992) recorded a significant increase in top yield due to P application.

3- Biological yield per faddan:

The effect of P application on biological yield was significant in both seasons (Table 10). Applying P at 15 Kg P_2O_5/fad significantly increased biological yield by 5.07 and 2.24% in

1994/95 and 1995/96 season, respectively. The increase in biological yield is mainly due to the positive effects of P application on growth characters and yield components such as root weight, root size, leaf length, leaf width, top weight/ plant and number of leaves/plant. The response of sugar beet to P application is due to the stimulation in photosynthetic rate.

The present results agree with those obtained by Hassanein (1992) and El-Essawy (1996) working under Egyptian environment.

4-Harvest index:

The effect of P application on harvest index was not significant in both seasons of experimentation as shown in Table (10). However, P application slightly reduced harvest index in the first season, but slightly increased this index in the second one. The present result reveals that no definite effect could be detected for the effect of P application on this trait. This result indicates clearly that the effect of P on root as well as top yields was similar that any increase in root yield was also associated by an increase in top yield.

The present results are in general agreement with those obtained by Schmehl and James (1971) who found that root/top ratio was not much changed by P application, while it was usually decreased by N fertilization.

5-Sugar yield per faddan:

The results in Table (10) showed that P application increased sugar yield in both seasons. This increase reached the level of significance in the second season, but it was far below the level of significance in the first one. The results showed that P application at 15 Kg P_2O_5/fad increased sugar yield over the check treatment by 0.42 and 3.41% in 1994/95 and 1995/96 season, respectively, The increase in sugar yield is mainly due to increase in root yield and not to an increase in sucrose%.

The present results are in general agreement with those reported by Nour and Fayed (1976), Abbott and Nelson (1983), Radenovic and Dobrodoliani (1988), Hassanein (1992) and Tsvei and Sidorov (1992) who found that P fertilization increased sugar yield.

B. III: Quality Characters as Influenced by P Fertilizer Level:

The data of the quality characters obtained in 1994/95 season were statistically analyzed, but in 1995/96 season, the samples collected from the four replications were bulked into one sample to save some of the needed chemicals. Consequently, the results of 1995/96 season were not statistically analyzed.

1- Total soluble solids percentage (T.S.S.%):

The results presented in Table (11) indicated very slight increase in T.S.S% due to P application in both seasons.

In 1994/95 season, applying 15 Kg P_2O_5/fad insignificantly increased T.S.S% from 19.78% (for the check treatment) to 20.07%. The corresponding T.S.S% values in 1995/96 season were 20.04% for the control and 20.51% for the P treated plants. It could be concluded that P application slightly increased T.S.S% probably due to low content of available P in the soil (Table 1-b).

Table (11): Effect of P fertilizer level on the quality characters of sugar beet in 1994/95 and 1995/96 seasons.

P	1994/95							1995/96						
	T.S.S	Sucrose	Purity	Sugar recovery	**Impurities%**			T.S.S	Sucrose	Purity	Sugar recovery	**Impurities%**		
Kg/fad	%	%	%	%	α amino N	K	Na	%	%	%	%	α amino N	K	Na
0	**19.783**	**17.206**	**81.778**	**14.963**	**0.163**	**1.574**	**0.266**	**20.041**	**17.921**	**85.893**	**14.920**	**0.279**	**1.382**	**0.113**
15	**20.067**	**17.353**	**83.218**	**15.147**	**0.172**	**1.629**	**0.286**	**20.510**	**18.073**	**86.147**	**15.316**	**0.276**	**1.333**	**0.138**
L.S.D 5%	**N.S**	**0.105**	**0.310**	**0.177**	**N.S**	**N.S**	**N.S**	-	-	-	-	-	-	-

The results obtained by El-Essawy (1996) showed that T.S.S.% was significantly affected by the different NPK combinations and the application of 120 Kg N+ 30 Kg P_2O_5 + 48 Kg K_2O/fad in the first season, and 90 Kg N+ 45 Kg P_2O_5+ 24 Kg K_2O/fad in the second season produced the highest T.S.S.%.

2- Sucrose percentage:

The results reported in Table (11) showed that the application of 15 Kg P_2O_5/fad significantly increased sucrose% (in 1994/95 season) compared with the check treatment. The data in Table (11) showed that sucrose% of the check treatment was 17.21 and 17.92% in the first and second season, respectively, these values increased due to P application and averaged 17.35 and 18.07% in the two successive seasons. It could be concluded that P favourably affected sucrose% in sugar beet juice.

The results reported by Herron *et al.* (1964), Imura and Hayaska (1987) showed that P application did not affect sucrose% in sugar beet, whereas Abbott and Nelson (1983), Hassanein (1992), and Leshchenko *et al.* (1993) indicated that P application led to an increase in sucrose% in sugar beet.

3- Purity percentage :

The results presented in Table (11) indicated a marked increase in purity% as a result of P fertilization in both seasons.

In 1994/95, applying 15 Kg P_2O_5/fad significantly increased purity% from 81.78% for the control to 83.22%. Also, the same level of P raised the purity% from 85.89% for the control treatment to reach 86.15%. The increase in purity% due to P fertilization is mainly due to the increase in sucrose%. It could be concluded that P application led to an increase in purity% of the sugar beet juice.

The results reported by Hassanein (1992) indicated the purity% was increased as a result of P fertilization. On the other hand, Schmehl and James (1971) found that P application had no apparent effect on sucrose and purity percentages of sugar beet.

4- Sugar recovery percentage:

The results presented in Table (11) showed that sugar recovery% significantly increased in 1994/95 season due to the application of 15 Kg P_2O_5/fad. Also in 1995/96 season, an increase in sugar recovery% was observed from the application of P fertilizer. Sugar recovery% of the check treatment was 14.96 and 14.92% in the first and second season, respectively, and the corresponding values of the P application treatment were 15.15 and 15.32% in the two successive season.

It could be concluded that P application favourably affected sugar recovery%. This effect of P on sugar recovery% is mainly due to the role of P in increasing sucrose and purity percentages in sugar beet juice.

The results reported by El-Essawy (1996) indicated that the quality of sugar beet juice was improved by the application of either 120 Kg N+ 30 Kg P_2O_5+ 48 Kg K_2O or 90 Kg N+ 45 Kg P_2O_5 + 48 Kg K_2O/fad.

5-Alpha amino- N percentage:

The results presented in Table (11) indicated a very slight increase in α-amino- N% as result of applying 15 kg P_2O_5/fad in

The results obtained by El-Essawy (1996) indicated no significant difference in sugar beet root juice due to applying different combinations of N, P and K. He also reported that adding P and K with N fertilizers improved quality of sugar beet roots.

C: Effects of Potassium Fertilizer Level:

C. I : Growth Characters and Yield Component as Influenced by K Fertilizer Level at Different Stages of Growth:

1- Number of leaves per plant:

Results in Table (12) showed that K fertilization significantly increased number of functioning leaves at different growth stages and in both seasons as well.

In 1994/95 season, applying K at 24 Kg K_2O/fad increased number of leaves/plant by 8.85, 4.90 and 4.88%, at 160, 185 and 210 days from planting, respectively compared with the control. Potassium application at 48 Kg K_2O/fad significantly increased number of leaves/plant over the check treatment by 13.09, 9.36 and 10.48% at 160, 185 and 210 days, respectively.

In 1995/96 season, a similar trend was observed where application of K at a rate of 48 Kg K_2O/ fad significantly increased number of leaves/ plant at the three growth stages. The increases in leaves number/ plant over the check treatment were 9.57, 8.03 and 8.35% at 160, 185 and 210 days, respectively. It could be concluded that K application positively affected number of leaves and a level of 48 Kg K_2O/fad was more effective than the lower K level (24 Kg K_2O /fad). The role of K as an essential element for the production and translocation of carbohydrates and in activating plant growth is illustrated. It is also known that sugar beet is

Table (12): Effect of K fertilizer level on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	K Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Number of leaves/plant	0	21.184	28.050	30.717	24.224	34.933	40.608
	24	23.058	29.425	32.217	25.683	36.708	43.100
	48	23.958	30.675	33.933	26.542	37.734	44.000
L.S.D 5%		1.046	1.800	1.317	0.509	0.555	0.933
Leaf length (cm)	0	12.109	12.066	10.342	14.475	12.492	11.725
	24	12.208	13.033	10.958	15.392	13.191	12.358
	48	13.917	13.517	10.958	15.816	13.433	12.650
L.S.D 5%		0.646	0.478	N.S	0.461	0.240	0.200
Leaf width (cm)	0	8.108	8.008	6.217	9.267	8.100	7.916
	24	8.441	9.017	6.548	9.682	8.558	8.450
	48	9.350	9.258	6.875	9.942	8.750	8.684
L.S.D 5%		0.575	0.498	0.263	0.205	0.156	0.149
Top fresh weight/plant (g)	0	158.392	152.442	71.892	282.008	316.817	286.975
	24	176.017	169.300	76.642	318.758	347.542	311.609
	48	183.974	169.917	77.517	326.591	365.217	320.442
L.S.D 5%		16.660	12.469	3.408	9.448	9.180	13.304

classified as a crop of high K requirement.

