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## INTRODUCTION

Sugar beet is a specially type of *Beta vulgaris*, L. grown for sugar production and is considered the second important sugar crop in Egypt and in many countries all over the world after sugar cane (*Sacchurum officinarum*, L.). Nowadays, the present world production of sugar beet roots is about 238.28 \* million tons, which comes from planting about 5.83 million ha with an average of 40.84 t/ha.

In Egypt, sugar beet has becomes an important crop for sugar production, hence the total cultivated area reached about 131200 \*\* fad and the total production exceeded 2.43 million ton roots with and average of 19.32 t/fad. Egyptian Government imports large amount of sugar every year to face the rapid increase of population and sugar consumption. By referring the total annual consumption of sugar amount, it raised to about 2.18\*\* million ton in 2002 year. Approximately, 66 % of this amount are produced locally from sugar beet (346913 ton sugar), sugar cane (938381 ton sugar) and natural sweets (158405 ton sugar), and the rest 33 % (0.73 million ton sugar) is imported from foreign countries. So that, increasing sugar production from unit area is considered one of the important national targets to minimize gab between sugar consumption and production.

Recently, sugar beet crop has an important position in Egyptian crop rotation as winter crop not only in the fertile soils, but also in poor, saline alkaline and calcareous soils. Whereas, it could be economically grown in the newly reclaimed soils such as at the Northern parts of Egypt as one of the most tolerant crops to salinity and wide range of climates. Sugar beet being, often, the most important cash crop in the rotation, it leaves the soil in good conditions for the benefit of the following cereal crops. By-products of sugar production, such as pulp, molasses and lime, flow bath into agriculture to increase livestock production and improve soil fertility as well as provide various middle products as alcohol, forage and other many products.

The great importance of sugar beet crop is not only from its ability to grow in the newly reclaimed areas as economic crop, but also for producing higher yield of sugar under these conditions as compared with sugar cane. Moreover, sugar beet is specialized as a short duration crop, where its growth period is about half that of sugar cane. Furthermore, sugar beet requires less water, which a kilogram of sugar requires about 1.4 m<sup>3</sup> and 4.0 m<sup>3</sup> water to be produced by sugar beet and sugar cane, respectively (Sohier, Ouda, 2001).

It is well know that high productivity of any crop is the final goal of many factors and operations. In addition, the pronounced role of the agronomical processes such as planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels play very important effect on sugar beet growth, yield and quality.

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\* FAO.org, Statistical database, Faostat agriculture, Primary crops, supplied at 3 Feb. 2004.

\*\* Egyptian society of sugar technology.

Planting dates of sugar beet is considered among most important factors that influenced its growth and productivity. Also, planting date is the great important factor in organizing and securing work schedule of beet factories. Thus, planting sugar beet on suitable date according to environmental conditions of region is best method to maximize sugar beet yield and quality.

Biofertilizers technologies are based on enhancing and improving the naturally existing nutrient transformation activities in the soil profiles, when the inoculant should be able to be adapted to the environmental conditions prevailing in the site of application. Whereas, inoculation seeds of various C<sub>3</sub> and C<sub>4</sub> plants with associative nitrogen-fixing bacteria led to improve plant growth and yield (Eid, 1982). So, biological nitrogen fixation of sugar beet with non-symbiotic nitrogen fixers play an important role in increasing growth and yield as well as decreasing chemical nitrogen fertilizer requirements and consequently minimizing environmental pollution by mineral fertilizers and to save its costs.

Nitrogen is the most important element of those supplied to sugar beet in fertilization. Nitrogen fertilizer has a pronounced effect on the growth and physiological and chemical characteristics of the crop. So that, nitrogen caused desirable effect on sugar beet growth and yield characters.

Decidedly, potassium is major plant nutrient needed for sugar beet, which plays an important role in plant nutrition association with the quality of the production.

Therefore, this investigation was established to determine the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels as well as their interactions on growth, yield and yield components as well as quality of sugar beet under the environmental conditions of Mansoura district.

## REVIEW OF LITERATURE

The compatible literature dealing with concern of the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilization levels as well as their interactions on growth, yield and its components and quality will be reviewed herein for each factor under study as follows:

I: Effect of planting dates.

II: Effect of biofertilization treatments.

III: Effect of the interaction between planting dates and biofertilization treatments.

IV: Effect of nitrogen fertilizer levels.

V: Effect of potassium fertilizer levels.

VI: Effect of nitrogen and potassium fertilizer levels.

VII: Effect of the interaction between planting dates and nitrogen & potassium fertilizer levels.

VIII: Effect of the interaction between biofertilization treatments and nitrogen & potassium fertilizer levels.

IX: Effect of the interaction among planting dates, biofertilization treatments and nitrogen & potassium fertilizer levels.

### **I: Effect of planting dates:**

Planting dates means the effect of edaphic factors and all environmental conditions in large scale on growth and yield of all field crops, which differ widely from region to another. Moreover, planting dates is considered the most important affecting factor for all field crops generally and sugar beet specially. It has a vital role for germination, growth, yield and root quality of sugar beet plants. Since the edaphic factors varied under Egyptian conditions and also from country to another, the literature on this work dealing with planting dates will depended mainly under Egyptian conditions:

**Badawi (1985)** recorded that planting sugar beet on 10<sup>th</sup> Oct. produced maximum total dry weight of plant, root/top ratio, root and foliage fresh weights, root length and diameter, TSS %, sucrose % and root, top as well as sugar yields/fad. Whilst, planting on 10<sup>th</sup> Nov. produced lower values of the above mentioned traits.

**Hanna *et al.* (1988)** concluded that planting sugar beet plants on 10<sup>th</sup> Oct. was suitable planting date for raising its productivity under environmental condition of EL-Mansoura district.

**Badawi (1989)** found that early planting *i.e.* 1<sup>st</sup> Sept. was associated with higher root fresh weight, foliage fresh weight, root length and diameter, leaf area index (LAI), TSS %, sucrose %, purity % and root, top as well as sugar yields/fad. He also recorded that planting on 1<sup>st</sup> Sept. or 1<sup>st</sup> Oct. has not significant differences in all studied characteristics under this investigation.

**EL-Kassaby and Leilah (1992 b)** detected that sowing dates (15<sup>th</sup> Sept., 1<sup>st</sup> Oct., 15<sup>th</sup> Oct., 1<sup>st</sup> Nov. and 15<sup>th</sup> Nov.) had significant effects on root diameter, root weight, and root as well as sugar yields/fad. Sowing sugar beet during Oct. recorded the highest yield components and root, top as well as sugar yields/fad than sowing during Nov.

**Leilah and Nasr (1992)** stated that sowing dates markedly affected sucrose and juice purity percentages as well as root and sugar yields/fad. They also confirmed that early sowing on 15<sup>th</sup> Sept. recorded the highest root yield/fad. On the other hand, the highest mean of sugar yield was obtained from sowing sugar beet on 15<sup>th</sup> Oct.

**Badawi *et al.* (1995)** observed that planting dates markedly affected leaf area index (LAI), total weight of root + foliage, root length and diameter as well as root, top and sugar yields/fad. Generally, they recommended that early planting, 1<sup>st</sup> Oct., tended to increase root, top and sugar yields/fad under the environmental conditions of Dakhlia Governorate.

**Azzazy (1998)** showed that non of the studied characters (root length and diameter, TSS %, sucrose %, purity % and root as well as sugar yields/fad) was significantly affected by sowing dates on 1<sup>st</sup> or 15<sup>th</sup> Nov., except top yield/fad only.

**Ghonema (1998)** reported that planting dates had obvious effect on all studied traits (leaf area index (LAI), root length and diameter, root fresh weight, sucrose and purity percentages as well as root and sugar yields/fad) with exception foliage fresh weight and root/top ratio in the second season only. He concluded that planting sugar beet during Oct. produced the maximum leaf area index (LAI), root length and diameter, root and foliage fresh weights, sucrose and purity percentages as well as root and sugar yields/fad as compared with planting during Sept. or Nov.

**Ramadan and Hassanin (1999)** revealed that sown sugar beet on 10<sup>th</sup> Sept. produced greater root length and diameter and root as well as recoverable sugar yields/fad. They also recorded that delaying sowing date to 10<sup>th</sup> Nov. intensified reducing in sucrose, purity and recoverable sugar percentages.

**Abd EL-Gawad *et al.* (2000)** studied the effect of some planting dates of sugar beet at 1<sup>st</sup> Oct. to 1<sup>st</sup> Dec. in the first season and 1<sup>st</sup> Sept. to 1<sup>st</sup> Dec. in the second season on yield and yield components. They found that early planting dates produced thicker, heaviest sugar beet root/plant and top yield per plant and faddan as well as sugar yield/fad. However, planting sugar beet at 1<sup>st</sup> Nov. was more favorable for emergence %, plant stand at harvest and root length.

**Abdou (2000)** found that planting sugar beet on 1<sup>st</sup> Oct. gave obvious increment in root and foliage fresh weights/plant, root/top ratio, root length and diameter, harvest index and root, top as well as sugar yields/fad. On the other hand, the greatest values of TSS, sucrose and purity percentages were resulted from planting sugar beet on 1<sup>st</sup> Sept.

**Abo-Salama and EL-Sayiad (2000)** investigated the effect of planting dates at 1<sup>st</sup> and 15<sup>th</sup> Oct. and 1<sup>st</sup> Nov. on sugar beet yield components, yield and quality. They indicated that early planting increased, in a highly significant manner, most of yield components and good quality parameters. The highest root yield, quality index and sugar yield (31.61 t/fad, 77.81 and 4.13 t/fad, respectively) were produced from early planting (1<sup>st</sup> Oct.).

**Kandil, et al. (2002 b)** found that root fresh and dry weights, foliage fresh and dry weights, LAI (at 120 and 150 days from planting), CGR, RGR and NAR had significant effect due to planting dates. The best planting dates, which produced the greatest values of all growth characters was on 15<sup>th</sup> of October.

**Kandil, et al. (2002 c)** reported that planting dates showed favorite effect on root and foliage fresh weights, root length and diameter, root/top ratio (in the second season), quality parameters (TSS, sucrose and juice purity percentages in the first season) and root, top as well as sugar yields/fad of sugar beet. Finally, planting date on 15<sup>th</sup> Oct. gave the highest means of the most yield components and yield as well as quality characters.

## **II: Effect of biofertilization:**

In recent years, the trend is to explore the possibility of supplementing chemical fertilizers with more particularly biofertilizers of microbial origin. This method aims to minimize the environmental pollution which resulted from mineral fertilizers and also to reduce its costs (Cakmakci *et al.*, 1999 and Abu EL-Fotoh *et al.*, 2000), in the same time maintenance of high yielding. Biofertilizers can be generally defined as preparations containing live or latent cells of efficient strains of nitrogen fixation, phosphate solubility and silicate decomposers used for application to soil with the objective of acceleration certain microbial processes to augment the extent of the availability of nutrients in a form which can be easily assimilated by plants. Biofertilizers may affect plant growth by one or more mechanisms such as nitrogen fixation, enhancing nutrient uptake, production of organic acids, protection against plant pathogens and excretion growth regulators like IAA and GA3, which stimulated growth and resulted in high yield. Many researches with this respect were done in foreign countries are arranged together with those done under Egyptian conditions as follows:

**Suslow et al. (1979)** in USA, tested biochemical and physiological responses of sugar beet to Plant Growth Promoting Rhizobacteria (PGPR), *Pseudomonas putida* and *Pseudomonas fluorescens*. They showed that seedlings vigor, root and foliage growth were increased by inoculation with PGPR.

**Sprenat (1990)** in UK, recorded that inoculation soil by *Azotobacter spp* caused solubilization of mineral nutrients and synthesis of vitamins, amino acids, auxins as well as gibberellins, which stimulate plant growth and induce high yields.

**Babu et al. (1991)** in India, observed that the application of biofertilizers is suggested as a sustainable way for increasing crop yields, which would reduce the use of chemical fertilizers and improve soil fertility.

**Prasad and Rokima (1991)** in India, showed that an integrated effect of organic, inorganic and biofertilizers on the available N, P and K contents of the soil and increased the N and K contents, but not its K content.

**EL-Badry and EL-Bassel (1993)** in Egypt, found that inoculation sugar beet with *Azospirillum* caused a significant saving in nitrogen fertilizer (about 25-40 %). They also reported that a significant increase in root yield (from 2.8 to 6.0 t/fad) and sugar yield as a result of inoculation by *Azospirillum*.

**Favilli et al. (1993)** in India, observed that inoculation seeds of sugar beet with *Azospirillum lipoferum* significantly enhanced root weight per plant and per hectare.

**Butorac (1995)** in Germany, studied the effect of fertilization treatments *i.e.* ; (a) no fertilizer ; (b) agrarvital containing limestone, micronutrients and nitrogen fixing bacteria ; (c) NPK fertilizers ; (d) waste containing N, P, K, Ca, Na, micronutrients and organic matter ; (e) NPK + waste water ; (f) NPK + agrarvital + waste water and (g) agrarvital + waste water on sugar beet yield and quality. He found that root yield, sugar content and sugar yield were lowest with NPK + agrarvital + waste water treatment, while root and sugar yields were highest with waste containing N, P, K, Ca, Na, micronutrients and organic matter treatment. Finally, he reported that sugar content was highest with no fertilizer treatment.

**Milic et al. (1995)** in Yugoslavia, showed that increasing number of free aerobic nitrofixators as a result of increasing nitrogen soil content led to improve seed emergence and growth.

**Singh and Bisoyi (1995)** in India, concluded that biofertilizers such as *Azolla*, *Azotobacter*, *Azospirillum*, *Rhizobium* and phospho microorganisms were important for plantation crops. They also concluded that nitrogen fixation and biomes accumulation by biofertilizers were reviewed and their role in mineralization and reclamation of soil problems and balancing of soil nitrogen.

**Ali (1996)** in Egypt, found that inoculation sugar beet with free-living bacteria, which could be able to fixing nitrogen (*Azospirillum spp*) significantly improved seed germination, reducing sugars and non-reducing sugars under all recommended nitrogen levels. On the other hand, inoculation sugar beet with *Azospirillum* and addition of nitrogen fertilizer resulted in low significant effect on nitrogen uptake by sugar beet in leaves and roots.

**Shabaev et al. (1996)** in Russia, comes to conclusion that inoculation sugar beet seeds with nitrogen fixation bacteria (*Pseudomonas putida* 23) increasing nitrogen available in the rhizosphere, which led to increments in root length, shoot length, nitrogen uptake and positive nitrogen balance.

Nitrogen fixation and inoculation of bacterially fixed atmospheric nitrogen in the plants took place in the second half of the vegetative period and accelerated plant development.

**Mrkovack et al. (1997)** in Hungary, stated that inoculation sugar beet seeds with certain strains of *Azotobacter* caused favorable effect in dry weight of plant and nitrogen content, which proportionally to the nitrogen content in the medium.

**Stajner et al. (1997)** in Yugoslavia, studied the effect of inoculation with *Azotobacter chroococcum* strains and treatments, which increased supply of nitrogen in solution culture on sugar beet cv. kwmaja where grown in sand culture in the greenhouse. They found that the activating of the antioxidant enzymes superoxide dismutase, peroxidase and catalase, the content of chlorophyll and carotenoids, soluble proteins and dry matter in leaves were increased by previously mentioned treatment.

**Mezei et al. (1998)** in Hungary, found that inoculation sugar beet seeds with *Azotobacter chroococcum* strains resulted in the highest callus mass and dry matter of plant, whereas improved growth of roots and leaves.

**Cakmakci et al. (1999)** in Turkey, studied seed inoculation of sugar beet (cv. sonja) with nitrogen fixing (*Bacillus polymyxa*) and phosphate dissolving (*Bacillus megaterium* var. *phosphaticum*) bacteria in comparison to control and mineral fertilizer application. They reported that sugar beet root yield was increased by 12.0 %, 7.5 % and 16.5 % due to seed inoculation treatments (*B. polymyxa*, *B. megaterium* var. *phosphaticum* and dual applications over control treatment), respectively. Other yield and yield components were also enhanced especially by dual application. While, increases in yield and yield components were lower than or comparable to mineral fertilizer application. Finally, they concluded that microbial inoculation of seeds with *Bacillus polymyxa* and *Bacillus megaterium* var. *phosphaticum*, alone or in dual combinations, may substitute costly NP fertilizers in sugar beet production.

**Sultan et al. (1999)** in Egypt, studied the response of sugar beet yield and its attributes to biological (inoculated and non-inoculated seeds with Azotobacterin) and mineral fertilization under weed control. They recorded that inoculation of sugar beet seeds with Azotobacterin significantly increased leaf area index (LAI), root length and diameter, TSS %, sucrose %, purity % and root as well as sugar yields/fad.

**Abo EL-Goud (2000)** in Egypt, stated that biofertilization treatments of fodder beet showed marked increases in root fresh and dry weights, foliage fresh and dry weights, leaf area index (LAI), root and top yields/fad.

**Abu EL-Fotoh et al. (2000)** in Egypt, studied the effect of NPK fertilization as recommended doses and 50 % from its and some biofertilizers (microbin and phosphorin separately or together) on yield and quality of sugar beet. They showed that the addition of biofertilizers

combined with NPK chemical fertilizers at the rate of 50 % of recommended dose produced higher root yield and quality characters compared with the other treatments. However, this investigation illustrated that biofertilizers alone can not be met the NPK requirements for sugar beet crop.

**Bassal et al. (2001)** in Egypt, found that bio-mineral nitrogen fertilization (inoculation with Syrialin at the rate of 400 g/fad) treatment had significant effects on root and foliage fresh weights, root length and diameter, root/top ratio, TSS %, sucrose %, purity % and root, top as well as sugar yields/fad.

**Cakmakci et al. (2001)** in Turkey, studied the effectiveness of seven N<sub>2</sub>-fixing bacterial, (five strains of *Bacillus*; BA-140, BA-142, M-3, M-13 and M-58, a strain of *Burkholderia* {BA-7} and *Pseudomonas* {BA-8}) isolated from various sources, on sugar beet production. They showed that seed inoculation with bacteria strains significantly affected yield, yield components and quality parameters of sugar beet. In conclusion, bacterial seed inoculations especially with BA-140 and BA-142 may satisfy nitrogen requirements of sugar beet under field conditions in upland areas.

**Maareg and Sohir, Badr (2001)** in Egypt, investigated the effect of some biofertilizers (Rhizobacterin, Syrialin and Phosphorine) on sugar beet growth and yield. They reported that Syrialin caused an increase in length, diameter and weight of roots, fresh weight of foliage, TSS %, sucrose %, purity % and sugar yield/fad.

**Kandil et al. (2002 b)** in Egypt, stated that root fresh and dry weights, foliage fresh and dry weights, LAI, CGR, RGR and NAR in both samples (after 120 and 150 days from planting) had a significant response due to biofertilization treatments. They also showed that the highest measurements were achieved from treating seeds with Rhizobacterin.

**Kandil et al. (2002 c)** in Egypt, confirmed that biofertilization treatments brought out significant effects on root and foliage fresh weights, root length and diameter, root/top ratio, root, top and sugar yields/fad. The highest means of previously mentioned characteristics were resulted from inoculation seeds of sugar beet with Rhizobacterin, except root/top ratio were obtained from uninoculated treatment.

**Ramadan et al. (2003)** in Egypt, studied the effect of mixture of nitrogen fixers namely, *Azospirillum sp.*, *Azotobacter sp.* and phosphate dissolving bacteria (*Bacillus sp.*) on root quality, yield and its components. They showed that biofertilization treatments had significant effect on root length and diameter, root, top and sugar yields/fad. On the other hand, biofertilization treatments exhibited insignificant effect in sucrose and purity percentages.

### **III: Effect of interaction between planting dates and biofertilization treatments.**

**Kandil et al. (2002 b)** showed that the interaction between planting dates and biofertilization treatments caused a significant effect on fresh and dry weights of root and foliage as well as LAI after 120 and 150 days from planting in both seasons of this dissertation.

**Kandil et al. (2002 c)** confirmed that the interaction between planting dates and biofertilization treatments exhibited significant increase of root diameter and purity % (in the first season), foliage fresh weight (in the second season), root, top and sugar yields/fad in both seasons.

#### **IV: Effect of nitrogen fertilizer levels:**

Sugar beet require a well-balanced supply of minerals throughout their life cycle for maximum growth, available minerals especially nitrogen affected plant growth and sugar beet productivity. This effect resulted in improving the color and vigor of the leaf canopy, net assimilation rate and dry matter accumulation. The Egyptian soils in general suffered from low content of nitrogen, therefore yields were drastically reduced, and may even be halved on most its. Thereby, it must be determining optimum nitrogen dose, which produce maximum root yield and best root quality parameters, at the same time reduce environmental pollution. Recently, there are many investigations concerned with optimizing application of nitrogen in order to maximizing yields and quality parameters as well as reducing environmental pollution under varying conditions of soil and climate (Draycott, 1993 and Badawi, 1996). In this concern, **Abdel- Aal and Ibrahim (1990)** in Egypt, observed that application of nitrogen fertilizer to sugar beet plants significantly increased root length and diameter, leaf area/plant, root, top and total weights/plant and root and sugar yields as well as juice purity % compared to untreated plants (without nitrogen fertilizer). Generally, the highest values for most traits were obtained by nitrogen fertilization at the rate of 75 kg N/fad. In contrast, TSS % and Sugar % gradually decreased with increasing nitrogen fertilization up to 75 kg N/fad.

**Emara (1990)** in Egypt, stated that increasing nitrogen fertilizer levels from 40 to 60 kg N/fad gave the highest means of root and foliage fresh weights, root and foliage dry weights, root length and diameter, LAI, NAR, CGR as well as root, top and sugar yields/fad. On the other side, increasing nitrogen fertilizer from 40 to 60 kg N/fad resulted in great reduce of sucrose and purity percentages, as well as root/top ratio.

**Khan et al. (1990)** in India, pointed out that each increase in nitrogen fertilizer levels associated with significant increase in root and sugar yields, but it decreased root sucrose content. They also concluded that application of 120 kg N/ha was produced highest yields and good quality of sugar beet in saline-sodic soils.

**Mahmoud et al. (1990 a)** in Egypt, recorded that increasing nitrogen fertilizer level up to 80 kg N/fad enhanced dry matter accumulation and leaf area index (LAI). On the other wise, relative growth rate (RGR), net assimilation rate (NAR) and root/top ratio were significantly reduced due to increasing nitrogen fertilizer levels.

**Mahmoud *et al.* (1990 b)** in Egypt, decided that the highest means of sucrose %, purity %, root, top and sugar yields were resulted from increasing nitrogen fertilization rate up to 80 kg N/fad, while sugar content was decreased with increasing nitrogen rate.

**Marlander (1990)** in Germany, found that root, total sugars and white sugar yields/ha reached maximum values at 159, 136 and 129 kg applied N/ha, respectively. He also recorded that sugars concentration, especially white sugar decreased with increasing nitrogen rate and were highest at 82 kg N/ha.

**Singhania and Sharma (1990)** in India, reported that fertilizing sugar beet plants with 0, 60, 120 and 180 kg N/ha produced 9.18, 15.53, 24.15 and 27.9 t/ha of root yield. Root sugar contents and purity percentage increased with increasing nitrogen rate up to 120 kg N/ha.

**Meirvenne *et al.* (1991)** in Belgium, pointed out that sugar beet plants receiving no nitrogen fertilizer yielded 56.71 t root/ha and 9.12 t sugar/ha. At the optimum nitrogen application rate (160 kg N/ha), yields were 64.31 t roots and 10.18 t sugar/ha.

**Vlassak *et al.* (1991)** in Belgium, found that root yields resulting from nitrogen fertilizer were 88.06, 84.24, 87.43 and 91.22 t/ha at the rates of 65, 110, 160 and 210 kg N/ha, respectively. Root sugar concentrations ranged from 16.4 % (210 kg N/ha) to 17.5 % (untreated plants).

**Assey *et al.* (1992 a)** in Egypt, illustrated that the response to nitrogen fertilization was up to 80 kg N/fad for foliage dry weight/plant and plant dry weight (at 100 days from planting), and up to 120 kg N/fad for both leaf area/plant and LAI (at 115 days from planting). However, root diameter, root dry weight and crop growth rate (CGR) at different stages of growth insignificantly affected due to nitrogen fertilizer levels.

**Assey *et al.* (1992 b)** in Egypt, pointed out that increasing nitrogen fertilizer level than 40 kg N/fad resulted in a remarkable increase in all yield components of sugar beet, with exception root/top ratio. They also showed that maximum root and sugar yields/fad were produced from adding 80 kg N/fad. On the other side, applying 30 kg N/fad resulted in higher sucrose %.

**Bell *et al.* (1992)** in UK, suggested that the highest nitrogen fertilizer rate (180 kg N/ha) decreased the final sugar concentration in storage roots. The alpha-amino nitrogen concentration in the roots was positively related to nitrate supply throughout growth.

**EL-Kassaby and Leilah (1992 a)** in Egypt, stated that increasing nitrogen rate up to 60 kg N/fad caused obvious effect on root fresh weight, root diameter and root as well as sugar yields/fad.

**Ali (1993)** in Egypt, found that supplying sugar beet plants with nitrogen fertilizer at the rate of 80 kg N/fad increased root and foliage fresh weights, leaf area/plant, root and sugar yields/fad. While, sucrose concentration in roots was reduced as nitrogen fertilization incremented.

**EL-Kased *et al.* (1993)** in Egypt, reported that root yield and impurity parameters of sugar juice were increased as a result of increasing nitrogen fertilization, vice versa with respect of

sucrose percentage. Total sugar production and the extractable sugar were significantly increased due to use the higher level of nitrogen fertilizer (100 kg N/fad).

**Strnad and Javurek (1993)** in Belgium, illustrated that addition of nitrogen not allows necessary for higher contents of sugar, where there was a negative correlation between sugar content and nitrogen fertilization.

**Wojcik (1993)** in Poland, reported that weight of leaves increased with increasing nitrogen rates from 0 to 260 kg N/ha. While, root length decreased and root weight was greatest at 80 kg N/ha. Root yield was increased from 53.0 t/ha without nitrogen fertilizer to 63.1 t/ha with 140 kg N/ha as urea. Finally, sugar contents were decreased and alpha-amino nitrogen contents were increased with increasing nitrogen rates to 140 kg N/ha.

**Barbanti *et al.* (1994)** in Italy, studied the effect of nitrogen fertilizer at the rates of 0, 60, 120 or 180 kg N/ha on sugar beet yields and quality. They suggested that intermediate applications of 60 or 120 kg N/ha proved to be the most effective nitrogen fertilizer application rates in terms of yield. Beet quality parameters were adversely affected by increasing nitrogen rate to 120 kg N/ha.

**Kemp *et al.* (1994)** in New Zealand, fertilized sugar beet with various rates of nitrogen (0 to 360 kg N/ha), which illustrated the effect of it on yield and quality of sugar beet. They found that highest root fresh weight was obtained when fertilized plants with 360 kg N/ha, while highest sugar yield was resulted by adding 180 kg N/ha. Juice purity ranged from 91 % (without nitrogen fertilizer) to 80 % (adding 360 kg N/ha), as well as maximum extractable sucrose yield was obtained with 180 kg N/ha.

**Lopez *et al.* (1994)** in Spain, fertilized sugar beet plants with 0, 120, 160, 200 or 260 kg N/ha as urea. They determined that response of sugar yield to nitrogen fertilizer rates, depended on the nitrogen available in the soil. They also found that optimum yield was obtained with fertilizing with 160 kg N/ha.