The present results are not in agreement with those reported by Kamel *et al.* (1979) and Neamat- Alla (1991) who found that K application did not significantly affect number of leaves in sugar beet.

2- Leaf length:

The results presented in Table (12) indicated that K application positively affected leaf length of sugar beet throughout the growing season in the two experimental years. The effect of K was almost significant and only in some exceptional cases, the increase in leaf length was below the significant level.

In 1994/95 season, applying K at 48 Kg K_2/fad increased leaf length over the check treatment by 14.93, 12.03 and 5.96%, at 160, 185 and 210 days from planting, respectively. In 1995/96 season, the corresponding increases for the level of 48 Kg K_2/fad were 9.26 7.53 and 7.89% at the three growth stages, respectively. All these increases were significant except that at 210 days from planting in the first season. It could be concluded that the role of K as an important element for sugar beet is clearly illustrated.

The present results are in agreement with those obtained by Sucin and Sebok (1979), Table *et al.* (1986), Neamat-Alla (1991) and Basha (1994). On the other hand, Kamel *et al.*(1979) found that there was no relevance between K application and leaf length of sugar beet.

3- Leaf width:

The results reported in Table (12) indicated a marked effect for K application on leaf width of sugar beet throughout the different growth stages and in both seasons as well. Most increases in leaf width due to applying K were significant with some few exceptions.

In 1994/95 season, applying 48 Kg K_2/fad significantly increased leaf width over the check treatment by 15.32, 15.61 and 10.58% at 160, 185 and 210 days from planting respectively. The corresponding increases for the same K level in 1995/96 season averaged 7.28, 8.02 and 9.70% at the three respective growth stages. It is worthy to note that all increases due to applying 48 Kg K_2O/fad were significant. The present results indicate clearly the role of K in stimulating sugar beet growth and agree with those obtained by Table *et al.* (1986) and Neamat- Alla (1991) who recorded significant increase in leaf width and LAI as a result of K fertilization. On the other hand, Kamel *et al.* (1979) found that K application did not significantly influence LAI of sugar beet.

4- Top fresh weight per plant:

The application of K had a significant effect of leaves weight/ plant at the three different growth stages as well as in both seasons of experimentation as shown in Table (12).

In 1994/95 season, applying K at 48 Kg K_2O/fad significantly increased top fresh weight/ plant over the check treatment by 16.15, 11.46 and 7.82% at 160, 185 and 210 days from planting, respectively.

Similarly in 1995/96 season, the application of 48 Kg K_2O/fad significantly increased top fresh weight/ plant by 15.81, 15.28 and

11.66% over the check treatment at the three successive sampling dates. It is worth mentioning that all increases in top fresh weight/ plant induced by either the lower (24 Kg) or the higher (48 Kg) K_2O/fad level were significant compared with the control at all growth stages and in both seasons as well. Also, at all growth stages in the first season and at 210 days in the second season, no significant difference in top fresh weight/ plant could be detected between the 24 and 48 Kg K_2O/fad levels. The present results indicate that the lower K level was sufficient to induce significant increase in top fresh weight of sugar beet.

The results herein agree with those obtained by Sucin and Sebok (1979), Table *et al.* (1986), Abdel- Aal (1990), Neamat- Alla (1991) and Basha (1994) who found that K application markedly increased top fresh weight and dry matter accumulation in sugar beet. On the other hand, the results reported by Basha *et al.* (1985) did not show significant effect on top fresh weight due to applying K fertilization.

5- Root length:

The results presented in Table (13) indicated that the application of K fertilizer significantly increased root length of sugar beet with one exception at 160 days in the first season where no significant differences were detected in root length due to K application. The results showed that applying 48 Kg K_2O/fad in 1994/95 season increased root length over the check treatment by 0.31, 12.58 and 4.11% at 160, 185 and 210 days, respectively.

Table (13): Effect of K fertilizer level on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	K Kg/fad	No. of days from planting					
		1994/95			1995/96		
		160	185	210	160	185	210
Root length (cm)	0	22.041	23.317	25.383	23.266	25.117	31.950
	24	21.858	25.225	27.109	24.650	26.209	32.850
	48	22.109	26.250	26.425	24.975	26.617	33.241
L.S.D 5%		N.S	0.734	0.801	0.341	0.341	0.271
Root diameter (cm)	0	5.467	7.634	8.998	8.809	10.242	11.116
	24	5.783	8.008	9.467	9.442	10.775	11.650
	48	6.217	8.200	9.767	9.584	10.983	11.900
L.S.D 5%		0.313	0.235	0.141	0.217	0.188	0.187
Root weight (g)	0	192.625	327.217	575.000	527.425	755.733	1236.800
	24	234.633	352.467	630.075	558.042	828.417	1259.000
	48	226.967	340.908	647.500	570.041	860.200	1305.550
L.S.D 5%		17.600	N.S	23.798	9.695	22.492	51.358
Root size (cm^3)	0	199.874	322.900	554.642	508.542	715.333	1116.833
	24	235.783	338.216	607.208	535.042	777.042	1151.125
	48	235.842	332.866	617.750	544.625	807.042	1163.875
L.S.D 5%		22.522	N.S	25.796	10.859	19.465	24.777
Root : top ratio/plant	0	1.391	2.408	8.495	2.032	2.529	4.674
	24	1.422	2.311	8.617	1.882	2.561	4.526
	48	1.485	2.218	8.787	1.879	2.479	4.484
L.S.D 5%		N.S	N.S	N.S	0.101	N.S	0.128

In 1995/96 season, the corresponding increases due to applying 48 Kg K_2O/fad were 7.35, 5.97 and 4.04% at the three successive growth stages, respectively. All these increases reached the level of significance except that at 160 days in the first season. It is worth noting that the lower K level (24 Kg K_2O/fad) was sufficient to induce a marked increase in root length at all growth stages in both seasons with one exception at the early stage of the first season. It could be concluded that K application at 24 and 48 Kg K_2O/fad induced a considerable increase in root length of sugar beet.

Similar results were also obtained by Kamel *et al.* (1979), Sobhy *et al.* (1992) and Basha (1994). On the other hand, Neamat-Alla (1991) recorded no significant effect for K application on root length of sugar beet.

6- Root diameter:

The results presented in Table (13) indicated a significant effect for K application on root diameter throughout the three growth stages as well as in both seasons of experimentation. Nevertheless, the increase in K level significantly increased root diameter. All differences in root diameter as affected by K level were significant indicating a marked role for K on this trait.

In 1994/95, the increase in K level from zero to 24 Kg K_2O/fad significantly increased root diameter by 5.78, 4.90 and 5.21% at 160, 185 and 210 days from planting, respectively. The corresponding increases in 1995/96 season were 7.19, 5.20 and 4.80% at the successive growth stages, respectively. Further increase in K level up to 48 Kg K_2O/fad significant by increased root diameter over the check treatment by 13.72, 7.41 and 8.55 at 160, 185 and 210 days, respectively in 1994/95 season. The corresponding increases in 1995/96 season were 8.80, 7.23 and 7.05% at the three respective growth stages. It could be concluded that K is an essential element for root formation in sugar beet and a level of 48 Kg K_2O/fad is required for producing greater roots.

Similar results were also obtained by Kamel *et al.* (1979), Abdel-Aal (1990) and Basha (1994) who found that K application significantly increased root diameter of sugar beet. On the other hand, Table *et al.* (1986) found that K application did not affect root diameter.

7- Root fresh weight per plant:

Results reported in Table (13) indicated a significant positive effect for K application on root fresh weight/ plant in both seasons as well as at the three growth stages with one exception at 185 days from planting in 1994/95 season, where the differences in root weight were below the level of significance.

In 1994/95 season, the application of 48 Kg K_2O/fad increased root fresh weight/ plant by 17.83, 4.18 and 12.61% over the check treatment at 160, 185 and 210 days from planting, respectively.

In 1995/96 season, the corresponding increases for the same K level were 8.08, 13.82 and 5.56% at the three successive growth stages. The present results are expected since K application significantly increased top fresh weight leading in turn to a marked increase in root weight.

Similar results were also obtained by Basha *et al.* (1985), Abdel- Aal (1990), Neamat-Alla (1991), Basha (1994) and Kasap and Killi (1994) who recorded significant increases in root weight by K application. On the other hand, Table *et al.* (1986) found no significant effect for K application on this trait.

8- Root size:

The results in Table (13) showed a positive and significant effect of k application on root size in both seasons and almost at all growth stages. It is worth noting that the application of 24 Kg K_2O/fad significantly increased root size at all growth stages with one exception at 185 days in 1994/95 season where the increases in root size were not significant. The results showed also that all increases in root size resulting from increasing K level from 24 to 48 Kg K_2O/fad were not significant.

In 1994/95 season, the application of 48 Kg K_2O/fad increased root size over the check treatment by 18.00, 3.09 and 11.38% at 160, 185 and 210 days, respectively.

In 1995/96 season, the corresponding increases averaged 7.10, 12.82 and 4.21% at the three respective growth stages. The present results are expected since K application markedly increased root length and root width and consequently the increase in root size is the natural result. From these results the role of K as an essential element for sugar beet is clearly demonstrated.

The results obtained herein did not agree with those reported by Basha *et al.* (1985) and Table *et al.*(1986) who found no significant effect for K fertilization on root size.

9- Root: top ratio per plant:

The results presented in Table (13) showed that K application had no definite effect on root: top ratio/ plant at different growth stages. In some case, insignificant increases were observed in root: top ratio and in some other instances an opposite trend was observed. The results showed no definite trend for K application on this trait and data were fluctuating from one growth stage to the other. It could be concluded that further investigation is required to elucidate the effect of K on root : top ratio/ plant.

The results reported by Table *et al.* (1986) indicated that the application of 40 Kg K_2O/fad produced the highest root : top ratio. Also, Neamat-Alla (1991) found that K application increased root: top ratio in sugar beet.

C. *II*: *Root, Top and Sugar Yields as Influenced by K Fertilizer Level:*

1- Root yield per faddan:

The results presented in Table (14) indicated a significant effect of K application on root yield of sugar beet in both seasons.

In 1994/95 season, the application of 24 and 48 Kg K_2O/fad significantly increased root yield over the control treatment by 10.44 and 14.51% respectively.

In 1995/96 season, the same levels of K_2O significantly increased root yield by 3.69 and 5.11%, respectively. It is worth noting that no significant differences were observed in root yield between 24 and 48 Kg K_2O/fad levels in both seasons. It was clear from Table (14) that the root yield in 1995/96 season was markedly

Table (14): Effect of K fertilizer level on root, top and sugar yields and the related characters of sugar beet in 1994/95 and 1995/96 seasons.

K	root yield (ton/fad)		Top yield (ton/fad)		Biological yield (ton /fad)		Harvest Index (%)		Sugar yield (ton/fad)	
kg/fad	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96	1994/95	1995/96
0	15.600	25.450	1.692	4.890	17.293	30.340	90.029	84.305	2.599	4.452
24	17.228	26.390	1.915	5.150	19.143	31.598	89.772	84.014	2.984	4.737
48	17.863	26.750	2.020	5.355	19.883	32.105	89.565	83.689	3.105	4.868
L.S.D 5%	0.834	0.505	0.156	0.316	0.918	0.710	N.S	N.S	0.136	0.089

higher than that in 1994/95 season due to earlier planting date in the second season. The present results are mainly due to effects of K application on growth characters and yield components, particularly root length, root width, root size and root fresh weight/ plant. It is well known that sugar beet is classified as a crop of high K requirement. It absorbs more K than any other mineral nutrient element.

It was reported by Holmes (1982) that sugar beet plants remove approximately 235 Kg K_2O for the production of 50 tons of whole beet per hectare, (equivalent to 98.7 Kg K_2O for producing 21 tons per faddan). The increase in root yield is mainly a result of the role of K in translocation and accumulation of sucrose. Several investigators reported that K application significantly increased root yield of sugar beet (Sanchez, 1979; Kamel *et al.* 1989; Hegazy *et al.* 1992; Basha, 1994; and Kasap and Killi, 1994).

2- Top yield per faddan:

The application of K significantly increased top yield /fad in both seasons of experimentation as shown in Table (14).

In 1994/95 season, applying K of 24 and 48 Kg K_2O/fad significantly increased top yield/ fad over the check treatment by 13.18 and 19.39%, respectively.

The corresponding increases in 1995/96 season, being 5.32 and 9.51% for the lower and higher K level, respective. It is worth noting that no significant increase in top yield was recorded for the application of the higher K level (48Kg K_2O/fad) compared with the lower level (24Kg K_2O/fad), as also indicated by the effect of K level on root yield. It could be concluded that K was quite important for increasing top yield of sugar beet showing its vital role on the production and translocation of carbohydrates. It also seems to be intimately related to N metabolism of plants. The present results are in full agreement with those obtained by Basha *et al.* (1985) and Basha (1994) who reported considerable increases in top yield of sugar beet as a result of K application.

3- Biological yield per faddan:

The effect of K fertilization on the biological yield of sugar beet is similar to that on root yield as well as top yield (Table 14). Applying K at 24 and 48 Kg K_2O/fad significantly increased biological yield over the check treatment by 10.70 and 14.98%, respectively in 1994/95 season, corresponding to 4.15 and 5.82% in 1995/96 season for the two k levels. The further increase in K level from 24 to 48 Kg K_2O/fad did not induce significant increase in biological yield as previously indicated with root and top yields/ fad. The present results are expected since K application increased root and top yields/fad.

4- Harvest index:

The results presented in Table (14) showed that harvest index was not significantly affected by K application. The results indicated slight decreases in harvest index as a result of raising K level. However, these reductions in harvest index were far below the level of significance. The results indicated that K application increased both root and top yield at about the same level that root: top ratio remained about the same at all K levels.

Similar results were also reported by Hassanein (1992) who found no relevance between K level and harvest index of sugar beet. Table *et al.*(1986) found that the highest harvest index was recorded by the application of 40 Kg K_2O/fad.

5- Sugar yield faddan:

The results presented in Table (14) showed that K application significantly increased sugar yield /fad in both seasons. The results indicated clearly that highest sugar yield/fad was obtained by applying 48 Kg K_2O/fad, being 3.11 and 4.87 tons/fad in the first and second season, receptively.

In 1994/95 season, the application of 24 and 48 Kg K_2O/fad significantly increased sugar yield by 14.81 and 19.47% over the control treatment, respectively. The corresponding increases in sugar yield in 1995/96 season were 6.40 and 9.34% for the lower and higher K level, respectively. It is worth noting that the higher K level did not induce significant increase in the first season compared with the lower level, whereas in the second season a significant difference was observed in sugar yield between both K levels. It could be concluded that K application is an important tool for increasing sugar yield and a level of 48 Kg K_2O/fad could be recommended under the conditions of the experiments. The increase in sugar yield is mainly due to the increase in root yield rather than the increase in sucrose%.

The present results are in agreement with those obtained by Draycott and Durrant (1976), Sanchez (1979), Table *et al.* (1986), Geinaidy (1988), Hassanein (1992) and Sobhy *et al.* (1992) who found that K fertilization markedly increased sugar yield.

C. III: Quality Characters as Influenced by K Fertilization Level:

The data of the quality characters of 1994/95 season were statistically analyzed , but in 1995/96 season, the samples collected from the four replications were bulked into one sample to save some of the needed chemicals. Consequently, the results of 1995/96 season were not statistically analyzed.

1- Total soluble solids percentage (T.S.S.%):

The results presented in Table (15) indicated that increasing K level markedly increased T.S.S.% in sugar beet at harvest in both seasons.

In 1994/95 season, the application of 24 and 48 Kg K_2O/fad significantly increased T.S.S.% by 8.08 and 8.61%, respectively compared with unfertilized treatment.