**Sharief and Eghbal (1994)** in Egypt, cleared that increasing nitrogen rate up to 150 kg/ha increased root length and diameter, leaf area index and root, top as well as sugar yields/ha, but TSS, sucrose and purity percentages were decreased.

**Abdrabou (1995)** in Egypt, showed that when applying higher nitrogen fertilizer rate (120 kg N/fad), dry weights/fad for root, top and whole plant as well as root/top ratio were significantly increased in the two studied seasons, except root dry weight in the second season only.

**Badawi *et al.* (1995)** under Egyptian conditions, concluded that applying nitrogen fertilizer at the rate of 75 kg N/fad showed noticeable increase in root length and diameter, root and top as well as sugar yields/fad, whilst, sucrose percentage was decreased.

**Besheit *et al.* (1995)** in Egypt, demonstrated that increasing nitrogen fertilization rate up to 69 kg N/fad significantly raised fresh and dry weights of root, top and sugar per faddan, but its reduced sucrose and purity percentages.

**EL-Attar *et al.* (1995)** in Egypt, showed that increasing nitrogen application to 80 kg N/fad recorded obvious increase in root weight/plant, root, top and gross sugar yields/fad.

**Smit *et al.* (1995)** in New Zealand, indicated that root and sugar yields were optimal when applied 240 and 200 kg N/ha, respectively. They also concluded that top fresh weight increased with increasing nitrogen availability, while sugar content was reduced.

**Abou-Amou *et al.* (1996)** in Egypt, reported that root, top and gross sugar yields/fad and quality parameters *i.e.* TSS, sucrose and purity percentages were significantly differed due to nitrogen fertilizer levels (0, 40 and 80 kg N/fad). The highest values of yield characters were obtained from applied 80 kg N/fad. On contrary, the highest means of quality parameters were recorded as a result of control treatment (without nitrogen fertilization).

**Allison *et al.* (1996)** in UK, investigated the effects of different rates of nitrogen fertilizer (0 to 180 kg N/ha) on the growth, yield and processing quality of sugar beet. They showed that increasing nitrogen fertilizer rate up to 180 kg N/ha had a little effect on yield.

**Badawi (1996)** in Egypt, reported that increasing nitrogen fertilizer rates from 0 to 60 kg N/fad gave the favorable effect on sugar beet yields and their attributes. While, raising nitrogen rates from 60 to 80 kg N/fad did not show marked effects for most studied characters. On the other hand, raising nitrogen rates up to 80 kg N/fad caused a decrease in TSS, sucrose and juice purity percentages. Finally, he recommended that, the rate of 60 kg N/fad was optimal for increasing root and sugar yields/fad in same manner decreasing fertilization coasts.

**Salama and Badawi (1996)** in Egypt, found that increasing nitrogen levels from 50 to 70 kg N/fad exhibited significant increase in root diameter and sugar yield/fad. However, raising nitrogen levels from 70 to 90 kg N/fad did not induce obvious effects for most studied traits and markedly reduced TSS and sucrose percentages.

**Neamet Alla (1997)** in Egypt, reported that increasing nitrogen fertilization rates from 60 to 105 kg N/fad significantly increased most studied characters. He also recorded that no significant difference was found between applied 90 and 105 kg N/fad in most characters under study. Root diameter, crop growth rate (CGR), net assimilation rate (NAR) and top yield were significantly increased by increasing nitrogen rate up to 105 kg N/fad. Meanwhile, root/top ratio, relative growth rate (RGR), total soluble solids (TSS) and Juice purity percentages were significantly decreased by incrementing nitrogen rate up to 75 kg N/fad.

**Ramadan (1997)** in Egypt, stated that increasing nitrogen rate up to 90 kg N/fad markedly increased root weight, root, top and sugar yields/fad, whereas further increase in nitrogen rate

decreased sugar yields. Number of harvested roots and root/top ratio were not show any significant response to nitrogen rates (30, 60 90 and 120 kg N/fad). Sucrose, juice purity and recoverable sugar percentages were decreased with all increase in nitrogen rate to 90 kg N/fad.

**Sharief *et al.* (1997)** in Egypt, reported that increasing nitrogen fertilizer rate up to 80 kg N/fad significantly increased root length and diameter, LAI, fresh and dry weights of root and foliage/plant, root and sugar yields/fad by 25.4 %, 37.1 %, 89.3 %, 117.7 %, 90.4 %, 105.9 %, 62.3 %, 81.1 % and 60.3 %, respectively, compared with applying 40 kg N/fad. However, percentages of TSS, sucrose and juice purity were decreased by 9.0 %, 12.3 % and 3.1 %, respectively due to increasing nitrogen dose up to 80 kg N/fad.

**AL-Labbody (1998)** in Egypt, cleared that increasing nitrogen fertilizer levels from 0 to 45 and 90 kg N/fad gradually increased root and foliage fresh weights per plant, root length and diameter, purity %, root and sugar yields/fad. With respect of quality parameters, increasing nitrogen fertilizer level up to 45 kg N/fad negatively affected TSS % and sucrose %.

**Azzazy (1998)** in Egypt, illustrated the effect of three nitrogen fertilizer levels (40, 60 and 80 kg N/fad) on yield and quality of sugar beet. He showed that root length and diameter and top yield/fad significantly influenced by increasing nitrogen fertilizer levels. On the other side, sugar yield/fad, sucrose and purity percentages were reduced.

**EL-Hennawy *et al.* (1998)** in Egypt, studied the response of sugar beet yield to different nitrogen rates viz., 60, 90 and 120 kg N/fad. They indicated that increasing nitrogen rate up to 120 kg N/fad resulted in highest values of root and top yields/fad, while root/top ratio tended to decrease as nitrogen rate increased. They also reported that excessive nitrogen application lowered beet quality in terms of root sucrose content and juice purity %.

**EL-Moursy *et al.* (1998)** in Egypt, found that increasing nitrogen fertilizer level up to 100 kg N/fad significantly increased root length and diameter, root fresh weight, root, top and sugar yields/fad as well as TSS %. Whilst, increasing nitrogen fertilizer levels from 40 through 100 kg N/fad caused great decrease in sucrose and purity percentages.

**Geypens *et al.* (1998)** concluded that root yields/ha increased, but sugar content decreased with increasing nitrogen rate above the recommended dose (80 kg N/ha).

**Ibrahim (1998)** in Egypt, investigated the effect of nitrogen fertilizer rates viz., 0, 25, 50, 75 and 100 kg N/fad on sugar beet yield components, yield and quality. He recorded that increasing nitrogen fertilizer rate up to 100 kg N/fad caused a remarkable increase in root and foliage fresh weights per plant, root length and diameter, root and sugar yields/fad, vice versa with respect of quality parameters in terms of TSS, sucrose and purity percentages.

**Kucke and Kleeberg (1998)** in Germany, investigated the effect of reduced nitrogen fertilization on yield, nitrogen balances and nitrogen leaching of sugar beet. They showed that

reducing the usual mineral nitrogen fertilization by 45-55 kg N/ha had a negligible effect on the yields (2-4 % reduction).

**Attia *et al.* (1999)** in Egypt, reviewed that fertilizing beet plants with 60 kg N/fad gave the desirable findings and the highest values of root and foliage fresh weights, root length and diameter, root/top ratio, root, top and sugar yields/fad, HI, TSS, sucrose and purity percentages. Hence the highest it values were resulted from adding 40 kg N/fad. Moreover, the highest values of sucrose and purity percentages were obtained from control treatment (without N).

**Basha (1999)** in Egypt, found that addition of 90 kg N/fad significantly raised root diameter and root/top ratio, but any further increase in nitrogen not exerted significant effect. Root and foliage weights/plant, root, top and sugar yields/fad were significantly improved by increasing nitrogen level up to 120 kg N/fad. Relation to quality parameters, the highest values of TSS, sucrose and apparent purity percentages were obtained from fertilizing with 60 kg N/fad.

**EL-Hawary (1999)** in Egypt, cleared that root fresh weight/plant, root length, root, top and sugar yields/fad were significantly increased with increasing nitrogen rates from 0 to 60 and 90 kg N/fad, while its gave opposite effect on sucrose %. Application nitrogen at the rate of 90 kg N/fad produced the highest means of root and sugar yields/fad, whilst the lowest ones resulted from control treatment (without nitrogen fertilization).

**EL-Kassaby *et al.* (1999)** in Egypt, pointed out that root fresh and dry weights, foliage fresh and dry weights, LAI, CGR, and NAR were proved to be significant increase as a result of nitrogen fertilizer levels (at 120 and 140 days from sowing). Increasing nitrogen fertilizer level up to 60 kg N/fad produced the highest values of these measurements.

**Mahasen, Fahmi (1999)** in Egypt, stated that nitrogen fertilizer levels exhibited significant effect on all growth traits (root fresh and dry weights, foliage fresh and dry weights and LAI), yield components (root and foliage fresh weights and root length and diameter) and yield characters (root, top and sugar yields/fad as well as HI). Increasing nitrogen levels from 50 to 70 and 90 kg N/fad enhanced all above-mentioned characters, while it resulted in great reduction on yield quality (TSS, sucrose and purity percentages).

**Mahmoud *et al.* (1999)** in Egypt, reported that increasing nitrogen level up to 100 kg N/fad substantially improved length, diameter and weights of roots, depressed sucrose content in the roots, decreased purity percentage and increased impurities in terms of alpha amino-nitrogen content in sugar beet juice. Application of 80 kg N/fad significantly increased root and gross sugar yields/fad, thereafter excess application of nitrogen had no marked effect on gross sugar yield. Nitrogen increment over 60 kg N/fad was accompanied by a marked increase in top yield.

**Soheir, Ouda *et al.* (1999)** in Egypt, studied the effect of nitrogen fertilizer levels *i.e.* 60, 80, 100 and 120 kg N/fad on sugar beet productivity. They found that root length and diameter, root

and sugar yields/fad significantly responded to nitrogen fertilizer levels. The highest values of root, top and sugar yields/fad were obtained from applying 120 kg N/fad.

**Abd EL-Moneim (2000)** in Egypt, indicated that nitrogen fertilizer levels significantly increased root length and diameter, root and top fresh weights, root, top and sugar yields/fad, but it decreased TSS, sucrose and purity percentages.

**Abdou (2000)** found that fertilizing sugar beet plants with 100 kg N/fad produced highest values of root and foliage fresh weights, root length and diameter, root, top and sugar yields/fad. Meanwhile, the highest means of TSS, sucrose and purity percentages as well as harvest index were obtained from addition of the lowest nitrogen fertilizer level (60 kg N/fad).

**Azab *et al.* (2000)** in Egypt, detected that values of root length, root fresh weight, root and top yields/fad were significantly raised with incrementing nitrogen fertilizer rate. Applying nitrogen fertilizer at the rate of 90 kg N/fad gave the highest values of previously mentioned traits. In contrast, sucrose and purity percentages significantly decreased with increasing nitrogen fertilizer up to 90 kg N/fad.

**EL-Shafai (2000)** in Egypt, showed that increasing nitrogen fertilizer level up to 92 kg N/fad exhibited obvious effect on root fresh weight/plant, root and sugar yields/fad, while sucrose percentage was decreased as nitrogen levels increased.

**EL-Zayat (2000)** in Egypt, found that increasing nitrogen from 70 to 90 kg N/fad substantially improved root length, dry matter accumulation, LAI, CGR, root, top and sugar yields/fad. There was no evidence for significant differences in root diameter, root/top ratio, RGR, NAR and quality parameters of sugar beet due to nitrogen rates (70 and 90 kg N/fad).

**Hassanin and Sohair, Elayan (2000)** in Egypt, reported that increasing nitrogen rate up to 90 kg N/fad improved size and weight of the individual root and increased root yield by 3.4 t/fad, sugar yield by 0.46 t/fad and top yield by 1.41 t/fad as compared with fertilizing with 60 kg N/fad. On the other hand, higher nitrogen rate depressed sugar beet quality.

**Laila, Saif (2000)** in Egypt, cleared that the quantitative criteria in terms of top and root yields significantly and positively responded to nitrogen fertilizer application up to 120 kg N/fad under conditions of Kafr EL-Sheikh Governorate.

**Zeinab, Moustafa *et al.* (2000)** in Egypt, studied the effect of various nitrogen rates *i.e.* 60, 80, 100, 120, 140 and 160 % of the recommended dose (75 kg N/fad) on root quality and yield. They stated that increasing nitrogen dressing up to 90 kg N/fad (20 % over recommended dose) exhibited the highest root quality, root and sugar yields t/fad. On the other side, further nitrogen dressing markedly decreased the most studies traits.

**EL-Geddawy *et al.* (2001)** in Egypt, found that levels of nitrogen (60, 80 and 100 kg N/fad) had no statistical differences with relation to TSS %, sucrose %, root and sugar yields/fad.

**EL-Harriri and Mirvat, Gobarh (2001)** in Egypt, noticed that adding 110 kg N/fad resulted in greatest values of root weight/plant, root length and diameter, TSS %, root and top yields/fad. On contrary, increasing nitrogen level up to 110 kg N/fad depressed significantly sucrose and purity percentages as compared with lower level (70 kg N/fad).

**EL-Shahawy, et al. (2001)** in Egypt, pointed out that the desirable effect of nitrogen fertilizer was recorded when applied 60 kg N/fad, which gave the highest values of root, top and sugar yields/fad. While, the highest means of sucrose % and purity % were obtained under control treatment (without nitrogen).

**Nemeat Alla (2001)** in Egypt, found that nitrogen fertilizer levels (90, 115 and 140 kg N/fad) significantly increased root and top yields/fad, but significantly decreased sucrose, purity percentages and sugar yield/fad. Also, no significant effect on root length and diameter and TSS % due to nitrogen fertilizer rates was detected.

**Nemeat Alla and EL-Geddawy (2001)** in Egypt, studied the effect of different levels of nitrogen fertilizer (80, 100, 120 and 140 kg N/fad) on yield and quality of sugar beet. They deduced that increasing nitrogen level up to 100 kg N/fad incremented root length and diameter, root and sugar yields/fad, while decreased TSS and sucrose percentages.

**Ostrowska et al. (2001)** in Poland, concluded that application nitrogen at the rate of 90 kg N/ha produced the highest root and gross sugar yields/ha.

**Shafika, Mostafa and Darwish (2001)** in Egypt, recommended that for increasing root and gross sugar yields/fad, it must be increasing nitrogen fertilizer level upon 105 kg N/fad.

**Sohier, Ouda (2001)** in Egypt, confirmed that root length, foliage fresh weight/plant and root sucrose content were responded to nitrogen fertilizer level up to 75 kg N/fad. While root diameter, root fresh weight/plant, TSS %, root, top and sugar yields/fad were responded up to 90 kg N/fad. On the other side, purity % did not clear any significant effect due to nitrogen fertilizer levels.

**Abo EL-Wafa (2002)** in Egypt, concluded that fertilizing sugar beet plants with 80 kg N/fad was responsible for producing economical yields. While, the highest values of sucrose percentage were recorded when adding 60 kg N/fad.

**EL-Shahawy et al. (2002)** in Egypt, recorded significant increase in root and sugar yields/fad with increasing applied nitrogen up to 80 kg N/fad.

**Kandil et al. (2002 b)** in Egypt, found that raising nitrogen fertilizer levels from 0 to 20, 40, 60 and 80 kg N/fad significantly improved root fresh and dry weights, foliage fresh and dry weights, LAI, CGR, RGR and NAR. The highest means of these characters were attained to increase nitrogen fertilizer level up to 80 kg N/fad.

**Kandil *et al.* (2002 c)** in Egypt, noticed that there was a significant increase in root and foliage weights, root length and diameter, root/top ratio, root, top and sugar yields/fad due to raising nitrogen fertilizer levels from 0 to 20, 40, 60 and 80 kg N/fad. They also recorded that the greatest values of TSS, sucrose and purity percentages were achieved from control treatment (without nitrogen).

**Nemeat Alla *et al.* (2002)** in Egypt, reported that increasing nitrogen fertilizer as soil application up to 90 kg N/fad significantly increased root length and diameter, root, top and sugar yields/fad. The reverse was true with respect to TSS %, sucrose % and purity %.

**Sohier, Ouda (2002)** in Egypt, indicated that root length and diameter and purity % were improved by incrementing nitrogen fertilizer levels from 70 to 100 kg N/fad. While, increasing nitrogen fertilizer level up to 130 kg N/fad increased root, top and sugar yields/fad. But nitrogen fertilizer did not significantly affected sucrose and TSS percentages.

**Ramadan *et al.* (2003)** in Egypt, reported that application of mineral fertilizers at the recommended rates significantly decreased TSS % (in the second season, sucrose % (in the first season) and purity % (in both seasons). Fertilizing beet plants with the highest level of 100 % mineral fertilizers (75 kg N + 15 kg P<sub>2</sub>O<sub>5</sub>/fad) gave the highest significant increase in root length and diameter, root, top and sugar yields/fad.

**Shalaby *et al.* (2003)** in Egypt, reported that applying nitrogen fertilizer at the rate of 80 and 100 kg N/fad produced the highest values of the chemical constituents of fresh sugar beet roots. They also showed that increasing nitrogen up to 120 kg N/fad could be significantly increased root, top and sugar yields/fad. On the other hand, sucrose %, juice purity % and TSS % decreased with increasing nitrogen fertilizer rate up to 120 kg N/fad.

#### **V: Effect of potassium fertilizer levels:**

Potassium is very mobile in plant tissues and moves readily from older tissues to the growing points of the root and foliage. Moreover, potassium is a major plant nutrient needed in sugar beet for best plant growth and production. It is important to photosynthesis, activating starch synthetase enzymes and the sugar yield, which is produced, relies on potassium for movement to the storage root (Nitoses and Evans, 1969). Potassium also improves performance by increasing leaf area, this allows the crop to intercept more radiation giving proportional increases in sugar yield. Potassium has important financial implications because, for a given weight of sugar produced, growers are often paid commensurately more for high sugar percentage roots. In addition, costs are decreased because, for a given weight of sugar, less weight of roots has to be harvested and transported (Draycott, 1993). Generally, potassium is usually taken up earlier than nitrogen and phosphorus and uptake increases faster than dry matter production. This means that potassium accumulates early in the growing period and then is translocated to other plant parts. There are

many investigations with respect to the effect of potassium fertilization on sugar beet productivity. In this connections,

**Ahmed (1988)** in Egypt, recorded a slight response for potassium at rate of 10 kg K<sub>2</sub>O/fad with respect to root and sugar yields/fad.

**Beringer *et al.* (1988)** in Germany, found that increasing potassium supply led to higher root weights/plant. They also recorded that there was a negative correlation between potassium fertilization and sugar concentration in the root.

**Genaidy (1988)** in Egypt, showed that application of 86 kg K/fad increased root and top yields/fad, sugar content, purity and gross sugar yield by 17, 12, 10, 17 and 27 %, respectively over the control treatment (without potassium fertilization).

**Abdel-Aal (1990)** in Egypt, decided that increasing K<sub>2</sub>O up to 72 kg/fad improved root length and diameter, foliage and root fresh weights/plant and root yield/fad.

**Kandil (1993)** in Egypt, showed that potassium fertilization exerted significant increase in all studied characteristics (root weight, length and width, number of leaves/plant, weight of leaves/plant and blade leaf area) compared to the control treatment (without potassium fertilizer). With exception for purity percentage, which cleared opposite trend.

**Basha (1994)** in Egypt, cleared that applying potassium fertilizer at the rate of 72 kg K<sub>2</sub>O/fad significantly enhanced root length and diameter, root and foliage fresh weights/plant, root, top and gross sugar yields/fad. In addition root quality parameters in terms of TSS, sucrose and purity percentages were taken similar trend with respect of potassium fertilization.

**Kasap and Killi (1994)** in Turkey, stated that average of root weight/plant and root yield/ha were increased by potassium fertilizer treatments. The highest root fresh weight/plant, root and sugar yields/ha were associated with applying potassium fertilizer at the rate of 60 kg K<sub>2</sub>O/ha.

**Nigrila *et al.* (1994)** in Romania, decided that application potassium fertilizer at the rate of 70 kg K<sub>2</sub>O/ha increased root yield from 80 to 83 t/ha and sugar yield from 9.2 to 10.0 t/ha.

**Badawi *et al.* (1995)** in Egypt, comes to conclusion that potassium fertilizer at the rate of 48 kg K<sub>2</sub>O/fad without nitrogen or phosphorus fertilization gave the highest sucrose percentage.

**Denesova and Andres (1995)** in Romania, reported that there were good effects on yields of root, sugar and the economic returns due to utilization potassium fertilizer at the rate of 200 kg/ha.

**Hegazy and Genaidy (1995)** in Egypt, found that applying potassium fertilizer at the economic optimum rate (48 kg K<sub>2</sub>O/fad) improved growth and yield of sugar beet when sowing it alone or intercropped with faba bean.

**Khalifa *et al.* (1995)** in Egypt, showed that root and sugar yields/fad were positively affected by potassium fertilizer rate up to 48 kg K<sub>2</sub>O/fad. Root quality *i.e.* sucrose %, white possible

extractable sugar % and sugar purity % were decreased by increasing potassium rates from 0 to 48 and 72 kg K<sub>2</sub>O/fad.

**Abd EL-Wahab *et al.* (1996)** in Egypt, studied the effect of different rates of potassium fertilizer viz., 0, 12, 24, 36 and 48 kg K<sub>2</sub>O/fad on yield and quality of sugar beet. They demonstrated that root length and diameter, root and sugar yields were significantly affected by potassium rates. In contrast, sucrose and juice purity percentages did not clear any significant differences between potassium fertilizer rates.

**Abou-Amou *et al.* (1996)** in Egypt, showed that potassium fertilizer levels (0, 24 and 48 kg K<sub>2</sub>O/fad) caused significant differences with respect to root and top yields/fad. While, root quality parameters in terms of TSS, sucrose and purity percentages were not responded due to potassium fertilization.

**EL-Kammah and Ali (1996)** in Egypt, pointed out that all agronomic characters of sugar beet *i.e.* root/top ratio, leaf area, root, top and sugar yields/fad were affected by increasing potassium rates from 0 to 12, 21 and 42 kg K<sub>2</sub>O/fad. Generally, the highest means of most studied traits were obtained from potassium application at the rate of 42 kg K<sub>2</sub>O/fad. All the quality parameters were insignificantly affected by increasing potassium rates from 0 to 42 kg K<sub>2</sub>O/fad.

**Morrisi (1997)** in Egypt, found that application of 48 kg K<sub>2</sub>O/fad significantly affected root length and diameter, sucrose and juice purity percentages.

**Ramadan (1997)** in Egypt, showed that increasing potassium rate up to 72 kg K<sub>2</sub>O/fad developed beet growth in terms of root weight, improved quality in terms of sucrose and purity percentages and increased yields of root, top and sugar per faddan.

**Sharief *et al.* (1997)** in Egypt, observed that root length and diameter, LAI, root fresh and dry weights, foliage fresh and dry weights, root and sugar yields/fad were tended to increase due to potassium fertilizer at the rate of 36 kg K<sub>2</sub>O/fad as compared with control (without potassium fertilization). On the other hand, TSS, sucrose and purity percentages had inverse effect.

**Basha (1998)** in Egypt, noticed that applying of 48 kg K<sub>2</sub>O/fad to fodder beet significantly increased root weight/plant, total weight of plants, root length and diameter, root and top yields/fad, whilst root/top ratio was reduced.

**EL-Moursy *et al.* (1998)** in Egypt, indicated that applying potassium fertilizer level up to 48 kg K<sub>2</sub>O/fad markedly enhanced root fresh weight/plant, root diameter, root, top and sugar yields/fad, vice versa with respect of juice purity percentage.

**Sayed *et al.* (1998)** in Egypt, confirmed that increasing potassium fertilizer rates from 0 to 48 kg K<sub>2</sub>O/fad significantly increased root diameter, root fresh weight/plant, root and sugar yields/fad.

**EL-Hawary (1999)** in Egypt, indicated that all studied traits significantly increased as potassium rates increased from 0 to 24 and 48 kg K<sub>2</sub>O/fad. The highest potassium fertilizer rate (48 kg K<sub>2</sub>O/fad) caused 24.27, 28.57 %, 12.97 and 15.08 % increase in root and sugar yields/fad in the first and second seasons, respectively.

**EL-Yamani (1999)** in Egypt, noticed that the highest values of root yield were obtained from fertilizing sugar beet plants with 24 kg K<sub>2</sub>O/fad. In addition, the highest values of sucrose % and gross sugar yield were recorded by application of 72 kg K<sub>2</sub>O/fad.

**Selim and EL-Ghinbihi (1999)** in Egypt, observed that increasing potassium fertilizer rate up to 48 kg K<sub>2</sub>O/fad improved root, top and sugar yields/fad. Moreover, sucrose content had a positive effect, but juice purity percentage was decreased as potassium fertilizer rates increased.

**EL-Shafai (2000)** in Egypt, pointed out that increasing potassium fertilizer levels from 0 to 48 kg K<sub>2</sub>O/fad positively increased root fresh weight/plant, sugar yield/fad and sucrose %. Whilst, root yield insignificantly increased as potassium level increased up to 48 kg K<sub>2</sub>O/fad.

**EL-Zayat (2000)** in Egypt, stated that increasing potassium fertilizer rates from 0 to 24 kg K<sub>2</sub>O/fad brought out significant increases in root length and diameter, dry matter accumulation, LAI, CGR, root, top and sugar yields/fad. On the other side, potassium fertilization failed to exhibit significant differences in RGR, NAR and quality parameters.

**EL-Harriri and Mirvat, Gobarh (2001)** in Egypt, indicated that high level of potassium fertilizer (48 kg K<sub>2</sub>O/fad) exhibited a significant increase on LAI, root/top ratio, root length and diameter, root and top yields/fad, TSS, sucrose and purity percentages as compared with control treatment.

**Hannan, Yossef (2001)** in Egypt, concluded that increasing potassium levels from 24 to 48 kg K<sub>2</sub>O/fad significantly increased root yield by 6.4 % as compared with control treatment.

**Sohier, Ouda (2001)** in Egypt, revealed that increasing potassium fertilizer levels from 0 to 24 and 48 kg K<sub>2</sub>O/fad caused a significant increase in root length and diameter, root and foliage weights/plant, root, top and sugar yields/fad, TSS and sucrose percentages. In contrast, purity % was not influenced by the application of potassium fertilizer.

**Kandil *et al.* (2002 a)** in Egypt, reported that potassium fertilizer significantly affected root and foliage fresh weights/plant, LAI and CGR. Vice versa with connection RGR and NAR. The highest values of root, top and sugar yields/fad were obtained from application of 36 kg K<sub>2</sub>O/fad. Whereas, increasing K<sub>2</sub>O level up to 48 kg K<sub>2</sub>O/fad did not exhibit any significant increase. With respect to quality parameters (TSS %, sucrose % and purity %), it is worthy to note that potassium fertilizer levels did not significantly affect these traits.

## **VI: Effect of nitrogen and potassium fertilizer levels.**

**EL-Kassaby *et al.* (1991)** in Egypt, concluded that fertilizing sugar beet with 70 kg N + 24 kg K<sub>2</sub>O/fad raise the root yield/fad.

**EL-Shafei (1991)** in Egypt, recommended that adding nitrogen and potassium fertilizers at the rate of 75 kg N + 96 kg K<sub>2</sub>O/fad produced highest root and top of sugar beet yields/fad.