In 1995/96 season the application of 24 and 48 Kg K_2O/fad induced an increase of 7.79 and 9.14% in the T.S.S.% over the check treatment. It could be concluded that K increased T.S.S.% in sugar beet and both levels applied had about the same effect on this character.

Similar results were also observed by Geinaidy (1988) and Basha (1994) who found that K fertilization increased T.S.S% in sugar beet.

2- Sucrose percentage:

The application of K considerably increased sucrose% in sugar beet at harvest in both seasons (Table 15). The application of zero, 24 and 48 Kg K_2O/fad produced sucrose% of 16.72, 17.51 and

Table (15): Effect of K fertilizer level on the quality characters of sugar beet in 1994/95 and 1995/96 seasons.

K Kg/fad	1994/95							1995/96						
	T.S.S %	Sucrose %	Purity %	Sugar recovery %	Impurities%			T.S.S %	Sucrose %	Purity %	Sugar recovery %	Impurities%		
					α amino N	K	Na					α amino N	K	Na
0	18.875	16.717	82.345	13.651	0.184	1.679	0.317	19.195	17.534	85.730	14.800	0.280	1.197	0.167
24	20.400	17.505	82.430	14.516	0.174	1.688	0.281	20.690	18.175	86.000	15.240	0.275	1.352	0.119
48	20.500	17.617	82.720	14.598	0.174	1.705	0.276	20.950	18.281	86.330	15.320	0.269	1.365	0.117
L.S.D 5%	0.422	0.129	N.S.	0.217	N.S.	0.040	N.S.	-	-	-	-	-	-	-

17.62, receptively in 1994/95 season, being 17.53,18.18 and 18.28% in 1995/96 season, respectively. The increases in 1994/95 season were significant. These increases in sucrose% show clearly the importance of K for root crops because of its role in translocation and accumulation of sucrose.

The present results agree with those obtained by Minenko and Tonkal (1980), Sabolic (1987), Geinaidy (1988), Ibrahim and Attia (1990) Neamat-Alla (1991), Basha (1994), Kasap and Killi (1994) and Cumakov (1996) who found increases in sucrose% due to K application. On the other hand, Draycott and Durrant (1976), Table *et al.*(1986) and Hassanein (1992) did not show a significant effect of K application on sucrose%.

3- Purity percentage:

The results in Table (15) showed that the application of K did not affect purity%, in spite of very slight increases in this trait in the second season due to K application. The application of zero, 24 and 48 Kg K_2O/fad produced purity% of 82.35, 82.43 and 82.72%, respectively in 1994/95 season, being 85.73, 86.00 and 86.33% in 1995/96, for the three respective K levels. It is worth noting that purity% was greater in the second season than in the first one. This is due to higher T.S.S.% and sucrose% in the second season, probably due to the earlier planting date. It could be concluded that purity% was not affected by K application in spite of some slight increases observed in both seasons.

Similar results were also obtained by Table *et al.* (1986), and Hegazy *et al.* (1992).

4- Sugar recovery percentage:

The results presented in Table (15) indicated that K application significantly increased sugar recovery% in 1994/95 season. The same trend was also observed in 1995/96 season where a marked increase in sugar recovery% was recorded as a result of applying K fertilizer. The data in Table (15) revealed that sugar recovery% in 1994/95 season was 13.65, 14.52 and 14.60% at the K levels of zero, 24 and 48 Kg K_2O/fad, respectively. The corresponding values in 1995/96 season were14.80, 15.24 and 15.32%, respectively. It could be concluded that K fertilization increased sugar recovery% as a result of K positive effect on T.S.S., sugar and purity percentages.

Results reported by Table *et al.*(1986), Hegazy *et al.*(1992), Basha (1994) and El-Essawy (1996) indicated that K application improved juice quality of sugar beet. Also Geinaidy (1988), Ibrahim and Attia (1990), Neamat- Alla (1991) and Basha (1994) found that K application increased purity% in sugar beet juice.

5- Alpha- amino- N%:

The results presented in Table (15) showed that K application did not affect α - amino-N% in sugar beet juice in both seasons. The differences observed in this trait among the K application levels are negligible and had no specific trend. In 1994/95 α amino- N% was 0.18, 0.17 and 0.17 at the K level of zero, 24 and 48 Kg K_2O/fad, respectively. The corresponding values in 1995/96 season were 0.28, 0.28 and 0.27%, respectively. It could be concluded that K fertilization did not affect α- amino- N content in sugar beet juice.

The results reported by El-Essawy (1996) showed that α-amino-N% was increased by N application, and the application of P+K fertilizers improved juice quality in sugar beet and reduced α-amino- N%.

6- Potassium percentage:

The results in Table (15) indicated that K fertilization did not apparently affect K% in sugar beet juice in both seasons. The slight increases in K% in the second season due to K application could be negligible.

In 1994/95 season, the application of zero, 24 and 48 Kg K_2O/fad, recorded K% of 1.68, 1.69 and 1.71%, respectively. The corresponding values in 1995/96 season were 1.20, 1.35 and 1.37%, respectively. It could be concluded that K application did not negatively affect juice quality and did not increase impurities in the juice.

Similar results were also reported by El-Essawy (1996) who foud that the application of N, P and K did not affect K content in sugar beet juice.

7- Sodium percentage:

The results in Table (15) showed that the application of K reduced Na% in sugar beet juice in both seasons. In 1994/95 season, K levels of zero, 24 48 Kg K_2O/fad recorded Na% of 0.32, 0.28 and 0.28%, respectively. The corresponding values of Na% in 1995/96 season. were 0.17, 0.12 and 0.12% for the three K levels, respectively. These observed reductions in Na% in sugar beet juice in the second season indicate a positive effect of K fertilization on juice quality by reducing the impurities and the anti-quality components.

Results reported by Mc Donnell *et al.,* (1966), El-Sheikh *et al.* (1967), James *et al.,* (1968) indicated that there is a reciprocal relationship between K and Na uptake by sugar beet plants. As K availability and uptake increase, Na uptake decreases and vice versa.

D: Interaction Effects:

For the sake of briefity the effects of the interaction between the experimental factors are present and discussed here as an overall summary showing the significant effects and the highest response values to the studied factors.

D. I: Interaction between N and P:

1- NxP Effects on Growth Characters and Yield Components:

The results in Tables (16) and (17), showed that there were significant interaction effects on the following characters:

- Number of leaves/ plant at 160 and 185 days from planting in 1995/96 season.
- Leaf length at 185 and 210 days from planting in 1995/96 season.
- Leaf width at 160 and 185 days in 1994/95 season and at 210 days in 1995/96 season.
- Top fresh weight/plant at 160 and 185 days in 1995/96 season.

Table (16): The highest response values, significance and combination of factors of N x P interaction effects on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age (day)	1994/95			1995/96		
		sig.	Value	Treatment	sig.	Value	Treatment
Number of leaves/plant	160	N.S	26.667	$100N+0.0P_2O_5$	sig	31.251	$100N+15P_2O_5$
	185	N.S	35.139	$100N+15P_2O_5$	sig	45.501	$100N+15P_2O_5$
	210	N.S	39.501	$100N+15P_2O_5$	N.S	55.667	$100N+15P_2O_5$
Leaf length (cm)	160	N.S	17.888	$100N+0.0P_2O_5$	N.S	19.111	$100N+15P_2O_5$
	185	N.S	16.473	$100N+15P_2O_5$	sig	16.055	$100N+15P_2O_5$
	210	N.S	13.678	$100N+15P_2O_5$	sig	15.444	$100N+15P_2O_5$
Leaf width (cm)	160	sig	12.305	$100N+15P_2O_5$	N.S	11.472	$100N+0.0P_2O_5$
	185	sig	11.334	$100N+15P_2O_5$	N.S	10.390	$100N+15P_2O_5$
	210	N.S	8.028	$100N+15P_2O_5$	sig	10.583	$100N+15P_2O_5$
Top fresh weight/plant (g)	160	N.S	298.16	$100N+0.0P_2O_5$	sig	536.44	$100N+15P_2O_5$
	185	N.S	263.33	$100N+0.0P_2O_5$	sig	565.58	$100N+15P_2O_5$
	210	N.S	119.86	$100N+15P_2O_5$	N.S	479.58	$100N+15P_2O_5$

Table (17): The highest response values, significance and combination of factors of N x P interaction effects on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age (day)	1994/95			1995/96		
		sig.	Value	Treatment	sig.	Value	Treatment
Root length (cm)	160	N.S	27.277	$100N+15P_2O_5$	sig	28.917	$100N+15P_2O_5$
	185	sig	32.361	$100N+15P_2O_5$	sig	30.334	$100N+15P_2O_5$
	210	sig	34.613	$100N+15P_2O_5$	sig	37.222	$100N+15P_2O_5$
Root diameter (cm)	160	N.S	7.361	$100N+15P_2O_5$	N.S	11.029	$100N+15P_2O_5$
	185	N.S	9.335	$100N+0.0P_2O_5$	N.S	12.472	$100N+15P_2O_5$
	210	N.S	11.445	$100N+15P_2O_5$	sig	14.027	$100N+15P_2O_5$
Root weight (g)	160	N.S	367.53	$100N+15P_2O_5$	sig	803.36	$100N+15P_2O_5$
	185	N.S	457.22	$100N+0.0P_2O_5$	sig	1140.36	$100N+15P_2O_5$
	210	N.S	915.83	$100N+15P_2O_5$	N.S	1495.33	$100N+15P_2O_5$
Root size (cm^3)	160	sig	409.72	$100N+15P_2O_5$	N.S	760.694	$100N+15P_2O_5$
	185	sig	531.53	$100N+15P_2O_5$	sig	1040.42	$100N+15P_2O_5$
	210	N.S	880.42	$100N+15P_2O_5$	N.S	1356.94	$100N+15P_2O_5$
Root : top ratio/plant	160	N.S	2.110	$0.0N+15P_2O_5$	sig.	2.782	$0.0N+15P_2O_5$
	185	N.S	3.440	$0.0N+0.0P_2O_5$	N.S	3.392	$0.0N+0.0P_2O_5$
	210	N.S	10.279	$0.0N+0.0P_2O_5$	N.S	5.352	$0.0N+0.0P_2O_5$

- Root length at 185 and 210 days in 1994/95 season and at 160, 185 and 210 days in 1995/96 season.
- Root diameter at 210 days in 1995/96 season.
- Root fresh weight/ plant at 160 and 185 days in 1995/96 season.
- Root size at 160 and 185 days in 1994/95 season and at 185 days in 1995/96 season.
- Root: top ratio/ plant at 160 days in 1995/96 season.

The highest values of all these characters were recorded by the combination of 100 Kg N+ 15 Kg P_2O_5/fad, showing a marked and significant interaction effect of combining the highest levels of both N and P.

2- NxP Effects on Root, Top and Sugar Yields:

The interaction between N and P had no significant effect on the root, tops and sugar yields of sugar beet in both seasons of experimentation as shown in Table (18). The results indicated that the highest root yield/fad was obtained by combining 100 Kg N + 15 Kg P_2O_5/fad in both seasons, being 23.92 and 33.62 t/fad in 1994/95 and 1995/96 season, respectively. The highest top yield/ fad was 2.54 tons which was produced in 1994/95 by combining 100 Kg N + 15 Kg P_2O_5/ fad. On the other hand, the highest top yield/fad (7.32 t) was recorded by combining 100 Kg N+ zero Kg P_2O_5/ fad. The highest biological yields were 26.45 and 40.92 t/fad in the first and second season, respectively which were recorded by combining 100 Kg N+ 15 Kg P_2O_5 /fad in both seasons. The highest sugar yield (3.93 t/fad) was the resultant of 75 Kg N+ zero Kg P_2O_5 /fad in 1994/95 season, and reached 6.02 t/fad in 1995/96 season which was produced by combing 100 Kg N+ 15 Kg P_2O_5

/fad. Concerning the harvest index, the highest value was 90.87% in the first season, resulting from 75 Kg N+ 15 Kg P_2O_5 /fad, being 85.87% in the second season which was recorded by applying 25 Kg N+ 15 Kg P_2O_5 /fad. It is worthy to note that all effects of the interactions between NXP on root, top, biological and sugar yields as well as on harvest index were not significant indicating that each experimental factor acted independently in affecting these characters.

3- NxP Effects on Quality Characters of Sugar Beet:

The results in Table (19) showed that NxP significantly affected T.S.S.%, sucrose% and purity% in 1994/95 season. The results indicated that the highest T.S.S.% (20.75%) in 1994/95 was recorded by combining 50 Kg N+ 15 Kg P_2O_5/fad. The highest sucrose% was the result of combining 75 Kg N+ 15 Kg P_2O_5/fad in 1994/95 season. The maximum value of purity (84.5%) was the result of the check treatment of N+ 15 Kg P_2O_5/fad.

The statistical analysis showed no significant effect of the interaction between N and P on α- amino- N content, K as well as Na% in sugar beet juice. In general, the application of 100 Kg N+ 15 Kg P_2O_5/fad recorded the highest α -amino-N and K contents, being 0.18 and 1.69% respectively. The highest Na% (0.31%) was recorded by combining 50 Kg N+ 15 Kg P_2O_5/fad.

Table (18): The highest response values, significance and combination of factors of N x P interaction effects on root, top and sugar yields of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96		
	sig.	Value	Treatment	sig.	Value	Treatment
Root yield(ton/fad)	N.S	23.917	$100N+15P_2O_5$	N.S	33.617	$100N+15P_2O_5$
Top yield (ton/fad)	N.S	2.537	$100N+15P_2O_5$	N.S	7.317	$100N+0.0P_2O_5$
Biological yield (ton/fad)	N.S	26.450	$100N+15P_2O_5$	N.S	40.917	$100N+15P_2O_5$
Harvest Index (%)	N.S	90.865	$75N+15P_2O_5$	N.S	85.873	$25N+15P_2O_5$
Sugar yield (ton/fad)	N.S	3.931	$75N+0.0P_2O_5$	N.S	6.015	$100N+15P_2O_5$

Table (19): The highest response values, significance and combination of factors of N x P interaction effects on quality characters of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96	
	sig.	Value	Treatment	Value	Treatment
T.S.S. %	sig	20.750	$50N+15P_2O_5$	21.667	$50N+15P_2O_5$
Sucrose %	sig	17.896	$75N+15P_2O_5$	18.720	$75N+0.0P_2O_5$
Purity %	sig	84.500	$0.0N+15P_2O_5$	86.200	$0.0N+15P_2O_5$
Sugar recovery %	N.S	15.701	$75N+15P_2O_5$	15.580	$75N+15P_2O_5$
α-amino N content%	N.S	0.184	$100N+15P_2O_5$	0.285	$100N+15P_2O_5$
K- content %	N.S	1.687	$100N+15P_2O_5$	1.344	$100N+0.0P_2O_5$
Na content %	N.S	0.313	$50N+15P_2O_5$	0.194	$100N+15P_2O_5$

Table (20): The highest response values, significance and combination of factors of N x K interaction effects on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age	1994/95			1995/96		
	(day)	sig.	Value	Treatment	sig.	Value	Treatment
Number of leaves/plant	160	sig	27.959	$100N+24K_2O$	N.S	31.251	$100N+48K_2O$
	185	N.S	35.000	$100N+24K_2O$	sig	45.501	$100N+48K_2O$
	210	N.S	42.542	$100N+48K_2O$	N.S	55.667	$100N+48K_2O$
Leaf length (cm)	160	sig	18.834	$100N+48K_2O$	N.S	20.33	$100N+48K_2O$
	185	N.S	17.209	$100N+48K_2O$	N.S	16.334	$100N+48K_2O$
	210	N.S	14.249	$100N+48K_2O$	N.S	15.541	$100N+48K_2O$
Leaf width (cm)	160	sig	12.34	$100N+48K_2O$	N.S	11.918	$100N+48K_2O$
	185	sig	11.541	$100N+48K_2O$	N.S	10.459	$100N+48K_2O$
	210	N.S	8.209	$100N+48K_2O$	N.S	10.876	$100N+48K_2O$
Top fresh weight/plant (g)	160	sig	313.541	$100N+48K_2O$	N.S	529.791	$100N+48K_2O$
	185	N.S	267.666	$100N+48K_2O$	sig	568.958	$100N+48K_2O$
	210	N.S	122.000	$100N+48K_2O$	N.S	480.125	$100N+48K_2O$