**Sobh *et al.* (1992)** in Egypt, cleared that application of 60 kg N + 24 kg K<sub>2</sub>O/fad produced highest root and top yields/fad as well as sugar constituents, while the highest values of sugar yield resulted from application of 60 kg N + 48 kg K<sub>2</sub>O/fad.

**Sorour *et al.* (1992)** in Egypt, showed that root and top yields/fad were highest with applying 75 kg N + 96 kg K<sub>2</sub>O/fad. On the other hand, the highest yield of sugar resulted from applying 60 kg N + 96 kg K<sub>2</sub>O/fad.

**Ghonema and Sarhan (1994)** in Egypt, comes to conclusion that increasing NK fertilizer levels up to 75 kg N + 48 kg K<sub>2</sub>O/fad significantly increased most yield components, yield and quality of sugar beet, with exception sucrose and juice purity percentages. Generally, they recommended that the highest root and sugar yields/fad can be obtained by adding 75 kg N + 48 kg K<sub>2</sub>O/fad.

**Badawi *et al.* (1995)** in Egypt, revealed that the combined fertilizer treatment of NK at the rate of 75 kg N + 48 kg K<sub>2</sub>O/fad was the most favorable for raising root, top and sugar yields/fad.

**Abou-Amou *et al.* (1996)** in Egypt, found that the application of 80 kg N + 48 kg K<sub>2</sub>O/fad resulted the highest values of root yield of sugar beet (27.07 t/fad), purity % (78.75 %) and gross sugar yield (4.61 t/fad). They concluded that potassium fertilization increased the efficiency of nitrogen uptake from the soil and its utilization by sugar beet plants, especially when the nitrogen fertilization was applied at its high level (80 kg N/fad).

**Gewefel and Aly (1996)** in Egypt, observed that total fresh weight of plant was the highest with application of 80 kg N + 50 or 100 kg K<sub>2</sub>O/fad.

**Gasiorowska (1997)** in Russia, recorded that increasing nitrogen and potassium rates (100 kg N + 120 kg K<sub>2</sub>O, 160 kg N + 190 kg K<sub>2</sub>O or 220 kg N + 260 kg K<sub>2</sub>O/ha) reduced root and foliage dry matter and also sugar content.

**Ramadan (1997)** in Egypt, concluded that the interaction between nitrogen and potassium fertilization was significant with respect to root/top ratio and root yield/fad.

**Samia, EL-Maghraby *et al.* (1998)** in Egypt, reported that there was a significant effect on the interaction between nitrogen and potassium fertilization on root and sugar yields/fad, whereas the combination of 90 kg N + 48 kg K<sub>2</sub>O/fad had superior effect on these characters.

**Sarhan (1998)** in Egypt, decided that addition of 100 kg N + 48 kg K<sub>2</sub>O/fad produced the highest values of leaf area/plant, root length and diameter, root and foliage fresh weights/plant, root, top and sugar yields/fad.

**Sayed *et al.* (1998)** in Egypt, illustrated that application of 60 kg N + 48 kg K<sub>2</sub>O/fad obtained the highest values of root and top yields/fad, root size and gross sugar yield/fad.

**EL-Hawary (1999)** in Egypt, reported that the interaction between nitrogen and potassium fertilization had significant effects on root length, root fresh weight/plant, sucrose %, root, top and sugar yields/fad. The highest values of these characters were recorded by fertilizing with 90 kg N + 48 kg K<sub>2</sub>O/fad.

**Sultan *et al.* (1999)** in Egypt, recorded that the combined application of 60 kg N + 48 kg K<sub>2</sub>O/fad markedly developed yield and root quality and should be recommended to get maximum yields compared to the application of nitrogen or potassium fertilizer alone.

**EL-Shafai (2000)** in Egypt, observed that root yield/fad and sucrose % had significant response as a result of the interaction between nitrogen and potassium fertilizer levels, vice versa with connection root fresh weight/plant, sugar yield and purity %.

**EL-Zayat (2000)** in Egypt, concluded that fertilization sugar beet plants with 90 kg N + 24 kg K<sub>2</sub>O/fad could be recommended for optimum root and extractable white sugar yields per unit area.

**EL-Harriri and Mirvat, Gobarh (2001)** in Egypt, pointed out that application of 110 kg N + 48 kg K<sub>2</sub>O/fad markedly increased number of leaves/plant, LAI, root/top ratio, root characters, TSS %, root and top yields/fad.

## **VII: Effect of the interaction between planting dates and nitrogen & potassium fertilizer levels.**

**Badawi *et al.* (1995)** concluded that early planting of sugar beet (1<sup>st</sup> Oct.) and fertilizing it with 75 kg N + 24 kg K<sub>2</sub>O/fad achieved the maximum root and sugar yields/fad.

**Azzazy (1998)** reported that root yield/fad (in the second season) significantly affected by the interaction between planting dates and nitrogen levels. On the contrary, TSS %, sucrose %, purity %, top and sugar yields/fad insignificantly affected by the interaction between planting dates and nitrogen levels.

**Kandil *et al.* (2002 b)** indicated that the interaction between planting dates and nitrogen levels had significant increases on root fresh and dry weights, foliage fresh and dry weights and LAI in both seasons. The highest values of these traits were obtained by planting beets during October and fertilizing with 80 kg N/fad.

**Kandil *et al.* (2002 c)** found that root length and diameter, root and foliage fresh weight/plant, root, top and sugar yields/fad significantly affected due to the interaction between

planting dates and nitrogen levels. In addition, the best results were achieved when planting during October and application of 80 kg N/fad

### **VIII: Effect of the interaction between biofertilization treatments and nitrogen & potassium fertilizer levels.**

**Favilli *et al.* (1993)** in India, showed that inoculation seeds of sugar beet with *Azospirillum lipoferum* + 60 kg N/ha produced the highest root weight per plant and per hectare compared with fertilizing plants with 100 kg N/ha alone.

**Milic *et al.* (1995)** in Yugoslavia, studied the effect of quantity of free aerobic nitrofixators, Na, K and P oxides and mineral nitrogen levels (0, 60, 90, 120 and 150 kg N/ha) on seed emergence and growth of sugar beet. They found that mineral nitrogen fertilizer levels at 60, 90 and 120 kg N/ha had a positive effect upon number of nitrofixators, which led to improve seed emergence and growth, while application of 150 kg N/ha caused a decrease.

**Sultan *et al.* (1999)** in Egypt, concluded that the maximum yields of sugar beet were achieved by inoculating seeds with Azotobacterin and application of NPK fertilization at the rate of 60 kg N + 30 kg P<sub>2</sub>O<sub>5</sub> + 48 kg K<sub>2</sub>O/fad.

**Abu EL-Fotoh *et al.* (2000)** in Egypt, indicated that using biofertilizers (Microbbin or Phosphorin) and NPK chemical fertilizers at the rate of 30 kg N + 15 kg P<sub>2</sub>O<sub>5</sub> + 12 kg K<sub>2</sub>O/fad induced obvious effect on the quality of sugar beet juice (alpha-amino nitrogen, and sucrose percentage). Finally, they concluded that biofertilizers alone can not be met the NPK requirements for sugar beet crop.

**Bassal *et al.* (2001)** in Egypt, observed that increasing bio-mineral nitrogen fertilization level up to 60 kg N/fad + Syrialin inoculation significantly increased root, top and sugar yields/fad as well as sucrose percentage.

**Kandil *et al.* (2002 c)** in Egypt, reviewed that the interaction between biofertilization treatments and nitrogen fertilizer levels exerted significant effect on root and foliage fresh weights/plant, root length and diameter, root and top yields/fad. While, root/top ratio, TSS %, purity % and sugar yield (in the first season) did not differed due to the interaction between biofertilization treatments and nitrogen fertilizer levels.

**Soha, Khalil (2002)** in Egypt, reported that fertilization with a mixture of Azotobacterin (*Azotobacter chroococcum*) and Phosphobacterin (*Bacillus megaterium*) combination with 50 kg N/fad affected significantly root fresh weight, top fresh weight, root length and diameter, TSS %, sucrose % and purity % as well as root, top and sugar yields/fad. Generally, the productivity of sugar beet was increased in spite of reducing the quantity of mineral nitrogen fertilizer until 50 kg N/fad, which worry save 25 kg N/fad and reduce the environmental pollution.

**Ramadan *et al.* (2003)** in Egypt, recorded that the interaction between biofertilization treatments and mineral fertilizer levels had significant decreases in TSS % (in the second season), sucrose and purity percentages (in both seasons). The application of 100 % of mineral fertilizers (75 kg N + 15 kg P<sub>2</sub>O<sub>5</sub>/fad) in the presence of biofertilization produced the highest increase in root length and diameter, root, top and sugar yields/fad.

**IX: Effect of the interaction among planting dates, biofertilization treatments and nitrogen & potassium fertilizer levels.**

**Abdou (2001)** found that the interaction among planting dates, biofertilization treatments and nitrogen fertilizer levels showed significant effect on root and foliage fresh weights, root diameter, root and top yields/fad. He concluded that planting sugar beet during October and treated seeds before planting with Rhizobacterin in addition adding 80 kg N/fad associated with best productivity of sugar beet.

## MATERIALS AND METHODS

Three field experiments were conducted at the Experimental Station, Faculty of Agriculture, Mansoura University, during the three successive winter seasons of 2000/2001, 2001/2002 and 2002/2003. The main objectives of this study were to determine the effect of planting dates, biofertilization treatments, nitrogen & potassium fertilizer levels and their interactions on growth, yield and its components as well as quality of sugar beet (*Beta vulgaris* var. *altissima*, L.) cv. Beta Poly 4.

The Beta Poly 4 cultivar is one of multigerm sugar beet cultivars, and annually imported from Hungary by Dakahlia Sugar Company at Belkass. It is one of short duration cultivars (180-200 days) and recommended to be grown under Dakahlia Governorate conditions.

### *Treatments and experimental design:*

Three field experiments were laid-out in a split-split plot design with three replications. In the first season (2000/2001), the experiment included sixty-four treatments comprising, two planting dates, four biofertilization treatments and eight combinations of nitrogen and potassium fertilizer levels. While in the second and third seasons (2001/2002 and 2002/2003), each experiment included ninety-six treatments comprising, three planting dates, four biofertilization treatments and eight combinations of nitrogen and potassium fertilizer levels.

The main plots were assigned to planting dates as follows: two planting dates only in the first season (1<sup>st</sup> Oct. and 1<sup>st</sup> Nov.) and three planting dates in the second and third seasons (1<sup>st</sup> Sept., 1<sup>st</sup> Oct. and 1<sup>st</sup> Nov.).

The sub-plots were allocated with the following four biofertilization treatments:

B<sub>0</sub> - Without biofertilization (control).

B<sub>1</sub> - Treated soil with Rhizobacterin (450 g/fad).

B<sub>2</sub> - Treated soil with Cerialine (450 g/fad).

B<sub>3</sub> - Treated soil with Rhizobacterin + Cerialine (225+225 g/fad, respectively).

Rhizobacterin and Cerialine as commercial products were produced by Biofertilizer Unit, Agriculture Research Center (ARC), Giza, Egypt, which included free-living bacteria able to fix atmospheric nitrogen in the rhizosphere of soil.

The biofertilizer treatments were done before first irrigation directly by mixing the recommended dose of each biofertilizer with fine clay as side-dress near from hills.

The sub sub-plots were occupied with the following eight combinations of nitrogen and potassium fertilizer levels:

1- 20 kg N + 24 kg K<sub>2</sub>O/fad.

2- 20 kg N + 48 kg K<sub>2</sub>O/fad.

3- 40 kg N + 24 kg K<sub>2</sub>O/fad.

4- 40 kg N + 48 kg K<sub>2</sub>O/fad.

5- 60 kg N + 24 kg K<sub>2</sub>O/fad.

6- 60 kg N + 48 kg K<sub>2</sub>O/fad.

7- 80 kg N + 24 kg K<sub>2</sub>O/fad.

8- 80 kg N + 48 kg K<sub>2</sub>O/fad.

Nitrogen and potassium fertilizers in the forms of urea (46 %N) and potassium sulphate (48 % K<sub>2</sub>O), respectively were applied as a side-dressing in two equal doses, one half after thinning (35 days after sowing) and the other before the third watering (70 days after sowing).

Each experimental basic unit (sub sub-plot) included four ridges, each 60 cm apart and 4.0 m length, resulted an area of 9.6 m<sup>2</sup> (1/437.5 fad) in the first and third seasons only. Whilst, in the second season the specialty area of experiment was very limit, thus each experimental unit consisted of four ridges, each 60 cm apart and 4.0 m length, but the external ridges of each plot as a border. The preceding summer crop was maize (*Zea mays*, L.) in all seasons.

#### *Mechanical and chemical analysis of soil:*

Soil samples were taken at random from the experimental field area at a depth of 15 and 30 cm from soil surface before soil preparation to measure the chemical and physical soil properties as shown in Table 1.

#### *Temperature and humidity:*

Meteorological data (monthly temperature C<sup>0</sup> and relative humidity %) of EL-Mansoura district during the three growing seasons of 2000/2001, 2001/2002 and 2002/2003 were shown in Table 2.

#### *Agricultural practices:*

The experimental field well prepared through two ploughing, leveling, compaction, ridging, division and then divided into the experimental units. Calcium super phosphate (15.5 % P<sub>2</sub>O<sub>5</sub>) was applied during soil preparation at the rate of 100 kg/fad.

Sugar beet balls were hand sown 3-5 balls/hill using dry sowing method on one side of the ridge in hills 20 cm apart during the aforementioned dates in the first, second and third seasons, respectively. The plots were irrigated immediately after sowing directly. Plants were thinned at the age of 35 days from planting to obtain one plant/hill (35000 plants/fad).

Plants were kept free from weeds, which were manually controlled by hand hoeing at two times. The common agricultural practices for growing sugar beet according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

**Table 1:** Physical and chemical soil characteristics at the experimental sites during the three seasons.

Soil analysis	First season 2000/2001	Second season 2001/2002	Third season 2002/2003
<b>A: Mechanical analysis</b>			
Clay (%)	48.8	48.9	49.0
Silt (%)	26.9	27.0	27.0
Fine sand (%)	21.0	20.8	20.7
Coarse sand (%)	3.0	3.1	3.0
Texture class	Clayey	Clayey	Clayey
<b>B: Chemical analysis</b>			
CaCO <sub>3</sub> (%)	3.5	3.4	3.3
Organic matter (%)	1.63	1.80	1.84
Total nitrogen (%)	0.061	0.093	0.112
Available phosphate ppm	9.2	9.8	10.9
Available potassium ppm	350.1	373.4	385.2
EC (ds/m) at 25 <sup>0</sup> C	2.0	1.7	1.6
PH	7.9	7.8	7.6

**Table 2:** Maximum and minimum monthly temperature (C<sup>0</sup>) and relative humidity (%) at the experimental site during 2000/2001, 2001/2002 and 2002/2003 seasons.

Month	Temperature (C <sup>0</sup> )						Relative humidity (%)					
	2000/2001		2001/2002		2002/2003		2000/2001		2001/2002		2002/2003	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
<b>September</b>	34.7	20.6	34.1	20.9	35.2	21.1	88	33	96	38	92	36
<b>October</b>	30.7	18.4	30.6	17.7	31.0	18.2	88	34	96	39	93	38
<b>November</b>	24.6	13.9	25.4	14.1	26.3	12.6	89	36	94	45	67	49
<b>December</b>	22.7	12.1	20.6	7.9	21.6	8.6	87	44	75	60	80	53
<b>January</b>	20.8	9.7	17.2	7.7	22.2	7.9	88	42	96	53	78	51
<b>February</b>	20.1	10.2	21.1	11.2	20.7	6.8	89	37	96	46	87	58
<b>March</b>	25.6	11.3	25.0	13.0	20.1	7.1	98	41	96	42	80	52
<b>April</b>	27.2	13.4	26.8	13.0	26.4	11.2	95	32	96	36	75	45
<b>May</b>	31.3	17.2	31.8	16.9	30.7	10.7	94	29	97	31	70	40

\* The source of this data is Ministry of Agriculture and reclamation of soils, Agriculture Research Center (ARC), central management of Agriculture guideline, bulletin of agricultural meteorological data.

*Sampling time:*

Two samples were taken during the growth period (120 and 150 days from planting), *i.e.* five guarded plants were chosen at random from outer ridges of each sub sub-plot. Each sample was separated into foliages and roots, then the roots and foliages were cut to small pieces. The following growth attributes was determined:

1. Root fresh weight (g).
2. Root dry weight (g).
3. Foliage fresh weight (g).
4. Foliage dry weight (g).

To determine root and foliage dry weight, all plant fractions were air-dried, then oven dried at 70<sup>0</sup>C till constant weight obtained.

5. Leaf area index (LAI): Leaf area measurement determined by the disk method using 10 disks of 1.0 cm diameter according to Watson (1958) and then following equation was used.

$$\mathbf{LAI} = \frac{\text{Unit leaf area per plant (cm}^2\text{)}}{\text{Plant ground area (cm}^2\text{)}}$$

6. Crop growth rate (CGR) in g/day: Determined according to Radford's (1967), where:  $W_1$  and  $W_2$  refer to dry weight of plant at sampling time  $T_1$  (120 DAP) and  $T_2$  (150 DAP), respectively.

$$\mathbf{CGR} = \frac{W_2 - W_1}{T_2 - T_1}$$

7. Relative growth rate (RGR) in g/g/day: Determined according to Watson's (1958).

$$\mathbf{RGR} = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

8. Net assimilation rate (NAR) in g/cm<sup>2</sup>/day: Determined according to Radford's (1967), where:  $W_1, A_1$  and  $W_2, A_2$ , respectively refer to dry weight and leaf area of plant at sampling time  $T_1$  and  $T_2$ , respectively.

$$\mathbf{NAR} = \frac{(W_2 - W_1) (\log_e A_2 - \log_e A_1)}{(T_2 - T_1) (A_2 - A_1)}$$

*Yield components and quality characters:*

At maturity (after approximately 195 days from planting) five plants were chosen at random from the outer ridges of each sub sub-plot to determine yield components and quality characters as follows:

1. Root fresh weight (g/plant).
2. Foliage fresh weight (g/plant).
3. Root/top ratio.
4. Root length (cm).
5. Root diameter (cm).
6. Total soluble solids (TSS %) in roots. It was measured in juice of fresh roots by using Hand Refractometer.
7. Sucrose percentage (%). It was determined Polarimetrically on lead acetate extract of fresh macerated roots according to the method of Le-Docte (1927).
8. Apparent purity percentage (%). It was determined as a ratio between sucrose % and TSS % of roots.

*Yield characters:*

At harvest, plants that produced from the two inner ridges of each sub sub-plot were collected and cleaned. Roots and tops were separated and weighted in kilograms, then converted to estimate:

1. Root yield (t/fad).
2. Top yield (t/fad).
3. Sugar yield (t/fad). It was calculated by multiplying root yield by sucrose percentage.

Root yield

4. Harvest index (HI) = 
$$\frac{\text{Root yield}}{\text{Biological yield (root yield + top yield)}}$$

*STATISTICAL ANALYSIS*

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split split-plot design by means of “MSTAT-C ” Computer software package and least significant difference (LSD) method was used to test the differences between treatment means at 5 % levels of probability, as published by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

The main objective of this chapter in the study is to attend to the obtained results and a try for explaining its. Effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on growth, yield and quality of sugar beet will be presented and discussed in separate topics under the following four headings:

1. Growth attributes.
2. Yield components.
3. Yield quality.
4. Yield.

### **1. GROWTH ATTRIBUTES:**

#### **1.1- Root fresh weight (g/plant):**

Root fresh weight of sugar beet plants (g/plant) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days from planting during 2000/2001, 2001/2002 and 2002/2003 seasons are presented in Table 3.

#### **Effect of planting dates:**

As shown from data in Table 3, planting dates had a significant effect on root fresh weight at 120 and 150 days from planting in the second and third seasons only. Planting in 1<sup>st</sup> October was accompanied with highest means of root fresh weight (276.5, 368.0 and 370.5 g/plant) and (314.9, 566.9 and 572.6 g/plant) at 120 and 150 days from planting in the first, second and third seasons, respectively. On the other hand, the lowest ones *i.e.* 243.2, 264.8 and 273.4 as well as 309.6, 513.8 and 499.4 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively were resulted from planting beet on 1<sup>st</sup> November in the first and third seasons and from 1<sup>st</sup> of September in the second season. The superiority of planting sugar beet on 1<sup>st</sup> October with respect to root fresh weight may be due to the suitable weather conditions during growth stages of plant that held not only maximum growth of roots but also rapid growth and formation a good canopy able to make efficient photosynthesis. These results are in harmony with those obtained by Badawi (1985), Badawi *et al.* (1995) and Kandil *et al.* (2002 b).

#### **Effect of biofertilization treatments:**

Significant differences were noticed in root fresh weight at 120 and 150 days from planting in response to biofertilization treatments in the three seasons as it is shown in Table 3. The heaviest fresh roots were produced from Rhizobacterin treatment, where results were 289.1, 344.6 and 334.2 g/plant as well as 343.9, 564.8 and 550.8 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively. Treated soil with Rhizobacterin + Cerialine came in the second rank after Rhizobacterin, while Cerialine treatment came in the third rank with concern root fresh weight at the two samples in all seasons of study. The lowest means of root fresh weight

(222.0, 267.1 and 274.4 g/plant) and (270.2, 497.7 and 500.9 g/plant) were obtained from control treatment (without biofertilization). This increase in root fresh weight by biofertilization treatments may be due to the role of biofertilization in nitrogen fixation via free living bacteria which reduce the soil pH especially in the rhizosphere which led to increase the availability of most essential macro and micro-nutrients, consequently increase growth and root weight. These findings were proportionately with those reported by Abo EL-Goud (2000) and Kandil *et al.* (2002 b).

**Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase root fresh weight from 186.1 to 263.0, 352.1 and 372.2 g/plant as well as from 275.1 to 460.9, 558.1 and 583.4 g/plant as average of three seasons at 120 and 150 days from planting, respectively. It can be noticed that increasing nitrogen levels from 60 to 80 kg N/fad caused a little increase as compared with other levels. These results were parallel with those reported by EL-Kassaby *et al.* (1999), Mahasen, Fahmi (1999) and Kandil *et al.* (2002 b).

As average of three growing seasons, increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root fresh weight from 269.7 to 316.9 g/plant as well as from 425.8 to 487.9 g/plant at 120 and 150 days from planting, respectively. Similar results were reported by Kandil *et al.* (2002 a)

Concerning the effect of nitrogen and potassium combination levels on root fresh weight g/plant, data tabulated in Table 3 show that increasing nitrogen and potassium combination levels caused a remarkable increase on root fresh weight at 120 and 150 days from planting in the three growing seasons. Application of 80 kg N + 48 kg K<sub>2</sub>O/fad produced the highest values of root fresh weight, where results were 363.0, 418.1 and 408.3 g/plant as well as 412.7, 712.5 and 703.4 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively. It can be noticeable that, application of 60 kg N + 48 kg K<sub>2</sub>O/fad came in the second rank with respect to this trait with light differences at 120 and 150 days from plating in the three seasons. Whilst, the lowest means of root fresh weight (152.4, 178.7 and 173.9 g/plant) and (199.1, 270.7 and 276.2 g/plant) were derived from application of 20 kg N + 24 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. The increment of root fresh weight gained by increasing nitrogen and potassium levels may be due to the role of nitrogen in developing root dimensions by increasing division or elongation of cells. Moreover, the role of potassium in activation of enzymes which related of accumulation of carbohydrates.

**Table 3:** Averages of root fresh and dry weight (g/plant) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days after planting during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Root fresh weight (g/plant)						Root dry weight (g/plant)						
	Seasons		2000/2001		2001/2002		2002/2003		2000/2001		2001/2002		2002/2003
Sampling times (Days After Planting)	120	150	120	150	120	150	120	150	120	150	120	150	
A: Planting dates:													
1 <sup>st</sup> September	-	-	264.8	513.8	278.5	507.8	-	-	57.35	119.73	62.31	120.84	
1 <sup>st</sup> October	276.5	314.9	368.0	566.9	370.5	572.6	59.97	80.69	81.69	126.13	77.90	131.11	
1 <sup>st</sup> November	243.2	309.6	305.2	514.5	273.4	499.4	54.04	75.74	61.97	114.41	53.92	108.52	
F. test	NS	NS	*	*	*	*	NS	NS	*	*	*	*	
LSD 5%			2.6	19.6	10.8	10.8			2.41	4.70	2.55	1.72	
B: Biofertilization treatments:													
Without	222.0	270.2	267.1	497.7	274.4	500.9	47.57	64.28	56.50	111.12	57.48	113.89	
Rhizobacterin	289.1	343.9	344.6	564.8	334.2	550.8	64.18	86.58	74.48	127.46	70.12	125.66	
Cerialine	255.4	309.7	310.0	521.6	302.8	515.9	55.41	78.27	65.45	117.36	64.02	117.83	
Rhizobacterin + Cerialine	272.6	325.3	329.1	542.9	318.3	538.7	60.85	83.71	71.58	124.41	67.21	123.25	
F. test	*	*	*	*	*	*	*	*	*	*	*	*	
LSD 5%	9.2	6.0	5.9	7.6	5.2	3.7	2.58	2.46	1.39	1.65	1.30	1.83	
C: Nitrogen and potassium combination levels:													
20 kg N + 24 kg K <sub>2</sub> O/fad	152.4	199.1	178.7	270.7	173.9	276.2	28.39	41.03	37.60	59.64	35.90	61.37	
20 kg N + 48 kg K <sub>2</sub> O/fad	179.8	232.8	220.6	332.5	210.9	339.2	37.46	51.02	48.03	75.23	44.84	79.16	
40 kg N + 24 kg K <sub>2</sub> O/fad	202.6	256.2	266.7	446.4	258.8	429.0	44.47	59.89	55.81	98.82	53.79	95.90	
40 kg N + 48 kg K <sub>2</sub> O/fad	238.7	296.5	307.7	516.0	303.2	521.4	52.68	72.02	65.95	118.01	65.12	121.67	
60 kg N + 24 kg K <sub>2</sub> O/fad	278.5	335.6	337.5	617.9	344.2	607.1	62.96	86.25	72.48	140.31	72.69	137.44	
60 kg N + 48 kg K <sub>2</sub> O/fad	351.5	399.5	403.6	697.6	397.0	690.7	79.50	103.93	89.62	164.63	86.75	164.60	
80 kg N + 24 kg K <sub>2</sub> O/fad	311.7	365.7	368.6	660.3	363.2	645.7	69.47	98.69	77.07	144.69	74.05	141.92	
80 kg N + 48 kg K <sub>2</sub> O/fad	363.0	412.7	418.1	712.5	408.3	703.4	81.10	112.87	89.47	159.39	84.51	159.18	
F. test	*	*	*	*	*	*	*	*	*	*	*	*	
LSD 5%	8.1	5.9	5.0	7.7	3.3	5.1	2.87	2.18	1.28	2.32	0.95	1.73	

### **Effect of interactions:**

The interaction between planting dates X nitrogen and potassium combination levels showed significant effect on root fresh weight at 120 and 150 days from planting (Table 4). The highest averages of this trait 368.2, 472.1 and 487.4 as well as 415.2, 764.1 and 762.1 g/plant were obtained from planting on 1<sup>st</sup> October and application of 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. Similar findings were supported by Kandil *et al.* (2002 b).