Table (21): The highest response values, significance and combination of factors of N x K interaction effects on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age (day)	1994/95			1995/96		
		sig.	Value	Treatment	sig.	Value	Treatment
Root length (cm)	160	N.S	27.290	$100N+48K_2O$	N.S	28.958	$100N+48K_2O$
	185	N.S	32.749	$100N+48K_2O$	N.S	30.416	$100N+48K_2O$
	210	N.S	34.835	$100N+48K_2O$	sig	37.416	$100N+48K_2O$
Root diameter (cm)	160	N.S	8.125	$100N+48K_2O$	N.S	11.000	$100N+48K_2O$
	185	N.S	9.668	$100N+48K_2O$	N.S	12.583	$100N+48K_2O$
	210	N.S	11.666	$100N+48K_2O$	N.S	14.125	$100N+48K_2O$
Root weight (g)	160	sig	349.584	$100N+48K_2O$	N.S	992.21	$100N+48K_2O$
	185	N.S	512.500	$100N+24K_2O$	N.S	1158.75	$100N+48K_2O$
	210	N.S	921.250	$100N+48K_2O$	N.S	1522.13	$100N+48K_2O$
Root size (cm^3)	160	N.S	382.708	$100N+48K_2O$	N.S	751.666	$100N+48K_2O$
	185	N.S	485.489	$100N+24K_2O$	N.S	1051.250	$100N+48K_2O$
	210	N.S	866.665	$100N+24K_2O$	N.S	1381.666	$100N+48K_2O$
Root : top ratio/plant	160	N.S	2.128	$0.0N+24\ K_2O$	N.S	2.664	$0.0N+0.0\ K_2O$
	185	N.S	3.494	$0.0N+0.0\ K_2O$	N.S	3.401	$0.0N+24\ K_2O$
	210	N.S	10.255	$0.0N+0.0\ K_2O$	N.S	5.460	$0.0N+48\ K_2O$

2- N x K Effects on Root, Top and Sugar Yields:

The results reported in Table (22) indicated that no significant effects were observed between N and K on root, top, biological and sugar yields/ fad as well as harvest index in both seasons. It was generally observed that the highest values of root, top, biological and sugar yields in both seasons were recorded by combining 100 Kg + 48 K_2O/fad. This combination produced 24.40 t roots, 2.68 t tops and 4.09 t sugar/fad in 1994/95 season.

In 1995/96 season, root, top and sugar yields averaged 33.68, 7.65 and 6.06 t/fad, respectively by combining 100 Kg N + 48 Kg K_2O/ fad. However, all effects of the interaction were not significant. Harvest index reached its highest value by combining 75 Kg N + 48 Kg K_2O/ fad in 1994/95 season and 25 Kg N + 48 Kg K_2O/fad in 1995/96 season. These combinations produced 90.94 and 85.17% harvest indices in the first and second season, respectively.

3- NxK Effect on Quality Characters of Sugar Beet:

Data in Table (23) indicated that there were significant interaction effects between N and K on T.S.S%, purity%, sugar recovery% and Na% in the first season. The highest sugar recovery% in 1994/95 was 15.90% which was recorded by combining 25 Kg N +24 Kg K_2O/fad. On the other hand, combing 25 Kg N+ 48 Kg K_2O/fad, recorded the highest Na content in sugar beet juice, being 0.30% in 1994/95 season.

Table (22): The highest response values, significance and combination of factors of N x K interaction effects on root, top and sugar yields of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96		
	sig.	Value	Treatment	sig.	Value	Treatment
Root yield(ton/fad)	N.S	24.400	$100N+48K_2O$	N.S	33.675	$100N+48K_2O$
Top yield (ton/fad)	N.S	2.675	$100N+48K_2O$	N.S	7.650	$100N+48K_2O$
Biological yield (ton/fad)	N.S	27.075	$100N+48K_2O$	N.S	41.325	$100N+48K_2O$
Harvest Index (%)	N.S	90.940	$75N+48K_2O$	N.S	85.165	$25N+48K_2O$
Sugar yield (ton/fad)	N.S	4.085	$100N+48K_2O$	N.S	6.060	$100N+48K_2O$

Table (23): The highest response values, significance and combination of factors of N x K interaction effects on quality characters of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96	
	sig.	Value	Treatment	Value	Treatment
T.S.S. %	sig	21.375	$50N+48K_2O$	22.375	$50N+48K_2O$
Sucrose %	N.S	17.855	$75N+24K_2O$	18.820	$75N+48K_2O$
Purity %	sig	83.600	$25N+48K_2O$	87.050	$0.0N+48K_2O$
Sugar recovery %	sig	15.901	$25N+24K_2O$	15.500	$75N+24K_2O$
α-amino N content%	N.S	0.183	$100N+24K_2O$	0.306	$100N+48K_2O$
K- content %	N.S	1.681	$100N+48K_2O$	1.409	$100N+48K_2O$
Na content %	sig	0.304	$25N+48K_2O$	0.245	$100N+0.0K_2O$

D. III : Interaction between P and K :

1- PxK Effects on Growth Characters and Yield Components:

The results reported in Tables (24) and (25) indicated a significant interaction effect between P and K on:

- Number of leaves/ plant at 160 days in 1994/95 season.
- Leaf length at 210 days in 1995/96 season.
- Leaf width at 160 days in 1994/95 season, and at 160, 185 and 210 days in 1995/96 season.
- Top fresh weight/ plant at 160 and 185 days in 1995/96 season.
- Root length at 210 days in 1995/96 season.
- Root diameter at 160 and 210 days in 1994/95 season, and at 210 days in 1995/96 season.
- Root fresh weight/ plant at 160 and 185 days in 1994/95 season and at 185 days in 1995/96 season.
- Root size at 160 and 185 days in 1994/95 season and at 185 days in 1995/96 season.
- Root: top ratio/ plant at 210 days in 1995/ 96 season.

With all these characters (except with root weight and size/ plant at 185 days in the first season) the highest values were recorded when 15 Kg P_2O_5 + 48 Kg K_2O/fad were applied indicating the importance of applying both nutrients. Root fresh weight and size/ plant at 185 days in 1994/95 season recorded their highest values with combining 15 Kg P_2O_5 + 24 Kg K_2O/fad. It could be concluded that combining both P +K positively affected

Table (24): The highest response values, significance and combination of factors of P x K interaction effects on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age	1994/95			1995/96		
	(day)	sig.	Value	Treatment	sig.	Value	Treatment
Number of leaves/plant	160	sig	24.717	$15P_2O_5+48K_2O$	N.S	27.267	$15P_2O_5+48K_2O$
	185	N.S	31.400	$15P_2O_5+48K_2O$	N.S	38.784	$15P_2O_5+48K_2O$
	210	N.S	34.266	$0.0P_2O_5+48K_2O$	N.S	45.284	$15P_2O_5+48K_2O$
Leaf length (cm)	160	N.S	14.084	$0.0P_2O_5+48K_2O$	N.S	16.083	$15P_2O_5+48K_2O$
	185	N.S	13.867	$15P_2O_5+48K_2O$	N.S	13.683	$15P_2O_5+48K_2O$
	210	N.S	11.433	$15P_2O_5+48K_2O$	sig	13.032	$15P_2O_5+48K_2O$
Leaf width (cm)	160	sig	9.900	$15P_2O_5+48K_2O$	sig	10.050	$15P_2O_5+48K_2O$
	185	N.S	9.383	$15P_2O_5+48K_2O$	sig	9.016	$15P_2O_5+48K_2O$
	210	N.S	7.117	$15P_2O_5+48K_2O$	sig	8.900	$15P_2O_5+48K_2O$
Top fresh weight/plant (g)	160	N.S	190.449	$0.0P_2O_5+24K_2O$	sig	351.816	$15P_2O_5+48K_2O$
	185	N.S	171.767	$0.0P_2O_5+48K_2O$	sig	389.783	$15P_2O_5+48K_2O$
	210	N.S	79.949	$15P_2O_5+24K_2O$	N.S	335.667	$15P_2O_5+48K_2O$

Table (25): The highest response values, significance and combination of factors of P x K interaction effects on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age	1994/95			1995/96		
	(day)	sig.	Value	Treatment	sig.	Value	Treatment
Root length (cm)	160	N.S	22.616	$15P_2O_5+24K_2O$	N.S	25.334	$15P_2O_5+48K_2O$
	185	N.S	27.000	$15P_2O_5+48K_2O$	N.S	26.917	$15P_2O_5+48K_2O$
	210	N.S	28.383	$15P_2O_5+48K_2O$	sig	33.683	$15P_2O_5+48K_2O$
Root diameter (cm)	160	sig	6.400	$15P_2O_5+48K_2O$	N.S	9.834	$15P_2O_5+48K_2O$
	185	N.S	8.218	$15P_2O_5+48K_2O$	N.S	11.183	$15P_2O_5+48K_2O$
	210	sig	10.001	$15P_2O_5+48K_2O$	sig	12.267	$15P_2O_5+48K_2O$
Root weight (g)	160	sig	248.52	$15P_2O_5+48K_2O$	N.S	592.88	$15P_2O_5+48K_2O$
	185	sig	363.27	$15P_2O_5+24K_2O$	sig	910.23	$15P_2O_5+48K_2O$
	210	N.S	665.75	$15P_2O_5+48K_2O$	N.S	1323.80	$15P_2O_5+48K_2O$
Root size (cm^3)	160	sig	263.12	$15P_2O_5+48K_2O$	N.S	563.92	$15P_2O_5+48K_2O$
	185	sig	348.23	$15P_2O_5+24K_2O$	sig	848.17	$15P_2O_5+48K_2O$
	210	N.S	642.33	$15P_2O_5+48K_2O$	N.S	1178.67	$15P_2O_5+48K_2O$
Root : top ratio/plant	160	N.S	1.563	$15P_2O_5+48K_2O$	N.S	2.076	$0.0P_2O_5+0.0K_2O$
	185	N.S	2.550	$0.0P_2O_5+0.0K_2O$	N.S	2.641	$0.0P_2O_5+24K_2O$
	210	N.S	8.806	$15P_2O_5+48K_2O$	sig	4.705	$15P_2O_5+0.0K_2O$

growth characters and yield components of sugar beet and recorded the highest values compared with single application of each element.

2- PxK Effects on Root, Top and Sugar Yields:

The results reported in Table (26) indicated a significant interaction effects between P and K on top yield as well as biological yield/fad in 1995/96 season. Other yield characters were not significantly affected by this interaction. The results indicated that root, top, biological and sugar yields per fad in both seasons reached their highest values with the application of 15 Kg P_2O_5 + 48 K_2O Kg/fad in both seasons. The results indicate the positive effects of combining both elements than the single application of each. Combining 15 Kg P_2O_5 + 48 Kg K_2O/fad produced 18.62, 2.06, 20.68 and 3.17 t/fad root, top, biological and sugar yields per fad, respectively in 1994/ 95 season. The corresponding highest values were 27.24, 5.54, 32.78 and 4.95 t/fad for root, top, biological sugar yields and sugar yield/fad in 1995/96 season, respectively.

It could be concluded that the highest P and K levels applied in this study produced the height values of root, top and sugar yields. Concerning harvest index, the results showed that it was not significantly influenced by PXK interaction. In general, the application of 15 Kg P_2O_5+ 48 Kg K_2O/fad in the first season and 15 Kg P_2O_5 + zero Kg K_2O/fad in the second season produced the greatest harvest index, being 89.68 and 84.77% in 1994/95 and 1995/96 seasons, respectively.

Table (26): The highest response values, significance and combination of factors of P x K interaction effects on root, top and sugar yields of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96		
	sig.	Value	Treatment	sig.	Value	Treatment
Root yield(ton/fad)	N.S	18.620	$15P_2O_5$+$48K_2O$	N.S	27.240	$15P_2O_5$+$48K_2O$
Top yield (ton/fad)	N.S	2.060	$15P_2O_5$+$48K_2O$	sig	5.540	$15P_2O_5$+$48K_2O$
Biological yield (ton/fad)	N.S	20.680	$15P_2O_5$+$48K_2O$	sig	32.780	$15P_2O_5$+$48K_2O$
Harvest Index (%)	N.S	89.673	$15P_2O_5$+$48K_2O$	N.S	84.771	$15P_2O_5$+$0.0K_2O$
Sugar yield (ton/fad)	N.S	3.165	$15P_2O_5$+$48K_2O$	N.S	4.949	$15P_2O_5$+$48K_2O$

Table (27): The highest response values, significance and combination of factors of P x K interaction effects on quality characters of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96	
	sig.	Value	Treatment	Value	Treatment
T.S.S. %	N.S	20.550	$15P_2O_5$+ $48K_2O$	21.090	$15P_2O_5$+$48K_2O$
Sucrose %	N.S	17.665	$15P_2O_5$+ $48K_2O$	18.180	$15P_2O_5$+$24K_2O$
Purity %	sig	83.490	$15P_2O_5$+$0.0K_2O$	86.400	$0.0P_2O_5$+$24K_2O$
Sugar recovery %	N.S	15.488	$15P_2O_5$+ $48K_2O$	15.640	$15P_2O_5$+$48K_2O$
α-amino N content%	N.S	0.171	$15P_2O_5$+ $48K_2O$	0.268	$15P_2O_5$+$48K_2O$
K- content %	N.S	1.643	$15P_2O_5$+ $48K_2O$	1.349	$0.0P_2O_5$+$48K_2O$
Na content %	N.S	0.293	$15P_2O_5$+$0.0K_2O$	0.200	$15P_2O_5$+$0.0K_2O$

3- PxK Effects on Quality Characters of Sugar Beet:

Results in Table (27) showed that PXK had no significant effects on the quality characters except on purity% in 1994/95 season. The highest purity% in that season (83.49%)was recorded by applying 15 Kg P_2O_5 without K fertilization.

D. IV: Interaction between N, P and K:

1- NXPXK Effect on Growth Characters and Yield Components:

The results presented in Tables (28) and (29) indicated a significant effect of the second order interaction on the following characters:

- Number of leaves/ plant at 160 and 185 days in 1995/96 season.
- Leaf length at 160, 185 and 210 days in 1995/96 season.
- Root length at 210 days in 1995/96 season.
- Root diameter at 160 and 210 days in 1994/95 season.

The highest values of these growth and yield component characters were recorded with combining 100 Kg N+ 15 Kg P_2O_5 + 48 Kg K_2O/fad.

These results indicate clearly the vital importance of application of the three major elements which proved to produce the best results of the major yield attributes of sugar beet.

Table (28): The highest response values, significance and combination of factors of N x P x K interaction effects on leaf characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age	1994/95			1995/96		
	(day)	sig.	Value	Treatment	sig.	Value	Treatment
Number of leaves/plant	160	N.S	29.165	$75N+15P_2O_5+24K_2O$	sig	33.835	$100N+15P_2O_5+48K_2O$
	185	N.S	37.000	$100N+15P_2O_5+48K_2O$	sig	49.000	$100N+15P_2O_5+48K_2O$
	210	N.S	42.918	$100N+0.0P_2O_5+48K_2O$	N.S	58.918	$100N+15P_2O_5+48K_2O$
Leaf length (cm)	160	N.S	20.750	$100N+0.0P_2O_5+48K_2O$	sig	21.583	$100N+15P_2O_5+48K_2O$
	185	N.S	17.335	$100N+15P_2O_5+48K_2O$	sig	16.750	$100N+15P_2O_5+48K_2O$
	210	N.S	14.748	$100N+15P_2O_5+48K_2O$	sig	16.083	$100N+15P_2O_5+48K_2O$
Leaf width (cm)	160	N.S	14.583	$100N+15P_2O_5+48K_2O$	N.S	11.918	$100N+15P_2O_5+48K_2O$
	185	N.S	12.000	$100N+0.0P_2O_5+0.0K_2O$	N.S	10.835	$100N+15P_2O_5+48K_2O$
	210	N.S	8.667	$100N+15P_2O_5+48K_2O$	N.S	11.168	$100N+15P_2O_5+48K_2O$
Top fresh weight/plant (g)	160	N.S	321.250	$100N+15P_2O_5+48K_2O$	N.S	586.500	$100N+15P_2O_5+48K_2O$
	185	N.S	274.500	$100N+0.0P_2O_5+48K_2O$	N.S	616.665	$100N+15P_2O_5+48K_2O$
	210	N.S	125.418	$100N+15P_2O_5+48K_2O$	N.S	516.250	$100N+15P_2O_5+48K_2O$

Table (29): The highest response values, significance and combination of factors of N x P x K interaction effects on root characters of sugar beet at different growth stages in 1994/95 and 1995/96 seasons.