The interaction between biofertilization treatments X nitrogen and potassium combination levels was significant in the three seasons (Table 5 and 6). The highest values of root fresh weight (394.0, 458.4 and 443.0 g/plant as well as 432.0, 748.5 and 734.4 g/plant) were resulted from application of Rhizobacterin combination with 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. Meanwhile, inoculation soil by Rhizobacterin and fertilizing with 60 kg N + 48 kg K<sub>2</sub>O/fad produced the best results after aforementioned interaction at both samples in all seasons.

### **1.2- Root dry weight (g/plant):**

The effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on root dry weight (g/plant) at 120 and 150 days from planting during 2000/2001, 2001/2002 and 2002/2003 seasons are listed in Table 3.

### **Effect of planting dates:**

Planting dates exhibited significant effect on root dry weight at 120 and 150 days from planting in the second and third seasons, vice versa in the first season (Table 3). The maximum averages of root dry weight (59.97, 81.69 and 77.90 g/plant) and (80.69, 126.13 and 131.11 g/plant) were achieved when planting on 1<sup>st</sup> October at 120 and 150 days from planting in the first, second and third seasons, respectively. On the other side, the lowest ones were obtained from planting on 1<sup>st</sup> November at 120 and 150 days from planting in all growing seasons, except second season at 120 days from sowing only that produced from planting on 1<sup>st</sup> September. The increase in root dry weight caused by planting beets on the first October may be ascribed to the more favorable climatic conditions, particularly temperature, day length and light intensity with suitable growth period of plant, consequently enhance establishment and growth as well as development roots. These results stand in harmony with those obtained by Badawi (1985) and Kandil *et al.* (2002 b).

**Table 4:** Averages of root fresh weight (g/plant) at 120 and 150 days from planting as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates NK levels	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>After 120 days from planting</b>								
20 kg N + 24 kg K <sub>2</sub> O/fad	166.2	138.7	156.0	217.2	162.7	158.8	215.5	147.4
20 kg N + 48 kg K <sub>2</sub> O/fad	206.9	152.6	178.0	275.6	208.3	188.4	257.3	187.0
40 kg N + 24 kg K <sub>2</sub> O/fad	223.4	181.9	213.4	325.8	261.0	230.6	312.6	233.3
40 kg N + 48 kg K <sub>2</sub> O/fad	272.4	205.0	256.5	365.6	301.0	266.6	371.7	271.2
60 kg N + 24 kg K <sub>2</sub> O/fad	297.4	259.6	279.8	401.2	331.4	315.1	413.1	304.3
60 kg N + 48 kg K <sub>2</sub> O/fad	356.2	346.8	347.6	463.0	400.3	362.8	474.3	353.9
80 kg N + 24 kg K <sub>2</sub> O/fad	321.0	302.4	320.7	423.9	361.3	333.0	431.8	324.6
80 kg N + 48 kg K <sub>2</sub> O/fad	368.2	358.0	366.4	472.1	416.0	372.3	487.4	365.3
F. test	*		*			*		
LSD 5 %	11.4		8.6			5.8		
<b>After 150 days from planting</b>								
20 kg N + 24 kg K <sub>2</sub> O/fad	198.2	200.0	253.0	290.1	269.0	278.5	291.5	258.7
20 kg N + 48 kg K <sub>2</sub> O/fad	235.4	230.1	295.3	363.2	338.9	329.1	357.6	330.7
40 kg N + 24 kg K <sub>2</sub> O/fad	265.9	246.6	431.9	452.6	454.7	407.1	454.5	425.3
40 kg N + 48 kg K <sub>2</sub> O/fad	298.3	294.7	502.4	536.0	509.5	483.1	578.3	502.7
60 kg N + 24 kg K <sub>2</sub> O/fad	338.5	332.6	597.1	671.5	585.1	571.6	676.3	573.3
60 kg N + 48 kg K <sub>2</sub> O/fad	403.5	395.5	677.5	753.3	662.0	677.6	750.1	644.6
80 kg N + 24 kg K <sub>2</sub> O/fad	364.5	366.9	658.1	704.6	618.2	625.	710.0	602.
80 kg N + 48 kg K <sub>2</sub> O/fad	415.2	410.2	694.9	764.1	678.5	690.0	762.1	658.2
F. test	*		*			*		
LSD 5 %	8.4		13.4			8.8		

**Table 5:** Averages of root fresh weight (g/plant) at 120 days from planting as affected by the interaction between biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

<b>Biofertilization treatments</b> <i>NK levels</i>	<b>Without</b>	<b>Rhizobacterin</b>	<b>Cerialine</b>	<b>Rhizobacterin + Cerialine</b>
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	119.1	184.1	141.0	165.5
20 kg N + 48 kg K <sub>2</sub> O/fad	143.3	212.1	170.0	193.6
40 kg N + 24 kg K <sub>2</sub> O/fad	156.0	231.1	207.1	216.3
40 kg N + 48 kg K <sub>2</sub> O/fad	183.6	263.5	249.1	258.6
60 kg N + 24 kg K <sub>2</sub> O/fad	241.0	307.6	272.6	292.8
60 kg N + 48 kg K <sub>2</sub> O/fad	320.6	382.0	344.1	359.3
80 kg N + 24 kg K <sub>2</sub> O/fad	278.1	338.5	303.3	326.8
80 kg N + 48 kg K <sub>2</sub> O/fad	334.6	394.0	355.6	368.0
<b>F. test</b>	*			
<b>LSD 5 %</b>	15.9			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	152.2	199.2	174.2	189.1
20 kg N + 48 kg K <sub>2</sub> O/fad	184.2	244.6	217.4	236.3
40 kg N + 24 kg K <sub>2</sub> O/fad	224.7	292.0	270.1	280.1
40 kg N + 48 kg K <sub>2</sub> O/fad	261.8	333.6	305.5	330.0
60 kg N + 24 kg K <sub>2</sub> O/fad	271.0	378.5	336.3	364.1
60 kg N + 48 kg K <sub>2</sub> O/fad	353.6	443.4	402.2	415.2
80 kg N + 24 kg K <sub>2</sub> O/fad	321.0	407.0	359.8	386.7
80 kg N + 48 kg K <sub>2</sub> O/fad	368.1	458.4	414.6	431.5
<b>F. test</b>	*			
<b>LSD 5 %</b>	10.0			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	154.2	195.6	168.3	177.5
20 kg N + 48 kg K <sub>2</sub> O/fad	193.6	224.0	210.8	215.2
40 kg N + 24 kg K <sub>2</sub> O/fad	231.7	277.2	264.6	261.6
40 kg N + 48 kg K <sub>2</sub> O/fad	257.2	326.1	304.1	325.4
60 kg N + 24 kg K <sub>2</sub> O/fad	305.1	375.3	333.1	363.3
60 kg N + 48 kg K <sub>2</sub> O/fad	359.4	432.4	389.5	406.6
80 kg N + 24 kg K <sub>2</sub> O/fad	324.1	400.0	352.1	376.5
80 kg N + 48 kg K <sub>2</sub> O/fad	369.8	443.0	400.2	420.3
<b>F. test</b>	*			
<b>LSD 5 %</b>	6.7			

**Table 6:** Averages of root fresh weight (g/plant) at 150 days from planting as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	166.5	231.6	190.0	208.5
20 kg N + 48 kg K <sub>2</sub> O/fad	179.3	281.0	218.6	252.1
40 kg N + 24 kg K <sub>2</sub> O/fad	192.0	309.3	256.1	267.6
40 kg N + 48 kg K <sub>2</sub> O/fad	230.5	333.0	298.8	323.8
60 kg N + 24 kg K <sub>2</sub> O/fad	295.8	355.0	341.0	350.5
60 kg N + 48 kg K <sub>2</sub> O/fad	377.3	421.1	393.1	406.5
80 kg N + 24 kg K <sub>2</sub> O/fad	328.6	388.3	372.6	373.1
80 kg N + 48 kg K <sub>2</sub> O/fad	391.6	432.0	407.3	420.0
F. test	*			
LSD 5 %	11.9			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	246.2	294.4	267.4	274.8
20 kg N + 48 kg K <sub>2</sub> O/fad	308.7	347.3	343.1	339.7
40 kg N + 24 kg K <sub>2</sub> O/fad	418.2	477.4	421.2	468.8
40 kg N + 48 kg K <sub>2</sub> O/fad	493.4	556.5	489.5	524.4
60 kg N + 24 kg K <sub>2</sub> O/fad	573.5	659.2	610.4	628.5
60 kg N + 48 kg K <sub>2</sub> O/fad	648.0	733.5	693.6	715.3
80 kg N + 24 kg K <sub>2</sub> O/fad	623.8	701.4	649.2	666.8
80 kg N + 48 kg K <sub>2</sub> O/fad	669.8	748.5	707.2	724.5
F. test	*			
LSD 5 %	15.5			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	252.2	298.3	269.3	285.2
20 kg N + 48 kg K <sub>2</sub> O/fad	314.7	361.6	331.0	349.3
40 kg N + 24 kg K <sub>2</sub> O/fad	400.8	449.6	420.8	444.6
40 kg N + 48 kg K <sub>2</sub> O/fad	502.0	530.8	507.2	545.5
60 kg N + 24 kg K <sub>2</sub> O/fad	587.1	636.5	593.7	611.0
60 kg N + 48 kg K <sub>2</sub> O/fad	659.1	722.5	677.7	703.6
80 kg N + 24 kg K <sub>2</sub> O/fad	618.4	672.6	636.5	655.1
80 kg N + 48 kg K <sub>2</sub> O/fad	672.8	734.4	690.7	715.7
F. test	*			
LSD 5 %	10.1			

### **Effect of biofertilization treatments:**

Regarding the effect of biofertilization treatments on root dry weight, it was significant at the two samples in the three seasons of study (Table 3). Root dry weight was markedly increased and achieved maximum values in treatment of inoculation soil with Rhizobacterin as compared with other biofertilization treatments. The corresponding values in order to previous treatment were 64.18, 74.48 and 70.12 g/plant as well as 86.58, 127.46 and 125.66 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively. The arrangement of biofertilization treatments after Rhizobacterin treatment was Rhizobacterin + Syrialin, Cerialine then control treatment with respect their desirable effect on this trait at both samples during the three seasons. The increase in root dry weight as a result of biofertilization treatments may be has the same reason for increasing root fresh weight, which mentioned before. These results are extremely similar to those suggested by Mrkovack *et al.* (1997), Mezei *et al.* (1998), Abo EL-Goud (2000) and Kandil *et al.* (2002 b).

### **Effect of nitrogen and potassium combination levels:**

Root dry weight tended to increase due to increasing nitrogen fertilizer levels from 20 to 40, 60 and 80, which values were 38.71, 56.32, 77.33 and 79.30 g/plant as well as 61.22, 94.41, 132.92 and 136.12 g/plant as average of three seasons at 120 and 150 days from planting, respectively. These results are in line with recorded by EL-Kassaby *et al.* (1999), Mahasen, Fahmi (1999), EL-Zayat (2000) and Kandil *et al.* (2002 b).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root dry weight from 57.14 to 68.80 g/plant and from 97.21 to 115.14 g/plant at 120 and 150 days from planting as average of the three seasons. EL-Zayat (2000) confirmed this conclusion.

With reference to the effect of nitrogen and potassium combination levels on root dry weight, results listed in Table 3 reveal that there was a significant effect at 120 and 150 days from planting in the three seasons of study. Raising nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad caused significant increase in root dry weight at both samples in all seasons. The highest values of root dry weight (81.10 and 112.87 g/plant) were recorded due to application of 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first season, respectively. While, in second and third seasons the highest once (89.62 and 86.75 g/plant as well as 164.63 and 164.60 g/plant) were produced from application of 60 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting, respectively. On opposition to, the lowest ones (28.39, 37.60 and 35.90 g/plant) and (41.03, 59.64 and 61.37 g/plant) were proceeded from fertilizing with 20 kg N + 24 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. This increase in root dry weight by increasing nitrogen and potassium combination

levels might have been resulted from increasing photosynthetic area per plant, which led to more photosynthates production and therefore increasing dry matter accumulation.

### **1.3- Foliage fresh weight (g/plant):**

Averages of foliage fresh weight (g/plant) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days from planting during 2000/2001, 2001/2002 and 2002/2003 seasons are registered in Table 7.

#### **Effect of planting dates:**

Data recorded in Table 7, clear that foliage fresh weight was significantly affected by planting dates at 120 and 150 days from planting in the three growing seasons, except at 120 days from planting in the second season only. The greatest values of foliage fresh weight (657.8, 411.6 and 441.6 g/plant) and (699.2, 518.3 and 554.1 g/plant) were derived from planting beets on 1<sup>st</sup> October at 120 and 150 days from planting in the first, second and third seasons, respectively. In contrast with, the lowest ones (484.9, 393.6 and 371.9 g/plant) and (572.4, 490.7 and 466.9 g/plant) were gained from cultivation beet plants on 1<sup>st</sup> November at 120 and 150 days from planting in the first, second and third seasons, respectively, with the exclusion of the second season at 120 and 150 days from sowing which resulted from planting on 1<sup>st</sup> September. This increase in foliage fresh weight when planting on 1<sup>st</sup> October may be originated from more suitable weather conditions during this period, which led to encouragement germination, establishment and vegetative growth of sugar beet. These findings are in good agreement with those confirmed by Badawi (1985), Badawi *et al.* (1995) and Kandil *et al.* (2002 b).

#### **Effect of biofertilization treatments:**

As shown in Table 7, foliage fresh weight exposed significant differences among biofertilization treatments at 120 and 150 days from sowing in the three seasons. Treated soil with Rhizobacterin fertilizer caused significant increase in foliage fresh weight over other biofertilization treatments and gave the highest values, which results were 660.0, 437.4 and 427.4 as well as 722.5, 545.1 and 539.3 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively. The lowest values in this terms (471.1, 357.0 and 358.9 g/plant) and (524.5, 452.4 and 447.8 g/plant) were achieved when left soil without biofertilization (chick treatment) at 120 and 150 days from planting in the first, second and third seasons, respectively. This increase in foliage fresh weight by biofertilization treatments may be attributed to its effect upon nitrogen fixation, enhancing nutrient uptake and excretion some growth substances such as IAA and GA<sub>3</sub> which improve growth and leaf canopy of sugar beet. Similar results were also corresponding by Abo EL-Goud (2000) and Kandil *et al.* (2002 b).

**Table 7:** Averages of foliage fresh and dry weight (g/plant) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days after planting during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Foliage fresh weight (g/plant)						Foliage dry weight (g/plant)					
	2000/2001		2001/2002		2002/2003		2000/2001		2001/2002		2002/2003	
Seasons	120	150	120	150	120	150	120	150	120	150	120	150
Sampling times (Days After Planting)	120	150	120	150	120	150	120	150	120	150	120	150
A: Planting dates:												
1 <sup>st</sup> September	-	-	393.6	490.7	373.4	485.0	-	-	39.13	55.94	37.23	52.69
1 <sup>st</sup> October	657.8	699.2	411.6	518.3	441.6	554.1	58.82	84.36	42.99	53.40	43.69	59.92
1 <sup>st</sup> November	484.9	572.4	395.2	504.6	371.9	466.9	47.65	68.78	38.34	56.09	35.63	50.32
F. test	*	*	NS	*	*	*	*	*	*	*	*	*
LSD 5%			-	14.1	34.3	27.2			0.41	1.76	3.18	2.51
B: Biofertilization treatments:												
Without	471.1	524.5	357.0	452.4	358.9	447.8	44.73	61.20	35.03	48.76	34.85	47.82
Rhizobacterin	660.0	722.5	437.4	545.1	427.4	539.3	61.25	88.82	44.53	59.96	42.28	58.85
Cerialine	548.5	630.8	390.3	496.2	387.4	498.6	51.48	75.89	39.28	54.23	38.02	53.51
Rhizobacterin + Cerialine	605.8	665.4	415.9	524.4	408.9	522.4	55.49	80.36	41.78	57.64	40.26	57.06
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD 5%	38.3	35.8	8.9	10.1	6.0	6.9	3.69	3.35	1.33	0.91	0.69	1.00
C: Nitrogen and potassium combination levels:												
20 kg N + 24 kg K <sub>2</sub> O/fad	352.7	394.2	228.0	294.3	221.5	299.4	29.16	40.65	22.52	31.24	21.36	31.74
20 kg N + 48 kg K <sub>2</sub> O/fad	401.0	448.6	291.6	372.6	291.5	363.4	34.94	48.35	29.91	40.96	29.11	39.79
40 kg N + 24 kg K <sub>2</sub> O/fad	480.6	536.7	350.7	444.4	349.4	440.3	42.97	60.29	34.65	48.20	33.88	47.24
40 kg N + 48 kg K <sub>2</sub> O/fad	552.4	602.3	403.4	509.6	399.5	501.9	50.59	70.82	41.54	56.88	40.03	55.33
60 kg N + 24 kg K <sub>2</sub> O/fad	631.3	703.7	445.3	561.9	435.7	561.4	58.32	83.80	44.61	61.95	42.55	60.39
60 kg N + 48 kg K <sub>2</sub> O/fad	732.1	817.1	501.7	623.8	498.4	624.8	68.82	100.70	52.31	70.28	50.69	69.67
80 kg N + 24 kg K <sub>2</sub> O/fad	676.2	753.8	463.7	591.7	457.9	585.9	65.65	97.56	44.46	62.50	43.47	61.78
80 kg N + 48 kg K <sub>2</sub> O/fad	744.6	830.1	516.6	638.0	510.8	639.0	75.44	110.37	51.23	69.17	49.72	68.55
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD 5%	16.9	16.7	6.3	6.7	5.6	4.9	2.70	2.60	0.87	1.03	0.66	0.72

### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase foliage fresh weight from 297.7 to 422.7, 540.8 and 561.6 g/plant as well as from 362.1 to 505.9, 648.8 and 673.6 g/plant at 120 and 150 days from planting as average over seasons, respectively. This tendency was recorded by EL-Kassaby *et al.* (1999), Mahasen, Fahmi (1999) and Kandil *et al.* (2000 b).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase this trait from 424.4 to 487.0 g/plant and from 514.0 to 580.9 g/plant at 120 and 150 days from planting as average during the three seasons. These results were in agreement with those reported by Kandil *et al.* (2000 a).

With connection the effect of nitrogen and potassium combination levels on foliage fresh weight, it was apparent that adding nitrogen and potassium fertilizers markedly increased foliage fresh weight at 120 and 150 days after sowing in the three seasons as shown in Table 7. Application of 80 kg N + 48 kg K<sub>2</sub>O/fad recorded maximum foliage fresh weight, where its increased this character by 111.11, 126.57 and 130.60 % as well as 110.57, 116.78 and 113.42 % over application of 20 kg N + 24 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. It was followed by application of 60 kg N + 48 kg K<sub>2</sub>O/fad at the very least differences in foliage fresh weight at both samples in all growing seasons. Such increase in foliage fresh weight may be due to the role of nitrogen and potassium in leaf initiation, increment chlorophyll concentration in leaves and photosynthesis process, which led to improve growth and leaf canopy.

### **Effect of interactions:**

In the three growing seasons, the interaction between planting dates X nitrogen and potassium combination levels showed significant effect on foliage fresh weight at 120 and 150 days from planting (Table 8). The highest averages of this trait (860.8, 520.6 and 568.6 g/plant as well as 900.8, 654.6 and 695.1 g/plant) were obtained when planting on 1<sup>st</sup> October and application of 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. Similar conclusion supported by Kandil *et al.* (2002 b).

The interaction between biofertilization treatment X nitrogen and potassium combination levels was significant in the three seasons of study (Table 9 and 10). The highest values of foliage fresh weight (848.3, 557.4 and 556.0 g/plant and 926.8, 691.0 and 686.4 g/plant) were resulted from application of Rhizobacterin accompanied with 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. Meanwhile, inoculation soil by Rhizobacterin and fertilizing with 60 kg N + 48 kg K<sub>2</sub>O/fad produced the best results after formerly treatment in all seasons.

**Table 8:** Averages of foliage fresh weight (g/plant) at 120 and 150 days from planting as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates NK levels	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>After 120 days from planting</b>								
20 kg N + 24 kg K <sub>2</sub> O/fad	395.4	310.0	224.7	232.0	227.2	203.1	261.3	200.0
20 kg N + 48 kg K <sub>2</sub> O/fad	458.7	343.3	277.5	313.1	284.3	271.2	318.6	284.9
40 kg N + 24 kg K <sub>2</sub> O/fad	556.6	404.5	334.9	368.5	348.9	327.5	388.8	332.1
40 kg N + 48 kg K <sub>2</sub> O/fad	635.9	469.0	391.7	415.4	403.2	382.1	445.6	370.8
60 kg N + 24 kg K <sub>2</sub> O/fad	733.9	528.7	442.0	459.2	434.8	404.9	484.9	418.0
60 kg N + 48 kg K <sub>2</sub> O/fad	846.5	617.7	499.4	509.3	496.4	477.5	555.6	462.4
80 kg N + 24 kg K <sub>2</sub> O/fad	774.5	578.0	460.2	474.7	456.1	431.9	509.7	432.0
80 kg N + 48 kg K <sub>2</sub> O/fad	860.8	628.3	518.0	520.6	511.1	489.1	568.6	474.8
F. test	*		*			*		
LSD 5 %	23.9		10.9			9.7		
<b>After 150 days from planting</b>								
20 kg N + 24 kg K <sub>2</sub> O/fad	431.6	356.9	296.8	293.0	293.0	287.0	334.1	277.0
20 kg N + 48 kg K <sub>2</sub> O/fad	497.6	399.5	350.5	388.4	378.8	344.0	419.5	326.6
40 kg N + 24 kg K <sub>2</sub> O/fad	603.5	469.9	439.0	455.7	438.3	422.0	493.6	405.2
40 kg N + 48 kg K <sub>2</sub> O/fad	660.0	544.6	488.4	536.7	503.9	491.5	544.5	469.5
60 kg N + 24 kg K <sub>2</sub> O/fad	782.3	625.0	546.1	575.1	564.6	544.0	617.5	522.7
60 kg N + 48 kg K <sub>2</sub> O/fad	886.8	747.4	600.1	643.4	627.9	605.3	684.2	585.0
80 kg N + 24 kg K <sub>2</sub> O/fad	830.6	677.0	586.6	599.5	589.0	564.7	644.0	549.1
80 kg N + 48 kg K <sub>2</sub> O/fad	900.8	759.3	618.2	654.6	641.2	622.0	695.1	600.0
F. test	*		*			*		
LSD 5 %	23.7		11.6			8.6		

**Table 9:** Averages of foliage fresh weight (g/plant) at 120 days from planting as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments <i>NK levels</i>	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	286.6	418.3	328.3	377.5
20 kg N + 48 kg K <sub>2</sub> O/fad	340.0	452.5	375.0	436.6
40 kg N + 24 kg K <sub>2</sub> O/fad	413.3	559.1	434.1	515.8
40 kg N + 48 kg K <sub>2</sub> O/fad	452.6	654.6	511.6	590.8
60 kg N + 24 kg K <sub>2</sub> O/fad	518.6	730.0	610.8	665.8
60 kg N + 48 kg K <sub>2</sub> O/fad	599.3	837.6	724.1	767.3
80 kg N + 24 kg K <sub>2</sub> O/fad	550.0	779.6	664.0	711.3
80 kg N + 48 kg K <sub>2</sub> O/fad	608.3	848.3	740.0	781.6
F. test	*			
LSD 5 %	33.9			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	192.5	257.6	221.0	240.7
20 kg N + 48 kg K <sub>2</sub> O/fad	252.6	322.5	286.5	305.0
40 kg N + 24 kg K <sub>2</sub> O/fad	312.0	385.4	346.3	359.3
40 kg N + 48 kg K <sub>2</sub> O/fad	360.4	438.8	390.5	424.0
60 kg N + 24 kg K <sub>2</sub> O/fad	396.6	484.6	435.4	464.7
60 kg N + 48 kg K <sub>2</sub> O/fad	454.4	550.4	487.0	515.0
80 kg N + 24 kg K <sub>2</sub> O/fad	419.7	502.5	449.8	482.6
80 kg N + 48 kg K <sub>2</sub> O/fad	467.5	557.4	505.8	535.6
F. test	*			
LSD 5 %	12.6			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	200.7	242.4	213.1	229.6
20 kg N + 48 kg K <sub>2</sub> O/fad	269.8	305.7	287.3	303.3
40 kg N + 24 kg K <sub>2</sub> O/fad	321.1	372.7	345.0	359.0
40 kg N + 48 kg K <sub>2</sub> O/fad	361.7	419.0	395.2	422.2
60 kg N + 24 kg K <sub>2</sub> O/fad	389.6	475.2	431.0	448.0
60 kg N + 48 kg K <sub>2</sub> O/fad	449.4	544.2	485.2	515.0
80 kg N + 24 kg K <sub>2</sub> O/fad	416.1	504.0	444.6	466.8
80 kg N + 48 kg K <sub>2</sub> O/fad	462.6	556.0	497.6	527.2
F. test	*			
LSD 5 %	11.2			

**Table 10:** Averages of foliage fresh weight (g/plant) at 150 days from planting as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments <i>NK levels</i>	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	335.3	457.6	368.6	415.5
20 kg N + 48 kg K <sub>2</sub> O/fad	392.6	505.5	427.8	468.3
40 kg N + 24 kg K <sub>2</sub> O/fad	467.1	625.1	501.8	552.6
40 kg N + 48 kg K <sub>2</sub> O/fad	497.6	685.8	578.8	647.1
60 kg N + 24 kg K <sub>2</sub> O/fad	563.8	812.0	717.8	721.1
60 kg N + 48 kg K <sub>2</sub> O/fad	667.1	908.8	836.6	855.8
80 kg N + 24 kg K <sub>2</sub> O/fad	597.0	858.1	769.6	790.5
80 kg N + 48 kg K <sub>2</sub> O/fad	675.8	926.8	845.5	872.1
F. test	*			
LSD 5 %	33.5			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	272.4	316.5	285.7	302.5
20 kg N + 48 kg K <sub>2</sub> O/fad	338.0	423.0	344.1	385.3
40 kg N + 24 kg K <sub>2</sub> O/fad	395.4	472.1	442.7	467.2
40 kg N + 48 kg K <sub>2</sub> O/fad	461.5	541.4	501.5	534.2
60 kg N + 24 kg K <sub>2</sub> O/fad	500.4	600.1	561.5	585.7
60 kg N + 48 kg K <sub>2</sub> O/fad	556.5	680.0	612.6	646.1
80 kg N + 24 kg K <sub>2</sub> O/fad	525.3	637.2	590.0	614.4
80 kg N + 48 kg K <sub>2</sub> O/fad	570.0	691.0	631.5	659.6
F. test	*			
LSD 5 %	13.1			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	266.0	324.3	297.1	310.2
20 kg N + 48 kg K <sub>2</sub> O/fad	332.3	390.6	359.2	371.4
40 kg N + 24 kg K <sub>2</sub> O/fad	384.3	471.6	448.1	457.1
40 kg N + 48 kg K <sub>2</sub> O/fad	432.6	537.7	506.5	530.6
60 kg N + 24 kg K <sub>2</sub> O/fad	501.2	605.6	550.2	588.5
60 kg N + 48 kg K <sub>2</sub> O/fad	563.5	670.0	619.7	646.1
80 kg N + 24 kg K <sub>2</sub> O/fad	525.4	628.0	575.8	614.5
80 kg N + 48 kg K <sub>2</sub> O/fad	576.8	686.4	632.3	660.0
F. test	*			
LSD 5 %	9.9			

#### **1.4- Foliage dry weight (g/plant):**

Means of foliage dry weight (g/plant) in response to planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days from planting in the three growing seasons are presented in Table 7.