Characters	Age (day)	1994/95			1995/96		
		sig.	Value	Treatment	sig.	Value	Treatment
Root length (cm)	160	N.S	27.667	$100N+15P_2O_5+48K_2O$	N.S	29.583	$100N+15P_2O_5+48K_2O$
	185	N.S	35.333	$100N+15P_2O_5+48K_2O$	N.S	31.250	$100N+15P_2O_5+48K_2O$
	210	N.S	38.585	$100N+15P_2O_5+48K_2O$	sig	38.918	$100N+15P_2O_5+48K_2O$
Root diameter (cm)	160	sig	8.333	$100N+15P_2O_5+48K_2O$	N.S	11.418	$100N+15P_2O_5+48K_2O$
	185	N.S	9.750	$100N+15P_2O_5+48K_2O$	N.S	13.000	$100N+15P_2O_5+48K_2O$
	210	sig	12.000	$100N+15P_2O_5+48K_2O$	N.S	14.833	$100N+15P_2O_5+48K_2O$
Root weight (g)	160	N.S	379.585	$100N+ 15P_2O_5+ 48K_2O$	N.S	83.333	$100N+15P_2O_5+48K_2O$
	185	N.S	562.500	$100N+0.0P_2O_5+0.0K_2O$	N.S	1245.750	$100N+15P_2O_5+48K_2O$
	210	N.S	981.250	$100N+ 15P_2O_5+ 48K_2O$	N.S	1538.000	$100N+15P_2O_5+48K_2O$
Root size (cm^3)	160	N.S	451.248	$100N+ 15P_2O_5+ 48K_2O$	N.S	781.250	$100N+15P_2O_5+48K_2O$
	185	N.S	549.582	$100N+0.0P_2O_5+0.0K_2O$	N.S	1113.750	$100N+15P_2O_5+48K_2O$
	210	N.S	937.915	$100N+ 15P_2O_5+ 48K_2O$	N.S	1408.333	$100N+15P_2O_5+48K_2O$
Root : top ratio/plant	160	N.S	2.215	$0.0N+0.0P_2O_5+24K_2O$	N.S	2.838	$0.0N+0.0P_2O_5+24K_2O$
	185	N.S	3.867	$0.0N+0.0P_2O_5+0.0K_2O$	N.S	3.535	$0.0N+0.0P_2O_5+24K_2O$
	210	N.S	10.645	$0.0N+0.0P_2O_5+0.0K_2O$	N.S	5.625	$0.0N+0.0P_2O_5+48K_2O$

2- NXPXK Effects on Root, Top and Sugar Yields:

The results presented in Table (30) indicated no significant effect of the second order interaction on root, top, biological and sugar yields as well as on harvest index in both seasons. The results showed that the highest values of root, top, biological and sugar yields were recorded in both seasons with combination of 100 Kg N+ 15 Kg P_2O_5 + 48 Kg K_2O/fad. This combination produced root, top, biological and sugar yields of 24.95, 2.70, 27.65 and 4.11 tons/fad in 1994/95 season, respectively. The corresponding yields in 1995/96 season averaged 34.60, 7.75, 42.15 and 6.21 t/fad, respectively. Concerning harvest index the results indicated that no significant interaction effect between the three experimental factors was observed. The data showed that combining 75 Kg N+ 15 Kg P_2O_5 + 48 Kg K_2O/fad in 1994/95 season and 25 Kg N+ 15 Kg P_2O_5+ 24 Kg K_2O/fad in the second season produced the greatest harvest indices being 91.11 and 86.35%, in the first and second season, respectively.

It could be concluded that under the present experimental conditions at Sakha, Kafr El-Sheikh Governorate the application of 100 Kg N+ 15 Kg P_2O_5 + 48 Kg K_2O/fad could be recommended to produce the highest root, top and sugar yields per fad. The results obtained by Hamissa *et al.* (1972) showed that there was no significant effect on yield of sugar beet for the application of either P or K whether added alone or in combination with N. On the other hand, Nour and Fayed (1976) found that the interaction among NPK was significant for root yield and T.S.S.%. Also Abdel- Ghaffar *et al.* (1981a) reported that the highest sugar content as well as root

Table (30): The highest response values, significance and combination of factors of N x P x K interaction effects on root, top and sugar yields of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96		
	sig.	Value	Treatment	sig.	Value	Treatment
Root yield(ton/fad)	N.S	24.950	$100N+15P_2O_5+48K_2O$	N.S	34.600	$100N+15P_2O_5+48K_2O$
Top yield (ton/fad)	N.S	2.700	$100N+15P_2O_5+48K_2O$	N.S	7.750	$100N+15P_2O_5+48K_2O$
Biological yield (ton/fad)	N.S	27.650	$100N+15P_2O_5+48K_2O$	N.S	42.150	$100N+15P_2O_5+48K_2O$
Harvest Index (%)	N.S	91.105	$75N+15P_2O_5+48K_2O$	N.S	86.345	$25N+15P_2O_5+24K_2O$
Sugar yield (ton/fad)	N.S	4.109	$100N+15P_2O_5+48K_2O$	N.S	6.207	$100N+15P_2O_5+48K_2O$

yield were produced by applying 30 Kg N+ 15 Kg P_2O_5/fad.

Similarly, El-Essawy (1996) found that the highest root and sugar yields/fad were obtained from the combination of 120 Kg N+ 30 Kg P_2O_5 + 24 Kg K_2O fad in the first season, and by combining 120 Kg N+ 45 Kg P_2O_5+ 48 Kg K_2O/fad in the second season.

3- NxPxK Effects on Quality Characters of Sugar Beet:

The results presented in Table (31) showed that none of the quality characters or the anti- quality components in sugar beet juice at harvest were significantly affected by the second order interaction in 1994/95 season. However, the highest sucrose% as well as sugar recovery% were recorded by combining 75 Kg N + 15 Kg P_2O_5 + 48 Kg K_2O/fad. This result indicates that this fertilization treatment is the recommended treatment for achieving the best quality.

Table (31): The highest response values, significance and combination of factors of N x P x K interaction effects on quality characters of sugar beet in 1994/95 and 1995/96 seasons.

Characters	1994/95			1995/96	
	sig.	Value	Treatment	Value	Treatment
T.S.S. %	N.S	21.500	$50N+15P_2O_5+48K_2O$	22.600	$50N+15P_2O_5+48K_2O$
Sucrose %	N.S	18.162	$75N+15P_2O_5+48K_2O$	18.980	$75N+15P_2O_5+48K_2O$
Purity %	N.S	85.100	$0.0N+15P_2O_5+48K_2O$	87.100	$0.0N+0.0P_2O_5+0.0K_2O$
Sugar recovery %	N.S	15.992	$75N+15P_2O_5+48K_2O$	15.860	$75N+15P_2O_5+48K_2O$
α-amino N content %	N.S	0.209	$100N+15P_2O_5+24K_2O$	0.304	$100N+15P_2O_5+48K_2O$
K- content %	N.S	1.747	$100N+15P_2O_5+48K_2O$	1.446	$100N+0.0P_2O_5+48K_2O$
Na content %	N.S	0.375	$50N+15P_2O_5+48K_2O$	0.378	$100N+15P_2O_5+0.0K_2O$

SUMMERY

THE EFFECT OF SOME FERTILIZATION ELEMENTS ON THE YIELD AND QUALITY OF SUGAR BEET.

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Two field experiments were carried out in Sakha Agric. Res. Sta. at Kafr El-Sheikh during 1994/95 and 1995/96 to study the effects of N, P and K fertilizer levels on growth, yield and quality of sugar beet.

The experiments were laid out in a complete randomized block design with four replications. The German sugar beet cultivar "Top" was used in both seasons. The soil of the experiments was clay loam with a pH value of 8.30 . Each experiment included 30 treatments which were the combination between:

- Five N levels: 0, 25, 50, 75 and 100 Kg N/ fad.
- Two P levels: 0 and 15 Kg P_2O_5/ fad.
- Three K levels: 0, 24 and 48 Kg K_2O/fad.

The plot area was 21 square meters containing 6 ridges.
Sugar beet seeds were planted in hills 20 cm apart.

Sowing date was on November, 9 in the first season and October, 7 in the second one. Harvesting was done after 210 days. Nitrogen was applied in the form of ammonium nitrate (33.5% N), P in the form of calcium superphosphate (15.5% P_2O_5), and K in the form of potassium sulphate (48% K_2O). N fertilizer was applied in three split applications 1/4 at planting, 1/2 before the first irrigation and 1/4 before the second irrigation. P fertilizer was added in one application during seedbed preparation. K fertilizer was added in