##### **Effect of planting dates:**

Planting dates had a significant effect on foliage dry weight at 120 and 150 days from planting in all growing seasons (Table 7). The highest values of this character (58.82, 42.99 and 43.69 g/plant) and (84.36, 56.09 and 59.92 g/plant) were resulted from planting beets on 1<sup>st</sup> October at 120 and 150 days from planting in the first, second and third seasons, respectively, with exception in the second season at 150 days from sowing which resulted from planting on 1<sup>st</sup> November. In spite of, planting on 1<sup>st</sup> November associated with the lowest values of foliage dry weight (47.65, 38.34 and 35.63 g/plant) and (68.78, 53.40 and 50.32 g/plant) at 120 and 150 days from planting in the first, second and third seasons, respectively, excluding in the second season at 150 days after planting. The stimulatory effect on foliage dry weight observed in this trait due to planting dates may be attributed to the suitable weather condition during vegetative growth, which contributed to good foliage growth and formation ample canopy able to make best photosynthesis, hence increase dry matter accumulation. Many investigation *i.e.* Badawi (1985) and Kandil *et al.* (2002 b) stated similar observations.

##### **Effect of biofertilization treatments:**

Foliage dry weight was significantly affected by biofertilization treatments at 120 and 150 days from sowing in the three seasons (Table 7). Inoculation soil after seedlings by Rhizobacterin was accompanied with maximum average means of foliage dry weight. The corresponding values with related to antecedent treatment were 61.25, 44.53 and 42.28 g/plant as well as 88.82, 59.96 and 58.85 g/plant at 120 and 150 days from planting in the first, second and third seasons, respectively. Noteworthy, application of Rhizobacterin + Cerialine treatment came in the second rank after Rhizobacterin treatment with light differences. The lowest values of this trait (44.73, 35.03 and 34.85 g/plant) and (61.20, 48.76 and 47.82 g/plant) were recorded for the control treatment (without biofertilization) at 120 and 150 days from planting in the first, second and third seasons, respectively. This increase in foliage dry weight in this case may be due to same reason for increasing root and foliage fresh weight as formerly mentioned. These results are sustainable with the previously obtained by Mrkovack *et al.* (1997), Mezei *et al.* (1998), Abo EL-Goud (2000) and Kandil *et al.* (2002 b).

##### **Effect of nitrogen and potassium combination levels:**

From data shown in Table 7, increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase foliage dry weight, where its values were 27.81, 40.62, 52.95 and 55.01

g/plant as well as 38.84, 56.62, 74.53 and 78.33 g/plant as average in the three growing seasons at 120 and 150 days from planting, respectively. Increasing nitrogen levels from 60 to 80 kg N/fad caused light increase as compared with other increases in nitrogen levels. EL-Kassaby *et al.* (1999), Mahasen, Fahmi (1999), EL-Zayat (2000) and Kandil *et al.* (2000 b) supported these results.

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase foliage dry weight from 40.32 to 47.95 g/plant and from 57.82 to 66.74 g/plant at 120 and 150 days from planting as average over seasons, respectively. EL-Zayat (2000) supported this trend.

Nitrogen and potassium combination levels significantly affected foliage dry weight at 120 and 150 days after sowing in the three seasons of study (Table 7). Maximum means of this character (75.44 and 110.37 g/plant) obtained from application of 80 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first season, respectively. Whilst, in the second and third seasons the highest values (52.31 and 50.69 g/plant and 70.28 and 69.67) associated with application of 60 kg N + 48 kg K<sub>2</sub>O/fad at 120 and 150 days after sowing, respectively. At all samples in all growing seasons, the differences between application of 60 kg N + 48 kg K<sub>2</sub>O/fad or 80 kg N + 48 kg K<sub>2</sub>O/fad were negligible as compared other differences among applications. The lowest values in this term (29.16, 22.52 and 21.36 g/plant) and (40.65, 31.24 and 31.74 g/plant) were produced from application of 20 kg N + 24 kg K<sub>2</sub>O/fad at 120 and 150 days from planting in the first, second and third seasons, respectively. The increase in foliage dry weight with the increase in nitrogen and potassium combination levels may be attributed to the role of it in stimulatory foliage growth, increase in chlorophyll content and causing canopy regeneration to continue late into the season and directs photosynthates into top production rather than root storage.

### **1.5- Leaf area index (LAI):**

Means of leaf area index (LAI) in response to planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days from planting during 2000/2001, 2001/2002 and 2002/2003 seasons are marked down in Table 11.

#### **Effect of planting dates:**

The effect of planting dates on LAI was significant at 150 days from planting in the first season and also at 120 and 150 days from planting in the third season only (Table 11). As seen from obtained results, planting beets on 1<sup>st</sup> October achieved maximum increase in LAI (3.64, 2.25 and 2.17) and (5.23, 2.86 and 2.91) at 120 and 150 days from planting in the first, second and third seasons, respectively, excepting in the second season at 150 days after sowing that resulted from planting on 1<sup>st</sup> September. On contrary of that, the lowest means of LAI (3.42, 2.15 and 1.83) and (4.58, 2.77 and 2.31) were produced due to planting beets on 1<sup>st</sup> November at 120 and 150 days from planting in the first, second and third seasons, respectively. The increase in LAI due to planting during 1<sup>st</sup> October might be ascribed to more suitable weather condition *i.e.* temperature,

day length, and light intensity which allow to better establishment and vegetative growth, hence formation good canopy capable to increase photosynthesis process. These findings are coincidence with those of Badawi *et al.* (1995), Ghonema (1998) and Kandil *et al.* (2002 b).

#### **Effect of biofertilization treatments:**

Regarding the effect of biofertilization treatments on LAI, it was significant at 120 and 150 days from sowing in the three seasons of study (Table 11). It is quite clear that Rhizobacterin treatment induced the greatest means of LAI. The corresponding values of aforementioned treatment were 3.96, 2.47 and 2.13 as well as 5.61, 3.00 and 2.74 at 120 and 150 days from planting in the first, second and third seasons, respectively. It was followed by inoculation soil with Rhizobacterin + Cerialine treatment (with minimum differences between them), Cerialine treatment. At last, control treatment (without biofertilization) gave minimum values of LAI at two samples over all growing seasons. The increase in LAI as a result of biofertilization treatments may be referred to their effect on nitrogen fixation and the uptake of nutrients, hence increased sugar beet growth and development. These findings are in fully accordance with results of Sultan *et al.* (1999), Abo EL-Goud (2000) and Kandil *et al.* (2000 b).

#### **Effect of nitrogen and potassium combination levels:**

Regarding the effect of nitrogen fertilizer levels only, increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase LAI from 1.76 to 2.42, 3.01 and 3.08 as well as from 2.32 to 3.18, 4.02 and 4.25 as average over three seasons at 120 and 150 days from sowing, respectively. This trend is in good compatible with those stated by EL-Kassaby *et al.* (1999), Mahasen, Fahmi (1999), EL-Zayat (2000) and Kandil *et al.* (2000 b).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase LAI from 2.43 to 2.70 and from 3.20 to 3.60 at 120 and 150 days from planting as average in the three seasons. EL-Zayat (2000), EL-Harriri and Mirvat, Gobarh (2001) and Kandil *et al.* (2000 a) confirmed this tendency.

With referred to the effect of nitrogen and potassium combination levels on LAI, it was significant at two samples in all seasons of this work (Table 11). It can be consider that the highest values of LAI (4.37 and 6.25) were recorded when application of 60 kg N + 48 kg K<sub>2</sub>O/fad in the first season at 120 and 150 days from planting, respectively. In the second and third seasons, the highest LAI values (2.70 and 2.59 as well as 3.60 and 3.42) were resulted from application of 80 kg N + 48 kg K<sub>2</sub>O /fad at 120 and 150 days from planting, respectively. It was worthy to mentioned that the differences between applying of 60 kg N + 48 kg K<sub>2</sub>O/fad or 80 kg N + 48 kg K<sub>2</sub>O/fad were lesser than others among nitrogen and potassium applications at both samples in all seasons of this research. Such increase in this trait may be returned to the role of nitrogen and potassium in increasing number of leaves and blade width per plant. In other words nitrogen and

**Table 11:** Averages of leaf area index (LAI) and crop growth rate (CGR) in g/day as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at 120 and 150 days after planting during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	LAI						CGR (g/day)		
	2000/2001		2001/2002		2002/2003		2000/2001	2001/2002	2002/2003
Seasons	120	150	120	150	120	150			
Sampling times (Days After Planting)	120	150	120	150	120	150	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>									
1 <sup>st</sup> September	-	-	2.19	2.86	1.92	2.56	-	1.61	2.46
1 <sup>st</sup> October	3.64	5.23	2.25	2.85	2.17	2.91	1.37	1.35	2.33
1 <sup>st</sup> November	3.42	4.58	2.15	2.77	1.83	2.31	1.59	1.34	2.31
F. test	NS	*	NS	NS	*	*	*	*	NS
LSD 5%			-	-	0.18	0.12		0.26	-
<b>B: Biofertilization treatments:</b>									
Without	3.05	3.98	1.96	2.57	1.82	2.32	1.10	1.23	2.34
Rhizobacterin	3.96	5.61	2.47	3.00	2.13	2.74	1.66	1.51	2.40
Cerialine	3.37	4.98	2.13	2.85	1.92	2.60	1.57	1.54	2.31
Rhizobacterin + Cerialine	3.72	5.04	2.23	2.89	2.03	2.71	1.59	1.52	2.42
F. test	*	*	*	*	*	*	*	NS	NS
LSD 5%	0.18	0.29	0.08	0.10	0.04	0.05	0.17	-	-
<b>C: Nitrogen and potassium combination levels:</b>									
20 kg N + 24 kg K <sub>2</sub> O/fad	2.38	3.21	1.33	1.72	1.12	1.55	0.80	0.21	1.19
20 kg N + 48 kg K <sub>2</sub> O/fad	2.68	3.57	1.59	2.04	1.45	1.84	0.89	0.45	1.55
40 kg N + 24 kg K <sub>2</sub> O/fad	3.14	4.11	1.98	2.60	1.74	2.27	1.09	1.21	1.84
40 kg N + 48 kg K <sub>2</sub> O/fad	3.49	4.78	2.18	2.78	1.97	2.51	1.31	1.57	2.39
60 kg N + 24 kg K <sub>2</sub> O/fad	3.86	5.53	2.54	3.21	2.16	2.88	1.62	1.95	2.75
60 kg N + 48 kg K <sub>2</sub> O/fad	4.37	6.25	2.69	3.17	2.43	3.10	1.87	2.16	3.22
80 kg N + 24 kg K <sub>2</sub> O/fad	4.01	5.64	2.56	3.50	2.34	3.19	2.03	1.89	2.87
80 kg N + 48 kg K <sub>2</sub> O/fad	4.29	6.12	2.70	3.60	2.59	3.42	2.22	2.00	3.11
F. test	*	*	*	*	*	*	*	*	*
LSD 5%	0.17	0.27	0.10	0.12	0.04	0.05	0.15	0.12	0.09

potassium fertilizers certainly stimulating growth and increasing leaf area per plant. The aforementioned results generally are in good agreement with those stated by Sarhan (1998) and EL-Harriri and Mirvat, Gobarh (2001).

#### **Effect of interactions:**

In the first and third seasons only, the interaction between planting dates X nitrogen and potassium combination levels showed significant effect on LAI at both samples (Table 12). The highest averages of LAI (4.46 and 2.91 as well as 6.56 and 3.90 in the first and third seasons at 120 and 150 days from planting, respectively) were obtained when planting on 1<sup>st</sup> October and application of 60 kg N + 48 kg K<sub>2</sub>O/fad in the first season or application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the third season. Similar results supported by Kandil *et al.* (2002 b).

The interaction between biofertilization X nitrogen and potassium combination levels was significant in the first and third seasons (Table 13 and 14). The highest values of LAI (5.04 and 2.87 as well as 7.12 and 3.65) were produced from application of Rhizobacterin + 60 kg N + 48 kg K<sub>2</sub>O/fad in the first season at 120 and 150 days from sowing or application 80 kg N + 48 kg K<sub>2</sub>O/fad in third season at 120 and 150 days after planting, respectively.

#### **1.6- Crop growth rate (CGR) in g/day:**

Means of crop growth rate (CGR) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels at the period of 120 to 150 days from planting during the three growing seasons are showed in Table 11.

#### **Effect of planting dates:**

Crop growth rate (CGR) was significantly affected by planting dates in the first and second seasons only (Table 11). Planting beets on 1<sup>st</sup> September resulted in the highest means of CGR (1.61 and 2.46 g/day) in the second and third seasons, respectively, while in the first season it was (1.59 g/day) resulted from planting on 1<sup>st</sup> November. It must be noticed that the differences between planting of 1<sup>st</sup> October or 1<sup>st</sup> November did not reached the level of significance in the three seasons . Similar results were illustrated by Kandil *et al.* (2002 b).

#### **Effect of biofertilization treatments:**

Data in Table 11 excreted that biofertilization treatments had a significant effect on crop growth rate (CGR) in the first season only, conversely in the second and third seasons. As seems to appear from data in Table 11, there were not indubitable trend with respect to response of CGR to biofertilization treatments, considering the maximum values (1.66, 1.54 and 2.42 g/day) were obtained from Rhizobacterin treatment in the first season, but from Cerialine treatment in the second season and from Rhizobacterin + Cerialine treatment in the third season, respectively. Generally, biofertilization treatments exhibited slight improvement in CGR in all planting dates in the three seasons over than control treatment. This effect of biofertilization treatment on enhancing

**Table 12:** Averages of leaf area index (LAI) at 120 and 150 days from planting as affected by planting dates and nitrogen & potassium fertilizer levels in the first and third seasons.

Seasons	2000/2001		2002/2003		
Planting dates	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
NK levels					
<b>After 120 days from planting</b>					
20 kg N + 24 kg K <sub>2</sub> O/fad	2.40	2.36	1.04	1.25	1.06
20 kg N + 48 kg K <sub>2</sub> O/fad	2.80	2.56	1.38	1.50	1.48
40 kg N + 24 kg K <sub>2</sub> O/fad	3.38	2.91	1.67	1.88	1.67
40 kg N + 48 kg K <sub>2</sub> O/fad	3.65	3.34	1.94	2.16	1.80
60 kg N + 24 kg K <sub>2</sub> O/fad	4.11	3.61	2.06	2.38	2.03
60 kg N + 48 kg K <sub>2</sub> O/fad	4.46	4.28	2.44	2.68	2.18
80 kg N + 24 kg K <sub>2</sub> O/fad	4.03	3.99	2.30	2.61	2.13
80 kg N + 48 kg K <sub>2</sub> O/fad	4.28	4.30	2.56	2.91	2.31
F. test	*		*		
LSD 5 %	0.25		0.08		
<b>After 150 days from planting</b>					
20 kg N + 24 kg K <sub>2</sub> O/fad	3.34	3.08	1.51	1.71	1.42
20 kg N + 48 kg K <sub>2</sub> O/fad	3.90	3.24	1.73	2.14	1.65
40 kg N + 24 kg K <sub>2</sub> O/fad	4.57	3.65	2.30	2.52	2.00
40 kg N + 48 kg K <sub>2</sub> O/fad	5.30	4.27	2.50	2.78	2.25
60 kg N + 24 kg K <sub>2</sub> O/fad	6.14	4.92	2.97	3.14	2.52
60 kg N + 48 kg K <sub>2</sub> O/fad	6.56	5.93	3.08	3.49	2.74
80 kg N + 24 kg K <sub>2</sub> O/fad	5.83	5.45	3.09	3.60	2.87
80 kg N + 48 kg K <sub>2</sub> O/fad	6.19	6.06	3.30	3.90	3.06
F. test	*		*		
LSD 5 %	0.39		0.08		

**Table 13:** Averages of leaf area index (LAI) at 120 days from planting as affected by biofertilization treatments and nitrogen & potassium fertilizer levels in the first and third seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	2.15	2.60	2.20	2.56
20 kg N + 48 kg K <sub>2</sub> O/fad	2.53	2.87	2.42	2.89
40 kg N + 24 kg K <sub>2</sub> O/fad	3.01	3.50	2.75	3.31
40 kg N + 48 kg K <sub>2</sub> O/fad	3.04	4.07	3.23	3.63
60 kg N + 24 kg K <sub>2</sub> O/fad	2.94	4.54	3.87	4.08
60 kg N + 48 kg K <sub>2</sub> O/fad	3.79	5.04	4.21	4.45
80 kg N + 24 kg K <sub>2</sub> O/fad	3.40	4.51	3.95	4.19
80 kg N + 48 kg K <sub>2</sub> O/fad	3.57	4.57	4.34	4.68
F. test	*			
LSD 5 %	0.33			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	1.01	1.24	1.06	1.16
20 kg N + 48 kg K <sub>2</sub> O/fad	1.38	1.52	1.42	1.48
40 kg N + 24 kg K <sub>2</sub> O/fad	1.57	1.78	1.78	1.83
40 kg N + 48 kg K <sub>2</sub> O/fad	1.80	1.99	1.95	2.13
60 kg N + 24 kg K <sub>2</sub> O/fad	2.02	2.36	2.12	2.12
60 kg N + 48 kg K <sub>2</sub> O/fad	2.33	2.64	2.32	2.43
80 kg N + 24 kg K <sub>2</sub> O/fad	2.11	2.65	2.22	2.39
80 kg N + 48 kg K <sub>2</sub> O/fad	2.33	2.87	2.49	2.67
F. test	*			
LSD 5 %	0.09			

**Table 14:** Averages of leaf area index (LAI) at 150 days from planting as affected by biofertilization treatments and nitrogen & potassium fertilizer levels in the first and third seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	2.59	3.58	3.11	3.57
20 kg N + 48 kg K <sub>2</sub> O/fad	3.03	4.03	3.29	3.94
40 kg N + 24 kg K <sub>2</sub> O/fad	3.38	5.20	3.68	4.19
40 kg N + 48 kg K <sub>2</sub> O/fad	4.01	5.55	4.59	4.98
60 kg N + 24 kg K <sub>2</sub> O/fad	4.20	6.37	6.11	5.44
60 kg N + 48 kg K <sub>2</sub> O/fad	4.97	7.12	6.57	6.32
80 kg N + 24 kg K <sub>2</sub> O/fad	4.70	6.20	5.86	5.80
80 kg N + 48 kg K <sub>2</sub> O/fad	4.91	6.86	6.66	6.06
F. test	*			
LSD 5 %	0.53			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	1.41	1.63	1.51	1.63
20 kg N + 48 kg K <sub>2</sub> O/fad	1.74	1.92	1.80	1.89
40 kg N + 24 kg K <sub>2</sub> O/fad	2.03	2.40	2.28	2.38
40 kg N + 48 kg K <sub>2</sub> O/fad	2.21	2.63	2.53	2.66
60 kg N + 24 kg K <sub>2</sub> O/fad	2.54	3.09	2.86	3.01
60 kg N + 48 kg K <sub>2</sub> O/fad	2.73	3.33	3.12	3.24
80 kg N + 24 kg K <sub>2</sub> O/fad	2.82	3.32	3.23	3.38
80 kg N + 48 kg K <sub>2</sub> O/fad	2.07	3.65	3.47	3.49
F. test	*			
LSD 5 %	0.10			

growth of sugar beet plants was expected. These results are in harmony with those supported by Kandil *et al.* (2002 b).

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase CGR from 0.85 to 1.57, 2.26 and 2.35 g/day as average during the three seasons, respectively. Similar results were confirmed by EL-Kassaby *et al.* (1999), EL-Zayat (2000) and Kandil *et al.* (2000 b).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase CGR from 1.62 to 1.90 g/day as average in the three seasons, respectively. EL-Zayat (2000) and Kandil *et al.* (2000 a) came to similar trend.

Regarding the effect of nitrogen and potassium combination levels on crop growth rate (CGR), it was significant in the three growing seasons as shown in Table 11. CGR was gradually increased with each increase in nitrogen and potassium combination levels over planting dates in the three seasons of this work. Raising nitrogen and potassium combination levels up to 60 kg N + 48 kg K<sub>2</sub>O/fad produced the maximum values of CGR (2.16 and 3.22 g/day) in the second and third seasons, respectively. While, in the first season the highest one (2.22 g/day) was resulted from application of 80 kg N + 48 kg K<sub>2</sub>O/fad. Moreover, there were insignificant differences between application of 60 kg N + 48 kg K<sub>2</sub>O/fad or 80 kg N + 48 kg K<sub>2</sub>O/fad in the second and third seasons. The lowest values of CGR (0.80, 0.21 and 1.19 g/day) were derived from application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. The increase in CGR due to raising nitrogen and potassium fertilizer levels may be attributed to its role in increasing dry matter accumulation in root and foliage as well as LAI as record before.

#### **Effect of interactions:**

In the three seasons, the interaction between planting dates X nitrogen and potassium combination levels exhibited significant effect on CGR (Table 15). The highest averages of this trait (2.31, 2.34 and 3.48 g/day) were obtained when planting beets on 1<sup>st</sup> of November and application 80 kg N + 48 kg K<sub>2</sub>O/fad in the first season and planting on 1<sup>st</sup> September and application 60 kg N + 48 kg K<sub>2</sub>O/fad in the second and third seasons, respectively.

#### **1.7- Relative growth rate (RGR) in g/g/day:**

Data collected in Table 16 display the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on relative growth rate (RGR) during 2000/2001, 2001/2002 and 2002/2003 seasons.

**Table 15:** Averages of crop growth rate (CGR) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates NK levels	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
20 kg N + 24 kg K <sub>2</sub> O/fad	0.68	0.92	0.25	0.26	0.13	1.32	1.04	1.22
20 kg N + 48 kg K <sub>2</sub> O/fad	0.72	1.07	0.49	0.41	0.44	1.59	1.56	1.50
40 kg N + 24 kg K <sub>2</sub> O/fad	1.09	1.09	1.34	1.30	1.00	1.88	1.75	1.90
40 kg N + 48 kg K <sub>2</sub> O/fad	1.11	1.52	1.74	1.79	1.20	2.39	2.31	2.47
60 kg N + 24 kg K <sub>2</sub> O/fad	1.40	1.84	2.29	1.77	1.79	2.75	2.91	2.59
60 kg N + 48 kg K <sub>2</sub> O/fad	1.79	1.95	2.34	2.04	2.10	3.48	3.09	3.09
80 kg N + 24 kg K <sub>2</sub> O/fad	2.05	2.02	2.26	1.45	1.98	2.97	2.94	2.69
80 kg N + 48 kg K <sub>2</sub> O/fad	2.13	2.31	2.16	1.77	2.05	3.32	3.04	2.98
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.21		0.21			0.16		

### **Effect of planting dates:**

With reference to the effect of planting dates on relative growth rate (RGR), it was significant in the second and third seasons only (Table 16). The highest values of RGR were recorded when planting beets on 1<sup>st</sup> November (0.126 g/g/day) in the first season or planting on 1<sup>st</sup> September (0.142 and 0.143 g/g/day) in the second and third seasons, respectively. On contrary of that, the lowest ones (0.119, 0.129 and 0.139 g/g/day) were registered by planting on 1<sup>st</sup> October in the first, second and third seasons, respectively. Similar results were reported by Kandil *et al.* (2002 b).

### **Effect of biofertilization treatments:**

It is clearly seen that relative growth rate (RGR) was insignificantly affected by biofertilization treatments through second and third seasons, vice versa in the first season only (Table 16). A slight increase in this case was found due to biofertilization treatments as compared with the control treatment (without biofertilization) in all seasons of study. On the whole, there were insignificant differences among biofertilization treatments over planting dates in the three seasons. Similar results were supported by Kandil *et al.* (2002 b).

### **Effect of nitrogen and potassium combination levels:**

When increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase RGR from 0.115 to 0.133, 0.143 and 0.145 g/g/day as average of the three seasons. The previous tendency is parallel with those stated by Kandil *et al.* (2000 b).

By increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase RGR from 0.132 to 0.136 g/g/day as average over seasons.

It was evident from the data of Table 16 that the application of nitrogen and potassium combination levels tended to significantly increase relative growth rate (CGR) over the chick treatment (20 kg N + 24 kg K<sub>2</sub>O/fad) in the three seasons. The highest averages of CGR (0.139, 0.148 and 0.152 g/g/day) were achieved by application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the first season and by application of 60 kg N + 48 kg K<sub>2</sub>O/fad in the second and third seasons, respectively. The differences between application of 60 kg N + 48 kg K<sub>2</sub>O/fad or 80 kg N + 48 kg K<sub>2</sub>O/fad failed to reach the level of significance in the second and third seasons. The increase in RGR due to increase in nitrogen and potassium combination levels may be ascribed to its role in increasing dry matter accumulation as mentioned formerly.

### **1.8- Net assimilation rate (NAR) in g/cm<sup>2</sup>/day:**

Data listed in Table 16 clear the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on net assimilation rate (NAR) during the three growing seasons.

**Table 16:** Averages of relative growth rate (RGR) in g/g/day and net assimilation rate (NAR) in g/cm<sup>2</sup>/day as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	RGR (g/g/day)			NAR (g/cm <sup>2</sup> /day)		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	0.142	0.143	-	3.26	2.98
1 <sup>st</sup> October	0.119	0.129	0.139	3.73	2.73	3.10
1 <sup>st</sup> November	0.126	0.139	0.140	3.38	2.93	2.69
F. test	NS	*	*	NS	*	*
LSD 5%		0.004	0.001		0.39	0.30
<b>B: Biofertilization treatments:</b>						
Without	0.112	0.137	0.140	2.79	2.86	2.71
Rhizobacterin	0.127	0.137	0.141	4.00	2.80	2.91
Cerialine	0.125	0.137	0.141	3.97	3.13	3.01
Rhizobacterin+Cerialine	0.125	0.137	0.141	3.46	3.10	3.06
F. test	*	NS	NS	*	*	*
LSD 5%	0.005	-	-	0.47	0.26	0.15
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	0.104	0.112	0.121	2.44	2.24	2.28
20 kg N + 48 kg K <sub>2</sub> O/fad	0.106	0.119	0.130	2.53	2.36	2.36
40 kg N + 24 kg K <sub>2</sub> O/fad	0.113	0.139	0.142	2.86	2.71	2.56
40 kg N + 48 kg K <sub>2</sub> O/fad	0.120	0.139	0.142	3.15	2.85	2.78
60 kg N + 24 kg K <sub>2</sub> O/fad	0.128	0.147	0.147	3.82	3.13	3.18
60 kg N + 48 kg K <sub>2</sub> O/fad	0.133	0.148	0.152	4.49	3.05	3.27
80 kg N + 24 kg K <sub>2</sub> O/fad	0.136	0.148	0.148	4.29	3.75	3.42
80 kg N + 48 kg K <sub>2</sub> O/fad	0.139	0.148	0.151	4.87	3.69	3.55
F. test	*	*	*	*	*	*
LSD 5%	0.004	0.002	0.003	0.51	0.30	0.12

### **Effect of planting dates:**

Planting dates of sugar beet adopted to appear a favorable effect on NAR in the second and third seasons (Table 16). The highest values of NAR (3.73, 3.26 and 3.10 g/cm<sup>2</sup>/day in the first, second and third seasons, respectively) were resulted from planting on 1<sup>st</sup> October in the first and third season, whilst in the second season it was produced from planting on 1<sup>st</sup> September. In reverse, The lowest values of NAR (3.38, 2.73 and 2.69 g/cm<sup>2</sup>/day in the first, second and third seasons, respectively) were achieved by planting beets on 1<sup>st</sup> November in the first and third seasons and from planting on 1<sup>st</sup> October in the second season. Similar results were partially agreed with those reported by Kandil *et al.*(2002b).

### **Effect of biofertilization treatments:**

Concerning the effect of biofertilization treatments on NAR, it showed a significant role in the three seasons (Table 16). The biofertilization treatments had a variable trend with respect to NAR, where the highest values of its (4.00, 3.13 and 3.06 g/cm<sup>2</sup>/day in the first, second and third seasons, respectively) were produced due to inoculate soil with Rhizobacterin fertilizer in the first season, Cerialine fertilizer in the second season and Rhizobacterin + Cerialine treatment in the third season. In general, biofertilization treatment caused noticeable increase in NAR over control treatment (without biofertilization). This favorable increase in NAR owing to biofertilization treatments may be returned to the role of Rhizobacterin and Cerialine in fixing more nitrogen and producing some growth substances that encourage plant growth and dry matter accumulation. These results are in stand with those confirmed by Kandil *et al.* (2002b).

### **Effect of nitrogen and potassium combination levels:**

Obtained results showed that increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase NAR from 2.37 to 2.82, 3.49 and 3.93 g/cm<sup>2</sup>/day as average of the three seasons, respectively. Similar results were supported by EL-Kassaby *et al.* (1999) and Kandil *et al.* (2000 b).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase NAR from 3.06 to 3.25 g/cm<sup>2</sup>/day as average of the three seasons, respectively.

With respect to the effect of nitrogen and potassium combination levels on NAR, it can be clearly stated that NAR was significantly affected by this factor in the three seasons (Table 16). Application of 80 kg N + 48 kg K<sub>2</sub>O/fad resulted in the highest values of NAR (4.87 and 3.55 g/cm<sup>2</sup>/day) in the first and third seasons, respectively. While, in the second season the highest mean (3.75 g/cm<sup>2</sup>/day) was obtained from application of 80 kg N + 24 kg K<sub>2</sub>O/fad. On the other side, the lowest ones (2.44, 2.24 and 2.28 g/cm<sup>2</sup>/day) were obtained from application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. Such increase in NAR may be reflected

to the role of nitrogen and potassium in increasing cell volume, leaf area/plant and consequently increasing NAR.

## **2. YIELD COMPONENTS:**

### **2.1- Root fresh weight (g/plant):**

Means of root fresh weight (g/plant) at harvesting time as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons are registered in Table 17.

#### **Effect of planting dates:**

As shown from tabulated data in Table 17, root fresh weight was markedly affected as a result of planting dates during the second and third seasons, but conversely with respect first season. Planting sugar beet at 1<sup>st</sup> October exerted significant increase in root fresh weight and gave the highest values (558.1, 795.9 and 814.8 g/plant) in the first, second and third seasons, respectively. On contrary, the lowest ones (543.7, 742.3 and 649.2 g/plant in the first, second and third seasons, respectively) were accompanied with planting on 1<sup>st</sup> November in the first and third seasons and on 1<sup>st</sup> September in the second

season. The favorable effect of planting on 1<sup>st</sup> October on root fresh weight might be ascribed to the suitable environmental conditions during this period such as temperature, relative humidity (Table 2), day length and light intensity which allow to rapid growth and formation good canopy able to make greatest photosynthesis, consequently increasing dry matter accumulation as well as root weight/plant. This trend of results is in good agreement with those confirmed by Badawi (1985), EL-Kassaby and Leilah (1992 b), Badawi *et al.* (1995), Ghonema (1998), Abd EL-Gawad *et al.* (2000), Abdou (2000), and Kandil *et al.* (2002 c).

#### **Effect of biofertilization treatments:**

With connection the effect of biofertilization treatments on root fresh weight, it is seems to clear that a significant response was found during the three growing seasons (Table 17). It was worthy to remark that biofertilization treatments caused a significant increase in root fresh weight over control treatment (without biofertilization) in all seasons of study. Inoculation soil with Rhizobacterin fertilizer induced the highest means of root fresh weight, which scores were 633.7, 814.1 and 824.2 g/plant over planting dates in the first, second and third seasons, respectively. It was followed by Rhizobacterin + Cerialine treatment, then Cerialine fertilizer in the three seasons. This increase in root fresh weight in consequence of applying biofertilizers may be due to nitrogen fixation, increase the uptake of nutrients and released some growth regulators which stimulating establishment and vegetative growth, hence increasing root and foliage fresh weight. There many investigators confirming this conclusion *i.e.* Favilli *et al.* (1993), Bassal *et al.* (2001), Maareg and Sohir, Badr (2001) and Kandil *et al.* (2002 c).

**Table 17:** Averages of root and foliage fresh weight (g/plant) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Root fresh weight (g/plant)			Foliage fresh weight (g/plant)		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	742.3	779.9	-	251.3	325.0
1 <sup>st</sup> October	558.1	795.9	814.8	491.0	284.4	387.1
1 <sup>st</sup> November	543.7	758.2	649.2	374.2	258.1	348.6
F. test	NS	*	*	*	*	*
LSD 5%		14.5	38.5		16.7	15.7
<b>B: Biofertilization treatments:</b>						
Without	462.6	687.9	670.5	372.6	242.1	315.3
Rhizobacterin	633.7	814.1	824.2	492.7	280.5	387.5
Cerialine	530.7	762.4	730.4	411.3	262.0	342.2
Rhizobacterin+Cerialine	576.5	797.4	766.6	453.8	273.9	369.3
F. test	*	*	*	*	*	*
LSD 5%	19.7	8.9	9.2	18.4	5.8	5.7
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	281.3	408.7	408.9	255.7	161.8	235.8
20 kg N + 48 kg K <sub>2</sub> O/fad	354.4	535.4	529.1	310.6	198.3	271.0
40 kg N + 24 kg K <sub>2</sub> O/fad	430.2	633.5	647.5	367.9	227.0	314.5
40 kg N + 48 kg K <sub>2</sub> O/fad	532.7	764.4	745.4	404.5	254.9	349.0
60 kg N + 24 kg K <sub>2</sub> O/fad	629.9	865.6	843.9	462.2	278.0	378.8
60 kg N + 48 kg K <sub>2</sub> O/fad	738.8	974.9	954.5	565.1	339.3	433.7
80 kg N + 24 kg K <sub>2</sub> O/fad	686.7	926.5	882.5	517.3	306.7	398.8
80 kg N + 48 kg K <sub>2</sub> O/fad	752.9	994.8	971.8	577.5	350.8	447.0
F. test	*	*	*	*	*	*
LSD 5%	13.6	7.2	10.1	11.0	3.7	4.9

### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase root fresh weight from 419.6 to 625.6, 834.2 and 869.2 g/plant as average of the three seasons and this increase amounted 49.0, 33.4 and 4.2 % between nitrogen levels, respectively. Noteworthy, increasing nitrogen levels from 60 to 80 kg N/fad caused little increase (4.2 %) in the comparison with other levels. These results are in line with those obtained by AL-Labbody (1998), Attia *et al.* (1999), EL-Hawary (1999), Abd EL-Moneim (2000), Azab *et al.* (2000), Sohier, Ouda (2001) and Kandil *et al.* (2002 c).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root fresh weight from 637.1 to 737.4 as average over seasons. Similar trend was recorded by EL-Moursy *et al.* (1998), Sayed *et al.* (1998), EL-Shafai (2000), Sohier, Ouda (2001) and Kandil *et al.* (2002 a).

Nitrogen and potassium combination levels exhibited significant effect on root fresh weight in the three growing seasons (Table 17). A gradual increase was observed in root fresh weight as reason of increasing nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad in all seasons of this research. The highest values of root fresh weight (752.9, 994.8 and 971.8 g/plant) were associated with application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. Adversely, the lowest ones were resulted from the chick treatment (20 kg N + 24 kg K<sub>2</sub>O/fad), which data were 281.3, 408.7 and 408.9 g/plant in the first, second and third seasons, respectively. Application of 60 kg N + 48 kg K<sub>2</sub>O/fad occupied second rank after application of the highest levels of nitrogen and potassium combination, where the differences between them were fewer than others among rest combinations. Such effect of nitrogen and potassium on this characteristic may be returned to its role in building up metabolites and activation of enzymes that associate with accumulation of carbohydrates, which translated from leaves to developing roots. The present results are in line with those obtained by Geweifel and Aly (1996), Sarhan (1998) and EL-Hawary (1999).

### **Effect of interactions:**

In the three seasons, the interaction between planting dates X nitrogen and potassium combination levels showed significant effect (Table 18). The highest averages of this trait (787.6, 1018.8 and 1053.7 g/plant) were obtained when planting beets on 1<sup>st</sup> Oct. and application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. While, the lowest ones (275.7, 384.6 and 361.2 g/plant in the first, second and third seasons, respectively) were resulted from planting on 1<sup>st</sup> Oct. in the first, 1<sup>st</sup> September in the second season or 1<sup>st</sup> Nov. in the third season by and application of 20 kg N + 24 kg K<sub>2</sub>O/fad. Similar conclusion was supported by Kandil *et al.* (2002 c).

The interaction between biofertilization treatment X nitrogen and potassium combination levels over planting dates was significant in the three seasons (Table 19). The highest values of root fresh weight (870.5, 1073.1 and 1059.4 g/plant) were resulted from application of Rhizobacterin combination with 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. Meanwhile, inoculation soil by Rhizobacterin and fertilizing with 60 kg N + 48 kg K<sub>2</sub>O/fad produced the best results after formerly interaction in all seasons without any significant differences in the first and third seasons. Kandil *et al.* (2002 c) and Soha, Khalil (2002) confirming these results.

## **2.2- Foliage fresh weight (g/plant):**

Data listed in Table 17 reveal the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on foliage fresh weight g/plant during the three growing seasons.

### **Effect of planting dates:**

With reference to the effect of planting dates on foliage fresh weight, it is apparent that planting dates markedly affected foliage fresh weight in the three seasons as shown in Table 17. The highest means of foliage fresh weight (491.0, 284.4 and 387.1 g/plant) were obtained on account of planting beets on 1<sup>st</sup> October in the first, second and third seasons, respectively. However, the lowest ones of this trait (374.2, 251.3 and 325.0 g/plant in the first, second and third seasons, respectively) were obtained from planting beets on 1<sup>st</sup> November in the first season and from 1<sup>st</sup> September in the second and third seasons. This improving in foliage fresh weight owing to planting beets on 1<sup>st</sup> October may be attributed to corresponding environmental conditions in order to maximum sugar beet growth and development. These results are stated by many workers *i.e.* by Badawi (1985), Badawi *et al.* (1995), Ghonema (1998), Abd EL -Gawad *et al.* (2000), Abdou (2000) and Kandil *et al.* (2002 c).

### **Effect of biofertilization treatments:**

It seems from returns of statistical analysis, there were a significant and positive relationship between foliage fresh weight and biofertilization treatments in the three seasons (Table 17). It can be clear seen that foliage fresh weight significantly increased biofertilization treatments (Rhizobacterin, Cerialine and Rhizobacterin + Syrialin) and the differences among its were high significant as compared with chick treatment (without biofertilization) in all growing seasons. The highest averages of foliage fresh weight (492.7, 280.5 and 387.5 g/plant) were achieved by inoculation soil with Rhizobacterin in the first, second and third seasons, respectively. However, the lowest ones (372.6, 242.1 and 315.3 g/plant) were reflected from control treatment. The best biofertilization treatment after Rhizobacterin treatment was application of Rhizobacterin + Cerialine thereafter Cerialine treatment in the three seasons of study. Obtained results provide evidence that

**Table 18:** Averages of root fresh weight (g/plant) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	275.7	287.0	384.6	442.2	399.4	403.0	462.5	361.2
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	344.2	364.6	520.1	568.5	517.5	524.0	588.3	475.0
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	412.1	448.3	617.5	688.6	654.6	644.0	724.1	574.6
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	525.1	540.3	733.5	806.5	753.2	776.0	802.5	657.9
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	638.8	621.0	831.3	900.6	864.7	913.5	898.3	720.0
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	772.9	704.6	953.0	1002.0	969.8	1008.1	1036.2	819.1
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	708.0	665.3	923.5	940.4	915.7	945.6	952.5	749.6
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	787.6	718.2	975.0	1018.8	990.8	1025.0	1053.7	836.6
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	19.3		12.6			17.5		

**Table 19:** Averages of root fresh weight (g/plant) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	244.5	306.3	279.3	295.3
20 kg N + 48 kg K <sub>2</sub> O/fad	312.1	398.5	360.5	346.6
40 kg N + 24 kg K <sub>2</sub> O/fad	376.1	475.1	430.1	439.5
40 kg N + 48 kg K <sub>2</sub> O/fad	439.3	601.3	528.6	561.6
60 kg N + 24 kg K <sub>2</sub> O/fad	510.8	751.0	599.1	658.6
60 kg N + 48 kg K <sub>2</sub> O/fad	620.8	854.6	692.1	787.5
80 kg N + 24 kg K <sub>2</sub> O/fad	559.8	812.6	647.5	726.8
80 kg N + 48 kg K <sub>2</sub> O/fad	637.3	870.5	708.1	795.8
F. test	*			
LSD 5 %	27.3			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	359.7	442.7	403.4	429.0
20 kg N + 48 kg K <sub>2</sub> O/fad	470.7	586.8	529.2	554.7
40 kg N + 24 kg K <sub>2</sub> O/fad	594.0	685.4	652.8	681.8
40 kg N + 48 kg K <sub>2</sub> O/fad	703.1	791.7	754.4	808.4
60 kg N + 24 kg K <sub>2</sub> O/fad	781.1	897.5	879.2	904.4
60 kg N + 48 kg K <sub>2</sub> O/fad	873.5	1051.6	967.5	1007.0
80 kg N + 24 kg K <sub>2</sub> O/fad	830.3	984.2	927.3	964.4
80 kg N + 48 kg K <sub>2</sub> O/fad	890.8	1073.1	985.6	1029.8
F. test	*			
LSD 5 %	14.5			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	356.1	457.2	391.6	430.6
20 kg N + 48 kg K <sub>2</sub> O/fad	468.8	591.6	528.6	527.2
40 kg N + 24 kg K <sub>2</sub> O/fad	579.7	716.1	617.7	676.6
40 kg N + 48 kg K <sub>2</sub> O/fad	673.3	836.0	722.0	750.5
60 kg N + 24 kg K <sub>2</sub> O/fad	762.0	925.5	826.0	862.2
60 kg N + 48 kg K <sub>2</sub> O/fad	856.5	1042.1	937.7	981.6
80 kg N + 24 kg K <sub>2</sub> O/fad	794.7	966.1	865.5	903.8
80 kg N + 48 kg K <sub>2</sub> O/fad	873.2	1059.4	954.4	1000.2
F. test	*			
LSD 5 %	20.3			

foliage fresh weight is improved by biofertilization treatments and the reason of this was mentioned formerly with connection root fresh weight. Bassal *et al.* (2001), Maareg and Sohir, Badr (2001) and Kandil *et al.* (2002 c) came to similar results.

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase foliage fresh weight from 238.9 to 319.6, 409.5 and 433.0 g/plant as average of the three seasons. Moreover this increase reached about 33.7, 28.1 and 5.7 % between nitrogen levels, respectively. Similar conclusion was obtained by AL-Labbody (1998), Attia *et al.* (1999), Mahasen, Fahmi (1999), AbdEL-Moneim (2000), Sohier, Ouda (2001) and Kandil *et al.* (2000 c).

Foliage fresh weight tended to increase by about 15.3 % due to increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad as average of the three seasons. Sohier, Ouda (2001) and Kandil *et al.* (2000 a) supported this tendency.

Data entered in Table 17 show that nitrogen and potassium combination levels had a significant effect on foliage fresh weight in the three growing seasons of study. Increasing nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad excreted obvious increases in foliage fresh weight, where these increases amounted 125.8, 116.8 and 89.5 % in the first, second and third seasons, respectively. It can be observed that application of 60 kg N + 48 kg K<sub>2</sub>O/fad ranked after application of 80 kg N + 48 kg K<sub>2</sub>O/fad, where its results were 565.1, 339.3 and 433.7 g/plant in the first, second and third season, respectively. Because, the differences between its were fewer than the differences among other combinations. The increase in foliage fresh weight can be easily ascribed to the role of nitrogen and potassium in activating foliage growth as a result of increasing leaf area as mentioned before. Confirming this conclusion, Geweifel and Aly (1996) and Sarhan (1998).

#### **Effect of interactions:**

Referring the effect of the interaction between planting dates X nitrogen and potassium fertilizer levels, it was significant in the three seasons (Table 20). The optimum treatment that produced the highest values of this trait was planting on 1<sup>st</sup> October in addition application of 80 kg N + 48 kg K<sub>2</sub>O/fad, where its results were 658.3, 373.4 and 492.0 g/plant in the first, second and third seasons, respectively. This trend was in line with reported by Kandil *et al.* (2002 c).

Concerning the effect of the interaction between biofertilization treatments X nitrogen and potassium combination levels over planting dates, it was significant in the three seasons as appear from Table 21. The highest means were obtained from Rhizobacterin treatment combination with fertilizing with 80 kg N + 48 kg K<sub>2</sub>O/fad, which were 659.1, 371.5 and 493.3 in the first, second and third seasons, respectively. However, the second best interaction was inoculation soil also with

**Table 20:** Averages of foliage fresh weight (g/plant) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	281.4	230.1	141.9	186.7	156.9	196.6	257.5	253.3
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	354.4	266.9	172.7	227.7	194.6	232.0	296.6	284.5
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	413.1	322.6	200.0	248.3	232.6	282.0	347.5	314.1
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	455.1	354.0	234.0	275.4	255.2	326.5	378.3	342.0
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	529.5	394.9	272.4	291.0	270.7	351.4	413.7	371.2
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	646.4	483.6	334.6	360.2	323.3	411.7	477.5	412.0
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	590.0	444.7	311.6	312.3	296.0	373.9	434.1	388.3
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	658.3	496.7	343.7	373.4	335.5	425.7	492.0	423.3
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	15.6		6.5			8.6		

**Table 21:** Averages of foliage fresh weight (g/plant) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	218.3	294.6	243.5	266.6
20 kg N + 48 kg K <sub>2</sub> O/fad	288.3	338.1	298.1	318.0
40 kg N + 24 kg K <sub>2</sub> O/fad	335.6	416.5	343.8	375.6
40 kg N + 48 kg K <sub>2</sub> O/fad	356.5	459.0	382.5	420.3
60 kg N + 24 kg K <sub>2</sub> O/fad	400.0	527.0	430.0	491.8
60 kg N + 48 kg K <sub>2</sub> O/fad	470.1	652.0	544.5	593.3
80 kg N + 24 kg K <sub>2</sub> O/fad	426.6	595.3	491.0	556.5
80 kg N + 48 kg K <sub>2</sub> O/fad	485.6	659.1	557.3	608.0
F. test	*			
LSD 5 %	22.1			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	142.5	177.6	158.8	168.3
20 kg N + 48 kg K <sub>2</sub> O/fad	177.7	210.5	201.4	203.6
40 kg N + 24 kg K <sub>2</sub> O/fad	202.4	236.8	229.1	239.5
40 kg N + 48 kg K <sub>2</sub> O/fad	226.5	267.4	253.1	272.5
60 kg N + 24 kg K <sub>2</sub> O/fad	246.8	297.4	278.0	289.8
60 kg N + 48 kg K <sub>2</sub> O/fad	321.4	356.5	332.1	347.4
80 kg N + 24 kg K <sub>2</sub> O/fad	291.4	326.1	299.2	310.0
80 kg N + 48 kg K <sub>2</sub> O/fad	327.8	371.5	344.3	359.7
F. test	*			
LSD 5 %	7.5			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	215.5	252.4	228.5	246.6
20 kg N + 48 kg K <sub>2</sub> O/fad	247.2	293.7	263.3	280.0
40 kg N + 24 kg K <sub>2</sub> O/fad	287.2	333.5	312.2	325.2
40 kg N + 48 kg K <sub>2</sub> O/fad	315.0	381.6	335.5	363.7
60 kg N + 24 kg K <sub>2</sub> O/fad	334.1	422.6	362.6	395.7
60 kg N + 48 kg K <sub>2</sub> O/fad	380.0	479.3	418.3	457.4
80 kg N + 24 kg K <sub>2</sub> O/fad	350.5	443.3	385.1	416.2
80 kg N + 48 kg K <sub>2</sub> O/fad	392.7	493.3	432.2	469.8
F. test	*			
LSD 5 %	9.9			

Rhizobacterin, but fertilizing with 60 kg N + 48 kg K<sub>2</sub>O/fad, which differences between their were very few in all seasons. Kandil et al. (2002 c) and Soha, Khalil (2002) obtained similar findings.

### **2.3- Root/top ratio:**

Data in Table 22 are in concern with the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on root/top ratio during 2000/2001, 2001/2002 and 2002/2003 seasons.

#### **Effect of planting dates:**

It is quite evident from the data listed in Table 22 that planting dates of sugar beet had significant effect on root/top ratio in the first and third seasons only. Planting sugar beet on first September registered the highest values of root/top ratio, since results were 2.97 and 2.38 in the second and third seasons, respectively. Meanwhile, in the first season the highest one (1.44) was recorded due to planting on 1<sup>st</sup> November. On contrary, the lowest values of root/top ratio (1.11, 2.78 and 1.83) were resulted from planting beets on 1<sup>st</sup> October in the first and second seasons and from planting on 1<sup>st</sup> November in the third season. Badawi (1985), Abdou (2000) and Kandil *et al.* (2002 c) came to similar results.

#### **Effect of biofertilization treatments:**

From data in Table 22, it is clear seen that there were insignificant effects for biofertilization treatments on root/top ratio during 2000/2001, 2001/2002 and 2002/2003 seasons. Nonetheless, there were gradual increases in root/top ratio as affected by biofertilization treatments in the three seasons of this investigation. These results were alleged with the previous results obtained by Bassal *et al.* (2001).

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40 and 60 kg N/fad tended to increase root/top ratio from 1.88 to 2.11 and 2.19 as average of the three seasons, respectively. Whilst, increasing nitrogen levels from 60 to 80 kg N/fad associated with reduction in this character from 2.19 to 2.15. These results are consistent with those reported by Attia *et al.* (1999) and Kandil *et al.* (2002 c).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to show light increase in root/top ratio from 2.08 to 2.09 as average of all seasons. In the three seasons of study, nitrogen and potassium combination levels significantly affected root/top ratio (Table 22). Increasing nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 60 kg N + 24 kg

K<sub>2</sub>O/fad caused gradual increases in root/top ratio, which the highest averages (1.38, 3.13 and 2.24) were registered by application of 60 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third season, respectively. Moreover, each increase nitrogen and potassium combination levels upon

**Table 22:** Averages of root/top ratio and root length (cm) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Root/top ratio			Root length (cm)		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	2.97	2.38	-	36.47	36.55
1 <sup>st</sup> October	1.11	2.78	2.08	31.55	37.93	40.05
1 <sup>st</sup> November	1.44	2.90	1.83	34.22	37.37	38.15
F. test	*	NS	*	*	NS	*
LSD 5%		-	0.07		-	1.10
<b>B: Biofertilization treatments:</b>						
Without	1.25	2.85	2.11	30.93	35.43	36.76
Rhizobacterin	1.28	2.89	2.11	34.77	38.63	39.56
Cerialine	1.30	2.89	2.11	32.27	37.11	37.77
Rhizobacterin+Cerialine	1.26	2.89	2.05	33.58	37.87	38.90
F. test	NS	NS	NS	*	*	*
LSD 5%	-	-	-	0.69	0.53	0.35
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	1.11	2.55	1.75	27.58	31.72	32.91
20 kg N + 48 kg K <sub>2</sub> O/fad	1.17	2.72	1.97	29.08	33.86	34.72
40 kg N + 24 kg K <sub>2</sub> O/fad	1.19	2.90	2.07	30.41	35.47	36.58
40 kg N + 48 kg K <sub>2</sub> O/fad	1.34	3.02	2.14	31.95	36.80	37.97
60 kg N + 24 kg K <sub>2</sub> O/fad	1.38	3.13	2.24	34.50	38.38	39.38
60 kg N + 48 kg K <sub>2</sub> O/fad	1.32	2.87	2.20	36.62	41.05	41.75
80 kg N + 24 kg K <sub>2</sub> O/fad	1.34	3.02	2.22	35.62	39.33	40.41
80 kg N + 48 kg K <sub>2</sub> O/fad	1.32	2.83	2.18	37.33	41.47	42.27
F. test	*	*	*	*	*	*
LSD 5%	0.05	0.06	0.05	0.48	0.36	0.28

previous level (60 kg N + 24 kg K<sub>2</sub>O/fad) associated with visible decrease in root/top ratio during all seasons. The decrease in root/top ratio with increasing in nitrogen level over 60 kg N/fad may be due to the increase in top weight more than the increase in root weight. Ramadan (1997) and EL-Harriri and Mirvat, Gobarh (2001) came to similar conclusion.

#### **2.4- Root length (cm):**

Data in Table 22 show the means of root length (cm) at harvesting as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during the seasons of 2000/2001, 2001/2002 and 2002/2003.

##### **Effect of planting dates:**

Data illustrated in Table 22 show that planting dates of sugar beet had a significant effect on root length at harvesting in the first and third seasons only. It can be easily comment that planting sugar beet on 1<sup>st</sup> October was accompanied with the tallest roots (37.93 and 40.05 cm) in the second and third seasons, respectively. While, in the first season the tallest ones were resulted from planting on the first of November. On the other hand, planting beets on 1<sup>st</sup> September recorded the shortest roots (36.47 and 36.55 cm) in the second and third seasons, respectively). Whilst, in the first season the lowest value of root length (31.55 cm) was obtained when planting beets was on 1<sup>st</sup> October. The desirable effect of planting dates on root length might be imputed to the suitable environmental conditions which play a vital role in activating establishment, growth and ripening of plants, hence increasing root dimension. These results are in partial compatible with those stated by Badawi (1985), Badawi *et al.* (1995), Ghonema (1998), Abdou (2000) and Kandil *et al.* (2002 c).

##### **Effect of biofertilization treatments:**

As shown in Table 22, root length of sugar beet significantly improved by biofertilization treatments (Rhizobacterin, Cerialine and mixture of Rhizobacterin + Cerialine) during 2000/2001, 2001/2002 and 2002/2003 seasons. Inoculation soil with Rhizobacterin biofertilizer created significant increases in root length more than other treatments and produced the maximum ones (34.77, 38.63 and 39.56 cm) in the first, second and third seasons, respectively. With respect Rhizobacterin + Cerialine treatment, it was ranked second after Rhizobacterin treatment, which values were 33.58, 37.87 and 38.90 cm with minimum differences between its in the first, second and third seasons, respectively. In opposition, the lowest values (30.93, 35.43 and 36.76 cm) were achieved as a results of control treatment (without biofertilization) in the first, second and third seasons, respectively. Such effect of biofertilization treatment on root size may be attributed to the active role of bacteria which released from biofertilizers in producing certain growth regulators and stimulation compounds such as GA<sub>3</sub> and IAA which play an important role in formation a large and active root system and therefore increasing nutrient uptake. Similar results were suggested by

several investigators *i.e.* Shabaev *et al.* (1996), Sultan *et al.* (1999), Bassal *et al.* (2001), Maareg and Sohir, Badr (2001), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase root length from 31.35 to 34.86, 38.61 and 39.41 cm as average in the three seasons, respectively. This increase amounted 10.14, 10.75 and 2.07 % between nitrogen levels. These results are in accordance with those reported by Azzazy (1998), Attia *et al.* (1999), EL-Hawary (1999), Abd EL-Moneim (2000), Sohair, Ouda (2001), Nemeat Alla *et al.* (2002) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root length from 35.19 to 37.07 cm as average in the three seasons. EL-Zayat (2000) and Sohair, Ouda (2001).

With regard to the effect of nitrogen and potassium combination levels on root length, it is obvious from data tabulated in Table 22 that increasing nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad was accompanied with significant increase in root length in the three seasons. Thereby, the highest averages of root length (37.33, 41.47 and 42.27 cm) were produced from fertilizing beets with 80 kg N + 48 kg K<sub>2</sub>O/fad. In reverse, the lowest ones were resulted from plants received 20 kg N + 24 kg K<sub>2</sub>O/fad, where findings were 27.58, 31.72 and 32.91 cm in the first, second and third seasons, respectively. It must be observation that application of 60 kg N + 48 kg K<sub>2</sub>O/fad) ranked after the highest level of nitrogen and potassium combination, which records were 36.62, 41.05 and 41.75 cm in the first, second and third seasons, respectively. Such effect of nitrogen and potassium may be ascribed to its role in increasing division and elongation of cells, consequently increasing root size. These results are in agreement with Sarhan (1998), Sayed *et al.* (1998), EL-Hawary (1999) and EL-Harriri and Mirvat, Gobarh (2001).

#### **Effect of interactions:**

A significant effect of the interaction between planting dates X nitrogen and potassium combination levels on root length was found in the three seasons (Table 23). The longest roots (39.00, 42.83 and 43.75 cm) were resulted from planting beets on 1<sup>st</sup> November (in the first season) or on 1<sup>st</sup> October (in the second and third seasons) plus fertilizing its with 80 kg N + 48 kg K<sub>2</sub>O/fad. While, replace the highest level of nitrogen (80 kg N/fad) with 60 kg N/fad from previous interaction produced the best results with insignificant differences in the same time save about 20 kg N/fad. Similar findings were observed by Kandil *et al.* (2002 c).

**Table 23:** Averages of root length (cm) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	26.83	28.33	32.08	32.00	31.08	30.16	35.08	33.50
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	28.50	29.66	33.58	33.75	34.25	32.08	37.08	35.00
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	29.25	31.58	35.16	35.58	35.66	34.66	38.66	36.41
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	30.75	33.16	36.08	37.16	37.16	36.58	39.66	37.66
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	32.75	36.25	37.25	39.33	38.58	38.25	40.91	39.00
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	34.75	38.50	39.50	42.25	41.41	40.41	43.33	41.50
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	33.91	37.33	38.50	40.58	38.91	39.00	41.91	40.33
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	35.66	39.00	39.66	42.83	41.91	41.25	43.75	41.83
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.67		0.66			0.48		

## **2.5- Root diameter (cm):**

The effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on root diameter (cm) during 2000/2001, 2001/2002 and 2002/2003 seasons are presented in Table 24.

### **Effect of planting dates:**

Root diameter exhibited significant differences among planting dates in the third seasons only (Table 24). The thickest roots were produced from plating on 1<sup>st</sup> October, results were 8.40, 10.21 and 10.53 cm in the first, second and third seasons, respectively. Whereas, the thinnest roots (8.23, 10.05 and 9.65 cm) were came out from planting beets on 1<sup>st</sup> November in the first, second and third seasons, respectively. The trend of these results is similar to those of root length and similar discussion could be cited. Confirming these findings, Badawi (1985), EL-Kassaby and Leilah (1992 b), Badawi *et al.* (1995), Ghonema (1998), Abdou (2000) and Kandil *et al.* (2002c).

### **Effect of biofertilization treatments:**

Data collected in Table 24 reveal that biofertilization treatments had a significant effect on root diameter in the three growing seasons of this research. Roots in the treatment of Rhizobacterin as biofertilizer (8.63, 10.58 and 10.55 cm) were significantly thicker than other treatments in the first, second and third seasons, respectively. Also, in can be supervision that Rhizobacterin + Cerialine treatment came in the second rank after aforementioned treatment with respect root diameter in all seasons. With concern Cerialine biofertilizer, it was occupied as eventual biofertilization treatments during the three seasons of this study. It can be cited that the increase in root diameter due to the same reason that led to the increase in root length as previously mentioned. These results are in full accordance with those reported by Sultan *et al.* (1999), Bassal *et al.* (2001), Maareg and Sohir, Badr (2001) and Ramadan *et al.* (2003).

### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase root diameter from 7.69 to 9.13, 10.49 and 10.79 cm as average in the three seasons. Increasing nitrogen levels from 60 to 80 kg N/fad led to slight increase (2.86 %) as compared to other increases due to increasing nitrogen levels. These findings are accomplished with those observed by AL-Labbody (1998) Attia *et al.* (1999), Abd EL-Moneim (2000), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root diameter from 9.14 to 9.91 cm as average over seasons. Sayed *et al.* (1998), Sohier, Ouda (2001) and Kandil *et al.* (2002 a).

**Table 24:** Averages of root diameter (cm) and total soluble solids (TSS %) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Root diameter (cm)			TSS %		
	Seasons	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	10.05	10.29	-	23.04	23.29
1 <sup>st</sup> October	8.40	10.21	10.53	22.79	23.33	22.38
1 <sup>st</sup> November	8.23	10.05	9.65	22.78	23.67	22.84
F. test	NS	NS	*	NS	NS	*
LSD 5%		-	0.06		-	0.42
<b>B: Biofertilization treatments:</b>						
Without	7.95	9.47	9.65	22.75	23.24	22.63
Rhizobacterin	8.63	10.58	10.55	22.81	23.76	22.89
Cerialine	8.21	10.08	10.06	22.91	23.37	22.89
Rhizobacterin+Cerialine	8.46	10.29	10.37	22.66	23.49	22.92
F. test	*	*	*	NS	*	NS
LSD 5%	0.12	0.11	0.12	-	0.26	-
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	6.35	7.56	7.85	21.75	22.50	22.02
20 kg N + 48 kg K <sub>2</sub> O/fad	7.00	8.59	8.80	22.37	22.98	22.70
40 kg N + 24 kg K <sub>2</sub> O/fad	7.51	9.34	9.55	22.83	23.43	22.94
40 kg N + 48 kg K <sub>2</sub> O/fad	8.17	10.04	10.19	24.00	23.81	23.63
60 kg N + 24 kg K <sub>2</sub> O/fad	8.69	10.64	10.75	24.41	24.33	23.69
60 kg N + 48 kg K <sub>2</sub> O/fad	9.73	11.65	11.48	23.29	24.90	23.93
80 kg N + 24 kg K <sub>2</sub> O/fad	9.18	11.22	11.03	22.16	22.88	21.54
80 kg N + 48 kg K <sub>2</sub> O/fad	9.89	11.81	11.62	21.45	22.88	22.22
F. test	*	*	*	*	*	*
LSD 5%	0.10	0.08	0.06	0.36	0.22	0.21

Respecting the effect of nitrogen and potassium combination levels on root diameter, it can be clearly seen that this character was significantly affected by increasing nitrogen and potassium combination levels during the three seasons (Table 24). It can be easily stated that, each increase in nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad associated with a progressive increase in root diameter during the three seasons. Application of the highest level of nitrogen and potassium (80 kg N + 48 kg K<sub>2</sub>O/fad) resulted in the highest values of root diameter (9.89, 11.81 and 11.62 cm) in the first, second and third seasons, respectively. However, application of 60 kg N + 48 kg K<sub>2</sub>O/fad arranged as second best application after the highest combination. The enhancing effect of nitrogen and potassium fertilization on root diameter may be attributed to the increase in cell size and numbers as a result of increasing division of cells as well as activating accumulation of metabolites in storage roots. These findings are accomplished with those recorded by Sarhan (1998) and Sayed *et al.* (1998).

### **Effect of interactions:**

The interaction between planting dates X nitrogen and potassium fertilizer levels had a significant effect on root diameter in the three seasons (Table 25). The highest means of this criteria (10.03, 11.95 and 12.30 cm) were produced when planting on 1<sup>st</sup> of October and application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. These results are in good accordance with those obtained by Kandil *et al.* (2002 c).

The interaction between biofertilization treatments X nitrogen and potassium combination levels indicated significant effect on root diameter in the first and third seasons only (Table 26). The highest values of root diameter (10.40 and 11.98 cm) can be obtained from using Rhizobacterin biofertilizer + 80 kg N + 48 kg K<sub>2</sub>O/fad in the first and third seasons, respectively. Whilst, the lowest ones (6.16 and 7.07 cm) were achieved with application of 20 kg N + 24 kg K<sub>2</sub>O/fad without biofertilization in the first and third seasons, respectively. Kandil *et al.* (2002 c) and Soha, Khalil (2002) came to similar trend.

## **3. YIELD QUALITY:**

### **3.1- Total soluble solids percentage (TSS %):**

Data presented in Table 24 bring out the means of total soluble solids percentage (TSS %) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

### **Effect of planting dates:**

Data inscribed in Table 24 indicate that planting dates had significant effect on TSS % in the third season only. It was detected that the highest values of TSS % (22.79, 23.67 and 23.29 % in the first, second and third seasons, respectively) were derived from planting beets on 1<sup>st</sup> October in the first season, while in the second and third seasons its resulted from planting on 1<sup>st</sup> November and 1<sup>st</sup>

**Table 25:** Averages of root diameter (cm) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	6.41	6.28	7.46	7.61	7.60	8.20	7.85	7.50
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	7.24	6.77	8.52	8.63	8.63	9.08	8.97	8.34
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	7.60	7.41	9.31	9.36	9.34	9.85	9.81	8.97
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	8.20	8.15	9.90	10.21	10.00	10.43	10.55	9.59
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	8.70	8.67	10.56	10.82	10.53	10.90	11.20	10.15
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	9.87	9.59	11.59	11.76	11.59	11.37	12.09	10.98
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	9.15	9.21	11.23	11.32	11.01	11.07	11.50	10.52
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	10.03	9.75	11.75	11.95	11.74	11.40	12.30	11.16
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.15		0.14			0.11		

**Table 26:** Averages of root diameter (cm) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels in the first and third seasons.

Biofertilization treatments <i>NK levels</i>	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	6.16	6.51	6.36	6.35
20 kg N + 48 kg K <sub>2</sub> O/fad	6.73	7.31	6.96	7.01
40 kg N + 24 kg K <sub>2</sub> O/fad	7.28	7.61	7.51	7.63
40 kg N + 48 kg K <sub>2</sub> O/fad	7.91	8.38	8.01	8.40
60 kg N + 24 kg K <sub>2</sub> O/fad	8.31	8.95	8.51	8.98
60 kg N + 48 kg K <sub>2</sub> O/fad	9.16	10.26	9.59	9.90
80 kg N + 24 kg K <sub>2</sub> O/fad	8.75	9.62	9.03	9.33
80 kg N + 48 kg K <sub>2</sub> O/fad	9.33	10.40	9.73	10.10
F. test	*			
LSD 5 %	0.22			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	7.07	8.40	7.76	8.16
20 kg N + 48 kg K <sub>2</sub> O/fad	8.05	9.33	8.65	9.15
40 kg N + 24 kg K <sub>2</sub> O/fad	8.77	10.00	9.55	9.86
40 kg N + 48 kg K <sub>2</sub> O/fad	9.67	10.58	10.13	10.37
60 kg N + 24 kg K <sub>2</sub> O/fad	10.46	11.03	10.62	10.88
60 kg N + 48 kg K <sub>2</sub> O/fad	11.14	11.82	11.36	11.60
80 kg N + 24 kg K <sub>2</sub> O/fad	10.75	11.27	10.95	11.15
80 kg N + 48 kg K <sub>2</sub> O/fad	11.26	11.98	11.50	11.75
F. test	*			
LSD 5 %	0.13			

September, respectively. In other words, TSS % had unstable trend due to planting dates over growing seasons of this research. Badawi (1985) and Kandil *et al.* (2002 c) came to results partially corresponding with obtained results in this study.

#### **Effect of biofertilization treatments:**

Statistical analysis of obtained results detected that TSS % was insignificantly responded to biofertilization treatments in the first and third seasons, but in the second season there was a significant effect (Table 24). It was worthy noticed that biofertilization treatments caused noticeable increases in TSS % over control (without biofertilization) in the three seasons. This increase in TSS % due to biofertilization treatments may be backed to its role in increasing growth and dry matter accumulation. Similar results were reported by many workers *i.e.* Sultan *et al.* (1999), Bassal *et al.* (2001) and Maareg and Sohir, Badr (2001).

#### **Effect of nitrogen and potassium combination levels:**

TSS % tended to increase as a result of increasing nitrogen fertilizer levels from 20 to 40 and 60 kg N/fad, where these increase reached 4.68 and 2.77 % as average in the three seasons. On the other hand, increasing nitrogen levels from 60 to 80 kg N/fad led to decrease TSS % by 7.88 %. Confirming this tendency Attia *et al.* (1999), Mahasen, Fahmi (1999), Abd EL-Moneim (2000), Nemeat Alla *et al.* (2002) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase TSS % from 22.87 to 23.18 % as average in the three seasons. Sohier, Ouda (2001) confirmed this trend.

Referencing the effect of nitrogen and potassium combination levels on TSS %, it can be clearly seen that this quality parameter had a significant effect in the three growing seasons (Table 24). It can be easily considered that application of 60 kg N + 48 kg K<sub>2</sub>O/fad gave the highest values of TSS %, where data were 24.90 and 23.93 % in the second and third seasons, respectively, whereas in the first season the highest one (24.41 %) was resulted from application of 60 kg N + 24 kg K<sub>2</sub>O/fad. Any increase in nitrogen and potassium combination levels upon 60 kg N + 48 kg K<sub>2</sub>O/fad caused remarkable decrease in TSS % in the three seasons of this study. The decrease in TSS % due to excessive nitrogen or potassium application can be ascribed to its role in increasing root weight and diameter, tissue water content as well as partitioning of more photosynthates to the tops than to the roots of sugar beet plants and consequently TSS % may be lowered. Confirming this conclusion Sobh *et al.* (1992) and Sultan *et al.* (1999).

#### **Effect of interactions:**

The interaction between planting dates X nitrogen and potassium combination levels showed significant effect on TSS % in the three seasons (Table 27). The highest value of TSS % in the first season (24.50 %) resulted from planting on 1<sup>st</sup> October by addition 60 kg N + 24 kg K<sub>2</sub>O/fad, but in the second season the highest one (25.04 %) was produced from planting on 1<sup>st</sup>

**Table 27:** Averages of total soluble solids (TSS %) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	21.50	22.00	22.37	22.50	22.62	22.29	21.33	22.45
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	22.00	22.75	22.83	22.95	23.16	22.95	22.20	22.95
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	23.00	22.66	23.16	23.50	23.62	23.50	22.45	22.87
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	23.83	24.16	23.50	23.91	24.04	24.33	23.04	23.54
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	24.50	24.33	24.29	24.29	24.41	24.45	23.37	23.25
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	23.66	22.91	25.04	24.62	25.04	24.29	23.91	23.58
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	22.41	21.91	23.58	22.08	23.00	22.04	20.87	21.70
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	21.41	21.50	22.41	22.79	23.45	22.45	21.83	22.37
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.50		0.38			0.37		

September and on 1<sup>st</sup> November and application of 60 kg N + 48 kg K<sub>2</sub>O/fad. While in the third season the highest one (24.45 %) obtained from planting on 1<sup>st</sup> September and application of 60 kg N + 24 kg K<sub>2</sub>O/fad.

### **3.2- Sucrose percentage (%):**

The effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on sucrose % during 2000/2001, 2001/2002 and 2002/2003 seasons are registered in Table 28.

#### **Effect of planting dates:**

According to the analysis of variance of obtained data, it can be stated that planting dates of sugar beet significantly affected sucrose % in the second and third seasons only (Table 28). Generally, it can be concluded that delaying planting of beets up to 1<sup>st</sup> October showed significant increase in sucrose % and produced the highest values, which data were 19.36, 19.22 and 19.12 % in the first, second and third seasons, respectively. While, in the case of more delaying planting of sugar beet until the first November, sucrose % showed a significant reduction. The corresponding results of previous case were 19.12, 18.75 and 18.81 % in the first, second and third seasons, respectively. The favorable effect of planting sugar beet on 1<sup>st</sup> October might be backed to the more suitable all environmental conditions during this period to formation more photosynthates products, translocation and accumulation sucrose in storage roots. Similar results are pertinence with those confirmed by Badawi (1985), Ghonema (1998), and Kandil *et al.* (2000 c).

#### **Effect of biofertilization treatments:**

As shown from data collected in Table 28, biofertilization treatments had significant effect on sucrose % in all growing seasons. Rhizobacterin treatment caused a significant increase in sucrose % over all treatments and induced the highest values *i.e.* 19.59, 19.19 and 19.28 % in the first, second and third seasons, respectively. The lowest means of sucrose content in roots (18.96, 18.80 and 18.69 % in the first, second and third seasons, respectively) were obtained on account of control treatment (without biofertilization) in the first and third seasons, and from Cerialine treatment in the second season. It can be suggested that this increase in sucrose % may be reflected to the role of biofertilizers especially Rhizobacterin in improving growth and dry matter accumulation by increasing the uptake and availability of most nutrients, consequently enhancement sucrose content in roots. Sultan *et al.* (1999), Bassal *et al.* (2001) and Maareg and Sohir, Badr (2001) suggested similar results.

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to decrease sucrose % from 20.37 to 19.58, 18.86 and 17.39 % as average of the three seasons. In other words, increasing nitrogen levels from 20 to 40, 60 and 80 kg/fad led to decrease sucrose % by 3.87, 3.67

**Table 28:** Averages of sucrose and apparent purity percentages as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Sucrose %			Apparent purity %		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<i>A: Planting dates:</i>						
1 <sup>st</sup> September	-	18.85	18.87	-	80.74	81.15
1 <sup>st</sup> October	19.36	19.22	19.12	84.95	82.47	85.64
1 <sup>st</sup> November	19.12	18.75	18.81	84.44	79.36	82.39
F. test	NS	*	*	NS	NS	*
LSD 5%		0.19	0.23		-	2.59
<i>B: Biofertilization treatments:</i>						
Without	18.96	18.81	18.69	83.46	81.14	82.78
Rhizobacterin	19.59	19.19	19.28	85.83	80.85	84.36
Cerialine	19.30	18.80	18.89	84.36	80.60	82.63
Rhizobacterin+Cerialine	19.27	18.96	18.87	85.14	80.84	82.46
F. test	*	*	*	NS	NS	*
LSD 5%	0.10	0.07	0.13	-	-	1.12
<i>C: Nitrogen and potassium combination levels:</i>						
20 kg N + 24 kg K <sub>2</sub> O/fad	20.52	19.92	19.73	93.86	88.62	89.76
20 kg N + 48 kg K <sub>2</sub> O/fad	21.05	20.57	20.45	93.67	89.55	90.16
40 kg N + 24 kg K <sub>2</sub> O/fad	19.54	19.20	19.11	85.71	81.98	83.42
40 kg N + 48 kg K <sub>2</sub> O/fad	20.16	19.77	19.71	84.10	83.04	83.49
60 kg N + 24 kg K <sub>2</sub> O/fad	18.68	18.56	18.52	76.57	76.31	78.24
60 kg N + 48 kg K <sub>2</sub> O/fad	19.30	19.13	18.99	82.98	76.88	79.40
80 kg N + 24 kg K <sub>2</sub> O/fad	17.22	16.90	17.21	77.75	74.00	80.06
80 kg N + 48 kg K <sub>2</sub> O/fad	17.78	17.48	17.75	82.93	76.48	79.96
F. test	*	*	*	*	*	*
LSD 5%	0.14	0.08	0.12	1.45	0.86	1.03

and 7.80 %, respectively. Similar trend was obtained by Azzazy (1998), Attia *et al.* (1999), Abd EL-Moneim (2000), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase sucrose % from 18.76 to 19.35 % as average of the three seasons. Selim and EL-Ghinbihi (1999), EL-Shafai (2000) and Sohier, Ouda (2001).

With regard to the effect of nitrogen and potassium combination levels on sucrose %, it is clearly seen that there was significant effect on sucrose % due to this factor in the three seasons (Table 28). It can be easily observed that each increase in nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad associated with gradual decrease in sucrose % in the three seasons. The maximum values of sucrose in beet roots were produced from fertilizing plants with 20 kg N + 48 kg K<sub>2</sub>O/fad, where results were 21.05, 20.57 and 20.45 % in the first, second and third seasons, respectively. On the contrary, the lowest ones (17.22, 16.90 and 17.21 %) were resulted from application of 80 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. The decrease in sucrose % owing to increasing nitrogen fertilizer levels can be attributed to its role in increasing non-sucrose substances such as proteins and alpha amino acid, and hence decreasing sucrose content in roots. Similar results were indicated by EL-Hawary (1999), Sultan *et al.* (1999) and EL-Harriri and Mirvat, Gobarh (2001).

#### **Effect of interactions:**

With regard to the effect of the interaction between planting dates X biofertilization treatments on sucrose %, it was significant in the three growing seasons (Table 29). The highest values of sucrose % (19.70, 19.60 and 19.47 % in the first, second and third seasons, respectively) resulted from planting on 1<sup>st</sup> October (in the first and second seasons) or on 1<sup>st</sup> September (in the third season) and utilizing Rhizobacterin treatment.

Respecting the interaction between planting dates X nitrogen and potassium combination levels, it was significant during the three seasons with concern sucrose % (Table 30). The highest means of sucrose % (21.40, 20.63 and 20.56 % in the first, second and third seasons, respectively) produced from planting on 1<sup>st</sup> November (in the first season) or on 1<sup>st</sup> October (in the second and third seasons) besides 20 kg N + 48 kg K<sub>2</sub>O/fad.

The interaction between biofertilization treatments X nitrogen and potassium combination levels on sucrose % was significant in the three growing seasons (Table 31). The highest values of sucrose % (21.21, 20.84 and 20.85 %) resulted from utilizing Rhizobacterin besides 20 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. On the other hand, the lowest ones were obtained by application of 80 kg N + 24 kg K<sub>2</sub>O/fad without biofertilization in all seasons. Abu EL-Fotoh *et al.* (2000), Bassal *et al.* (2001) and Soha, Khalil (2002) confirming these results.

**Table 29:** Averages of sucrose % as affected by planting dates and biofertilization treatments during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates Biofertilization treatments	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Without</b>	19.15	18.78	18.79	19.01	18.63	18.52	18.93	18.63
<b>Rhizobacterin</b>	19.70	19.49	19.12	19.60	18.84	19.47	19.38	19.00
<b>Cerialine</b>	19.25	19.35	18.61	19.09	18.70	18.77	19.05	18.87
<b>Rhizobacterin+Cerialine</b>	19.37	19.18	18.87	19.17	18.83	18.73	19.12	18.76
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.14		0.13			0.23		

**Table 30:** Averages of sucrose % as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates NK levels	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	20.17	20.86	19.86	20.15	19.75	19.87	19.80	19.54
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	20.70	21.40	20.57	20.63	20.51	20.23	20.56	20.55
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	19.59	19.49	19.25	19.38	18.95	19.04	19.05	19.25
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	20.29	20.04	19.70	20.06	19.55	19.46	19.88	19.79
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	18.85	18.52	18.58	18.67	18.43	18.74	18.54	18.29
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	19.61	19.00	19.09	19.36	18.94	19.13	19.12	18.72
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	17.52	16.91	16.65	17.36	16.67	17.09	17.59	16.97
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	18.19	17.38	17.10	18.14	17.20	17.44	18.41	17.40
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.21		0.14			0.21		

**Table 31:** Averages of sucrose % as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	20.38	20.58	20.58	20.53
20 kg N + 48 kg K <sub>2</sub> O/fad	20.90	21.21	20.96	21.15
40 kg N + 24 kg K <sub>2</sub> O/fad	19.33	19.61	19.63	19.58
40 kg N + 48 kg K <sub>2</sub> O/fad	19.76	20.45	20.26	20.18
60 kg N + 24 kg K <sub>2</sub> O/fad	18.41	19.26	18.55	18.51
60 kg N + 48 kg K <sub>2</sub> O/fad	18.95	19.80	19.25	19.23
80 kg N + 24 kg K <sub>2</sub> O/fad	16.73	17.58	17.21	17.35
80 kg N + 48 kg K <sub>2</sub> O/fad	17.26	18.26	17.93	17.68
F. test	*			
LSD 5 %	0.30			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	19.78	20.26	19.67	19.96
20 kg N + 48 kg K <sub>2</sub> O/fad	20.53	20.84	20.24	20.67
40 kg N + 24 kg K <sub>2</sub> O/fad	19.15	19.28	19.14	19.21
40 kg N + 48 kg K <sub>2</sub> O/fad	19.63	19.91	19.65	19.88
60 kg N + 24 kg K <sub>2</sub> O/fad	18.48	18.87	18.51	18.37
60 kg N + 48 kg K <sub>2</sub> O/fad	18.95	19.47	19.16	18.93
80 kg N + 24 kg K <sub>2</sub> O/fad	16.66	17.16	16.74	17.02
80 kg N + 48 kg K <sub>2</sub> O/fad	17.30	17.70	17.31	17.62
F. test	*			
LSD 5 %	0.17			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	19.58	20.04	19.54	19.77
20 kg N + 48 kg K <sub>2</sub> O/fad	20.33	20.85	20.23	20.38
40 kg N + 24 kg K <sub>2</sub> O/fad	18.84	19.36	19.16	19.08
40 kg N + 48 kg K <sub>2</sub> O/fad	19.34	20.01	19.71	19.78
60 kg N + 24 kg K <sub>2</sub> O/fad	18.18	18.98	18.68	18.23
60 kg N + 48 kg K <sub>2</sub> O/fad	18.76	19.43	19.11	18.66
80 kg N + 24 kg K <sub>2</sub> O/fad	16.95	17.56	17.11	17.24
80 kg N + 48 kg K <sub>2</sub> O/fad	17.55	18.03	17.61	17.81
F. test	*			
LSD 5 %	0.24			

**Table 32:** Averages of sucrose % as affected by planting dates, biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Planting dates  Biofertilization Treatments  Nitrogen & potassium levels	1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.							
	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine				
<b>2000/2001</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	19.93	20.36	20.16	20.23	20.83	20.80	21.00	20.83				
20 kg N + 48 kg K <sub>2</sub> O/fad	20.50	20.93	20.56	20.83	21.30	21.50	21.36	21.46				
40 kg N + 24 kg K <sub>2</sub> O/fad	19.70	19.60	19.50	19.56	18.96	19.63	19.76	19.60				
40 kg N + 48 kg K <sub>2</sub> O/fad	20.13	20.30	20.33	20.40	19.40	20.60	20.20	19.96				
60 kg N + 24 kg K <sub>2</sub> O/fad	18.66	19.50	18.43	18.80	18.16	19.03	18.66	18.23				
60 kg N + 48 kg K <sub>2</sub> O/fad	19.30	20.10	19.43	19.63	18.60	19.50	19.06	18.83				
80 kg N + 24 kg K <sub>2</sub> O/fad	17.10	18.10	17.30	17.60	16.36	17.06	17.13	17.10				
80 kg N + 48 kg K <sub>2</sub> O/fad	17.86	18.73	18.26	17.90	16.66	17.80	17.60	17.46				
F. test	*											
LSD 5 %	0.42											
Planting dates  Biofertilization Treatments  Nitrogen & potassium levels	1 <sup>st</sup> Sep.				1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.			
	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2001/2002</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	19.70	20.26	19.53	19.96	20.00	20.50	20.03	20.10	19.66	20.03	19.46	19.83
20 kg N + 48 kg K <sub>2</sub> O/fad	20.86	20.86	20.03	20.53	20.40	20.90	20.50	20.73	20.33	20.76	20.20	20.76
40 kg N + 24 kg K <sub>2</sub> O/fad	19.20	19.50	18.86	19.46	19.30	19.60	19.33	19.30	18.96	18.76	19.23	18.86
40 kg N + 48 kg K <sub>2</sub> O/fad	19.70	19.90	19.40	19.80	19.80	20.30	19.93	20.23	19.40	19.53	19.63	19.63
60 kg N + 24 kg K <sub>2</sub> O/fad	18.50	18.86	18.60	18.36	18.50	19.16	18.43	18.60	18.46	18.60	18.50	18.16
60 kg N + 48 kg K <sub>2</sub> O/fad	18.90	19.56	19.06	18.83	19.03	19.96	19.30	19.16	18.93	18.90	19.13	18.80
80 kg N + 24 kg K <sub>2</sub> O/fad	16.50	16.76	16.53	16.83	17.20	17.90	17.20	17.16	16.30	16.83	16.50	17.06
80 kg N + 48 kg K <sub>2</sub> O/fad	17.00	17.30	16.90	17.20	17.90	18.50	18.03	18.13	17.00	17.30	17.00	17.53
F. test	*											
LSD 5 %	0.28											
<b>2002/2003</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	19.76	20.33	19.56	19.83	19.56	20.00	19.76	19.86	19.43	19.80	19.30	19.63
20 kg N + 48 kg K <sub>2</sub> O/fad	20.03	20.96	19.83	20.10	20.46	20.76	20.43	20.60	20.50	20.83	20.43	20.46
40 kg N + 24 kg K <sub>2</sub> O/fad	18.43	19.50	19.00	19.23	18.90	19.20	19.00	19.10	19.20	19.40	19.50	18.93
40 kg N + 48 kg K <sub>2</sub> O/fad	18.83	20.10	19.23	19.70	19.60	20.23	19.80	19.90	19.60	19.70	20.10	19.76
60 kg N + 24 kg K <sub>2</sub> O/fad	18.20	19.80	18.93	18.03	18.53	18.66	18.50	18.46	17.83	18.50	18.63	18.20
60 kg N + 48 kg K <sub>2</sub> O/fad	19.00	20.13	19.00	18.04	18.93	19.33	19.30	18.93	18.36	18.83	19.03	18.66
80 kg N + 24 kg K <sub>2</sub> O/fad	16.73	17.33	17.20	17.10	17.26	18.10	17.36	17.63	16.86	17.26	16.76	17.00
80 kg N + 48 kg K <sub>2</sub> O/fad	17.20	17.66	17.40	17.50	18.20	18.76	18.23	18.46	17.26	17.66	17.20	17.46
F. test	*											
LSD 5 %	0.42											

Referring to the effect of interaction among the three factors under investigation, it is clearly seen that this interaction was significant in the three seasons (Table 32). The highest percentages of sucrose (21.50, 20.90 and 20.96 %) were produced from planting beets on 1<sup>st</sup> November or October or September in addition application of Rhizobacterin treatment + 20 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively.

### **3.3- Apparent purity percentage (%):**

Data presented in Table 28 indicate the response of apparent purity % to planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels in 2000/2001, 2001/2002 and 2002/2003 seasons.

#### **Effect of planting dates:**

Respecting the effect of planting dates on purity %, it was reach to the level of significance at 5 % of probability in the third season only, but in the first and second seasons, this effect failed to reach the level of significance at 5 % of probability (Table 28). Planting sugar beet on 1<sup>st</sup> October gave the maximum values of juice purity %, which records were 84.95, 82.47 and 85.64 % in the first, second and third seasons, respectively. Whereas, the minimum ones (84.44, 79.36 and 81.15 % in the first, second and third seasons, respectively) were obtained in view of plating beets on 1<sup>st</sup> November in the first and second seasons, but in the third season its produced from planting on 1<sup>st</sup> September. The favorable effect of planting sugar beet on 1<sup>st</sup> October on purity % might be backed to the more suitable all environmental conditions during this period to formation more photosynthates products, translocation and accumulation sucrose in storage roots. Similar findings are acceptable with those supported by Leilah and Nasr (1992), Ghonema (1998) and Abo-Salama and EL-Sayiad (2000).

#### **Effect of biofertilization treatments:**

As shown from data presented in Table 28, apparent purity % did not responded due to biofertilization treatments in the first and second seasons, while in the third season there was a significant response. It can be detected that inoculation soil of beets fields with Rhizobacterin biofertilizer produced the highest values of juice purity %, where findings were 85.83 and 84.36 in the first and third seasons, respectively. In contrast with that chick treatment (without biofertilization) gave the highest average of this character (81.14 %) in the second season only. Such light increases in apparent purity % due to biofertilization treatment certainly reflected to the role of biofertilizers especially Rhizobacterin in improving growth and dry matter accumulation, consequently enhancement sucrose content and reduction of impurity parameters in roots. Sultan *et al.* (1999), Bassal *et al.* (2001) and Maareg and Sohir, Badr (2001) confirming these results.

### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to decrease juice purity % from 90.94 to 83.62, 78.54 and 78.40 % as average of the three seasons. Similar results are in agreement with those obtained by Azzazy (1998), Attia *et al.* (1999), Mahasen, Fahmi (1999), Abd EL-Moneim (2000), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase purity % from 82.19 to 83.55 % as average during the three seasons. Kandil *et al.* (2002 a) came to similar trend.

The tabulated data in Table 28 reveal that nitrogen and potassium combination levels had a significant effect on apparent purity % in the three seasons of study. Raising nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad cleared a remarkable reduction in juice purity % in all seasons. The highest values of purity % were recorded by fertilizing beet plants with 20 kg N + 24 kg K<sub>2</sub>O/fad in the first season and by 20 kg N + 48 kg K<sub>2</sub>O/fad in the second and third seasons. The corresponding data of its were 93.86, 89.55 and 90.16 % in the first, second and third season, respectively. The reduction in purity % owing to increase nitrogen fertilizer levels can be attributed to its role in increasing impurity substances such as proteins and alpha amino acid, and hence decreasing juice purity %. Similar results are in line with recorded by Abou-Amou *et al.* (1996).

### **Effect of interactions:**

With regard to the interaction between planting dates X nitrogen and potassium combination levels on juice purity %, it was significant in the three growing seasons (Table 33). In the first season, the highest value of purity % (94.90 %) resulted from planting on 1<sup>st</sup> November and application of 20 kg N + 24 kg K<sub>2</sub>O/fad. While, in the second season the highest one (90.12 %) was obtained from planting on 1<sup>st</sup> September and application of 20 kg N + 48 kg K<sub>2</sub>O/fad. On the other hand, in the third season the highest one (92.98 %) was produced from planting on 1<sup>st</sup> October and addition of 20 kg N + 24 kg K<sub>2</sub>O/fad.

## **4. YIELD CHARACTERS:**

### **4.1- Root yield (t/fad):**

Means of root yield (t/fad) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels in the three seasons of this experimentation are listed in Table 34.

### **Effect of planting dates:**

Planting dates of sugar beet exhibited significant effect on root yield in the three seasons of study (Table 34). Generally, the optimum planting date was on 1<sup>st</sup> October so that produced the highest values of root yield, which results were 15.500, 21.596 and 21.278 t/fad in the first, second and third seasons, respectively. On the contrast, the lowest means of root yield (14.573, 20.709 and

**Table 33:** Averages of apparent purity % as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	92.82	94.90	88.82	89.66	87.38	89.24	92.98	87.05
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	93.10	94.23	90.12	89.91	88.61	88.17	92.70	89.60
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	85.32	86.11	83.14	82.50	80.30	81.08	84.89	84.29
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	85.22	82.98	83.85	83.90	81.37	80.03	86.33	84.10
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	76.98	76.16	76.52	76.89	75.53	76.65	79.37	78.71
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	82.98	82.99	76.32	78.65	75.68	78.79	80.01	79.40
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	78.22	77.27	70.74	78.66	72.59	77.56	84.390	78.21
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	84.98	80.88	76.40	79.61	73.43	77.68	74.41	77.78
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	2.07		1.51			1.83		

19.404 t/fad in the first, second and third seasons, respectively) were achieved when delaying planting up to 1<sup>st</sup> November in the first and third seasons and on 1<sup>st</sup> September in the second season. The desirable effect of planting sugar beet on 1<sup>st</sup> October on root yield might be ascribed to the reasonable environmental conditions during this period such as temperature, relative humidity (Table 2), day length and light intensity which allow to rapid germination, establishment, vegetative growth, development and ripening consequently increasing dry matter accumulation, yield components as well as root yield per unit area. These results are in agreement with those reported by Badawi (1985), EL-Kassaby and Leilah (1992 b), Badawi *et al.* (1995), Ghonema (1998), Abdou (2000), Abo-Salama and EL-Sayiad (2000) and Kandil *et al.* (2002 c).

#### **Effect of biofertilization treatments:**

The collected data in Table 34 show that there were remarkable significant differences among biofertilization treatments on root yield per faddan during the three growing seasons. Noteworthy, Rhizobacterin biofertilizer was the best treatment among other biofertilization treatments, which resulted in the maximum root yield (16.127, 22.485 and 21.887 t/fad) in the first, second and third seasons, respectively. Furthermore, it exceeded control treatment (without biofertilization) by 14.61, 20.40 and 17.83 % in the first, second and third seasons, respectively. It was followed by the mixture of Rhizobacterin + Cerialine as biofertilizers, while Cerialine biofertilizer came in the third rank with related to its effect on root yield in all seasons of this study. This effect of biofertilization treatments expressly Rhizobacterin biofertilizer may be ascribed to its role in improving plant growth, vigor of plant and yields through fixing atmospheric nitrogen and mineralization and/or mineralizing organic compounds as well as release of certain growth regulators, stimulatory compounds and nutrients in soil by the introduced organisms. Similar results were in coincidence with those fixed by EL-Badry and EL-Bassel (1993), Favilli *et al.* (1993), Cakmakci *et al.* (1999), Cakmakci *et al.* (2001), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

#### **Effect of nitrogen and potassium combination levels:**

With expecting the effect of nitrogen fertilizer levels on root yield, increasing its levels from 20 to 40, 60 and 80 kg N/fad tended to increase root yield from 11.711 to 17.109, 22.807 and 23.682 t/fad as average of the three growing seasons. Noteworthy, increasing nitrogen levels from 60 to 80 kg caused an increase in root yield amounted by 3.836 %. On the other hand, increasing nitrogen levels from 20 to 40 kg or from 40 to 60 kg N/fad caused increasing in root yield amounted by 46.093 and 33.304 %, respectively. Similar findings were established by other workers including Attia *et al.* (1999), EL-Hawary (1999), Abd EL-Moneim (2000), EL-Shahawy *et al.* (2002) and Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

**Table 34:** Averages of root and top yields (t/fad) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Root yield (t/fad)			Top yield (t/fad)		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	20.709	20.595	-	8.712	8.588
1 <sup>st</sup> October	15.500	21.596	21.278	9.594	8.907	8.919
1 <sup>st</sup> November	14.573	20.753	19.404	8.565	8.469	9.323
F. test	*	*	*	*	*	*
LSD 5%		0.231	0.699		0.263	0.200
<b>B: Biofertilization treatments:</b>						
Without	14.071	18.674	18.574	8.531	7.999	8.256
Rhizobacterin	16.127	22.485	21.887	9.727	9.194	9.581
Cerialine	14.700	20.901	20.215	8.822	8.658	8.751
Rhizobacterin+Cerialine	15.248	22.018	21.028	9.238	8.933	9.185
F. test	*	*	*	*	*	*
LSD 5%	0.212	0.211	0.331	0.066	0.093	0.046
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	9.208	11.322	11.099	6.260	4.764	5.364
20 kg N + 48 kg K <sub>2</sub> O/fad	10.704	14.103	13.829	7.108	6.281	6.474
40 kg N + 24 kg K <sub>2</sub> O/fad	12.412	17.322	17.254	7.875	7.097	7.763
40 kg N + 48 kg K <sub>2</sub> O/fad	14.246	21.203	20.218	8.654	8.631	8.887
60 kg N + 24 kg K <sub>2</sub> O/fad	16.396	24.544	23.369	9.496	9.656	9.729
60 kg N + 48 kg K <sub>2</sub> O/fad	19.392	26.808	26.332	11.283	11.178	11.354
80 kg N + 24 kg K <sub>2</sub> O/fad	18.296	25.694	24.668	10.426	10.544	10.406
80 kg N + 48 kg K <sub>2</sub> O/fad	19.637	27.158	26.637	11.533	11.419	11.568
F. test	*	*	*	*	*	*
LSD 5%	0.145	0.151	0.310	0.082	0.080	0.071

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase root yield from 17.632 to 20.022 t/fad as average of the three seasons. Similar findings were established by other workers including EL-Moursy *et al.* (1998), Selim and EL-Ghinbihi (1999), EL-Zayat (2000), Sohier, Ouda (2001) and Kandil *et al.* (2002 a).

Concerning the effect of nitrogen and potassium combination levels on root yield (t/fad), it is clearly seen that increasing these levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad significantly increased root yield in all seasons of this research (Table 34). It can be easily stated that gradual and conspicuous increases in root yield were observed as a result of increasing nitrogen and potassium combination levels in all seasons. The highest yield of roots per faddan was produced from fertilizing beet plants with 80 kg N + 48 kg K<sub>2</sub>O/fad, which recorded data were 19.637, 27.158 and 26.637 t/fad in the first, second and third seasons, respectively. It was followed by application of 60 kg N + 48 kg K<sub>2</sub>O/fad at the very least differences in comparison with other applications. In contrast, application the lowest level of nitrogen and potassium combinations (20 kg N + 24 kg K<sub>2</sub>O/fad) gave the lowest values of root yield (9.208, 11.322 and 11.099 t/fad) in the first, second and third seasons, respectively. The increase in root yield due to application of nitrogen and potassium fertilization can be explained through the fact that nitrogen and potassium has a vital role in building up metabolites, activating enzymes and carbohydrates accumulation which transferred from leaves to developing roots which in turn enhanced root length, diameter as well as root fresh weight and finally root yield per unit area. Badawi *et al.* (1995), Samia, EL-Maghraby *et al.* (1998), EL-Shafai (2000), EL-Harriri and Mirvat, Gobarh (2001) recorded similar tendency.

#### **Effect of interactions:**

The effect of interaction between planting dates X biofertilization treatments on root yield was significant in the first and second seasons only. The optimum treatment that produced the highest values of root yield (16.900 and 23.054 t/fad) was planting on 1<sup>st</sup> October and utilization Rhizobacterin treatment in the first and second seasons, respectively (Table 35). On the other side, the lowest values (13.833 and 18.512 t/fad) were followed from planting on 1<sup>st</sup> November and left soil without biofertilization (control treatment) in the first and second seasons, respectively. Similar results were established by Kandil *et al.* (2002 c).

The interaction between planting dates X nitrogen and potassium combination levels was significant on root yield in the three seasons (Table 36). The highest values of root yield (20.217, 27.583 and 27.277 t/fad) were produced from planting beets on 1<sup>st</sup> October in combination with 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. On the contrary of that, the lowest ones (8.875, 10.850 and 10.246 t/fad) accompanied with planting on 1<sup>st</sup> November and

application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. Similar results were established by Badawi *et al.* (1995), Azzazy (1998) and Kandil *et al.* (2002 c).

The effect of interaction between biofertilization treatments X nitrogen and potassium combination levels on root yield was significant in the three seasons. The optimum treatment that produced the highest values of root yield was utilization Rhizobacterin combination with 80 kg N + 48 kg K<sub>2</sub>O/fad, where its results were 21.050, 28.978 and 28.280 t/fad in the first, second and third seasons, respectively (Table 37). It was followed by the treatment of using Rhizobacterin plus 60 kg N + 48 kg K<sub>2</sub>O/fad with lower differences compared with other treatments in all growing seasons. These results were reported by Favilli *et al.* (1993), Sultan *et al.* (1999), Bassal *et al.* (2001), Kandil *et al.* (2002 c), Soha, Khalil (2002) and Ramadan *et al.* (2003).

With connection the effect of the triple interaction on root yield (t/fad), it was significant in the three seasons of study (Table 38). The highest means of root yield (21.967, 29.367 and 29.013 t/fad) were resulted from planting sugar beet during the first of October and utilization of Rhizobacterin in addition to 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. The best interaction ranked after formerly treatment was planting on 1<sup>st</sup> October + Rhizobacterin + 60 kg N + 48 kg K<sub>2</sub>O/fad in all growing seasons. Abdou (2001) obtained results partially like this direction.

#### **4.2- Top yield (t/fad):**

Data related to the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on top yield (t/fad) during of 2000/2001, 2001/2002 and 2002/2003 seasons are shown in Table 34.

##### **Effect of planting dates:**

Planting dates had a significant effect on top yield (t/fad) during the three seasons of study (Table 34). By Dwelling obtained data, the highest values of top yield (9.594, 8.907 and 9.323 t/fad in the first, second and third seasons, respectively) could be obtained from planting beets on 1<sup>st</sup> October in the first and second seasons, but from 1<sup>st</sup> November in the third season. On contrary of that, the lowest means in this terms (8.565, 8.469 and 8.588 t/fad in the first, second and third seasons, respectively) were obtained from planting on 1<sup>st</sup> November in the first and second seasons and on 1<sup>st</sup> September in the third one. This enhancing in top yield/fad owing to planting beets on 1<sup>st</sup> October may be attributed to corresponding environmental conditions in order to maximum sugar beet growth and development. These results are in accordance with those referred by Badawi (1985), EL-Kassaby and Leilah (1992 b), Badawi *et al.* (1995), Abd EL-Gawad *et al.* (2000), Abdou (2000) and Kandil *et al.* (2002 c).

**Table 35:** Averages of root yield (t/fad) as affected by planting dates and biofertilization treatments in the first and second seasons.

Seasons	2000/2001		2001/2002		
Planting dates	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
Biofertilization treatments					
Without	14.308	13.833	18.700	18.808	18.512
Rhizobacterin	16.900	15.354	22.167	23.054	22.233
Cerialine	15.008	14.392	20.338	21.663	20.704
Rhizobacterin+Cerialine	15.783	14.712	21.633	22.858	21.562
F. test	*		*		
LSD 5 %	0.302		0.366		

**Table 36:** Averages of root yield (t/fad) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
NK levels								
20 kg N + 24 kg K <sub>2</sub> O/fad	9.542	8.875	11.331	11.783	10.850	11.275	11.777	10.246
20 kg N + 48 kg K <sub>2</sub> O/fad	10.942	10.467	13.942	14.675	13.692	14.158	14.522	12.809
40 kg N + 24 kg K <sub>2</sub> O/fad	12.633	12.192	16.942	18.433	16.592	17.379	18.271	16.112
40 kg N + 48 kg K <sub>2</sub> O/fad	14.708	13.783	20.317	22.217	21.072	20.201	21.492	18.960
60 kg N + 24 kg K <sub>2</sub> O/fad	17.250	15.542	24.058	24.942	24.633	23.532	24.007	22.568
60 kg N + 48 kg K <sub>2</sub> O/fad	19.967	18.812	26.525	27.217	26.683	26.839	27.039	25.118
80 kg N + 24 kg K <sub>2</sub> O/fad	18.742	17.850	25.642	25.917	25.525	24.221	25.837	23.944
80 kg N + 48 kg K <sub>2</sub> O/fad	20.217	19.058	26.917	27.583	26.975	27.158	27.277	25.477
F. test	*		*			*		
LSD 5 %	0.204		0.262			0.537		

**Table 37:** Averages of root yield (t/fad) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments <i>NK levels</i>	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	8.650	9.783	9.017	9.383
20 kg N + 48 kg K <sub>2</sub> O/fad	9.867	11.600	10.300	11.050
40 kg N + 24 kg K <sub>2</sub> O/fad	11.633	13.133	12.500	12.383
40 kg N + 48 kg K <sub>2</sub> O/fad	13.500	14.967	13.783	14.733
60 kg N + 24 kg K <sub>2</sub> O/fad	15.367	18.033	15.783	16.400
60 kg N + 48 kg K <sub>2</sub> O/fad	18.167	20.867	18.933	19.600
80 kg N + 24 kg K <sub>2</sub> O/fad	16.917	19.583	18.100	18.583
80 kg N + 48 kg K <sub>2</sub> O/fad	18.467	21.050	19.183	19.850
F. test	*			
LSD 5 %	0.298			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	10.211	12.644	10.811	11.622
20 kg N + 48 kg K <sub>2</sub> O/fad	12.567	15.078	13.944	14.822
40 kg N + 24 kg K <sub>2</sub> O/fad	15.111	18.533	17.444	18.200
40 kg N + 48 kg K <sub>2</sub> O/fad	18.511	22.533	21.056	22.711
60 kg N + 24 kg K <sub>2</sub> O/fad	21.633	26.189	24.189	26.167
60 kg N + 48 kg K <sub>2</sub> O/fad	24.122	28.567	26.722	27.822
80 kg N + 24 kg K <sub>2</sub> O/fad	22.778	27.356	25.933	26.711
80 kg N + 48 kg K <sub>2</sub> O/fad	24.456	28.978	27.111	28.089
F. test	*			
LSD 5 %	0.302			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	9.928	12.194	10.726	11.550
20 kg N + 48 kg K <sub>2</sub> O/fad	12.947	14.581	13.562	14.228
40 kg N + 24 kg K <sub>2</sub> O/fad	15.484	18.880	16.753	17.898
40 kg N + 48 kg K <sub>2</sub> O/fad	18.380	21.917	19.856	20.718
60 kg N + 24 kg K <sub>2</sub> O/fad	21.668	24.712	23.262	23.833
60 kg N + 48 kg K <sub>2</sub> O/fad	23.963	27.994	26.311	27.060
80 kg N + 24 kg K <sub>2</sub> O/fad	21.991	26.534	24.553	25.591
80 kg N + 48 kg K <sub>2</sub> O/fad	24.232	28.280	26.693	27.344
F. test	*			
LSD 5 %	0.616			

**Table 38:** Averages of root yield (t/fad) as affected by planting dates, biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Planting dates	1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.							
Biofertilization Treatments	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine				
Nitrogen & potassium levels												
<b>2000/2001</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	9.033	10.067	9.400	9.667	8.267	9.500	8.633	9.100				
20 kg N + 48 kg K <sub>2</sub> O/fad	10.067	11.967	10.533	11.200	9.667	11.233	10.067	10.900				
40 kg N + 24 kg K <sub>2</sub> O/fad	11.333	14.233	12.033	12.933	11.933	12.033	12.967	11.833				
40 kg N + 48 kg K <sub>2</sub> O/fad	13.700	15.833	13.767	15.533	13.300	14.100	13.800	13.933				
60 kg N + 24 kg K <sub>2</sub> O/fad	15.900	19.000	16.600	17.500	14.833	17.067	14.967	15.300				
60 kg N + 48 kg K <sub>2</sub> O/fad	18.500	21.767	19.500	21.100	17.833	19.967	18.367	19.100				
80 kg N + 24 kg K <sub>2</sub> O/fad	17.100	20.367	18.533	18.967	16.733	18.800	17.667	18.200				
80 kg N + 48 kg K <sub>2</sub> O/fad	18.833	21.967	19.700	20.367	18.100	20.133	18.667	19.333				
F. test	*											
LSD 5 %	0.408											
Planting dates	1 <sup>st</sup> Sep.				1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.			
Biofertilization Treatments	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
Nitrogen & potassium levels												
<b>2001/2002</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	10.167	12.567	10.933	11.667	10.433	13.633	11.000	12.067	10.033	11.733	10.500	11.133
20 kg N + 48 kg K <sub>2</sub> O/fad	13.233	14.700	13.267	14.567	12.933	15.567	14.700	15.500	11.533	14.967	13.867	14.400
40 kg N + 24 kg K <sub>2</sub> O/fad	15.800	18.867	15.867	17.233	15.233	18.833	19.700	19.967	14.300	17.900	16.767	17.400
40 kg N + 48 kg K <sub>2</sub> O/fad	18.233	21.500	19.267	22.267	18.267	23.967	22.800	23.833	19.033	22.133	21.100	22.033
60 kg N + 24 kg K <sub>2</sub> O/fad	21.400	25.400	23.555	25.933	21.333	26.833	24.733	26.867	22.167	26.333	24.33	25.700
60 kg N + 48 kg K <sub>2</sub> O/fad	23.833	28.200	26.767	27.300	24.567	28.833	26.900	28.567	23.967	28.667	26.500	27.600
80 kg N + 24 kg K <sub>2</sub> O/fad	22.600	27.433	26.067	26.467	22.867	27.400	26.067	27.333	22.867	27.233	25.667	26.333
80 kg N + 48 kg K <sub>2</sub> O/fad	24.333	28.667	27.033	27.633	24.833	29.367	27.400	28.733	24.200	28.900	26.900	27.900
F. test	*											
LSD 5 %	0.523											
<b>2002/2003</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	10.543	12.117	10.847	11.593	10.533	12.820	11.523	12.233	8.707	11.647	9.807	10.823
20 kg N + 48 kg K <sub>2</sub> O/fad	13.497	14.747	13.937	14.450	13.907	15.173	14.173	14.833	11.437	13.823	12.577	13.400
40 kg N + 24 kg K <sub>2</sub> O/fad	16.33	19.040	17.153	17.020	16.217	20.073	18.100	18.693	13.933	17.527	15.007	17.980
40 kg N + 48 kg K <sub>2</sub> O/fad	18.943	22.110	19.820	19.930	18.957	23.340	20.770	22.900	17.240	20.300	18.977	19.323
60 kg N + 24 kg K <sub>2</sub> O/fad	21.680	24.567	23.920	23.960	22.073	25.933	23.480	24.543	21.250	23.637	22.387	22.997
60 kg N + 48 kg K <sub>2</sub> O/fad	23.950	28.683	27.073	27.650	24.547	28.833	26.763	28.013	23.393	26.467	25.097	25.517
80 kg N + 24 kg K <sub>2</sub> O/fad	19.577	26.743	25.220	25.343	23.737	27.750	24.967	26.897	22.660	25.110	23.473	24.533
80 kg N + 48 kg K <sub>2</sub> O/fad	24.173	29.013	27.353	28.093	24.867	29.013	27.020	28.207	23.657	26.813	25.707	25.733
F. test	*											
LSD 5 %	1.064											

### **Effect of biofertilization treatments:**

In the three growing seasons, biofertilization treatments caused a significant increase in top yield per faddan. The optimum biofertilization treatments was Rhizobacterin treatment, thereby its caused significant increase and the greatest values of top yield, which registered data were 9.727, 9.194 and 9.581 t/fad in the first, second and third seasons, respectively (Table 34). However, Rhizobacterin + Cerialine treatment came in the second rank after aforementioned treatment, then Cerialine treatment with concern its effect on top yield in the three seasons. On the other hand, the lowest averages of this character (8.531, 7.999 and 8.256 t/fad) were arised from control treatment (without biofertilization) in the first, second and third seasons, respectively. This progressive effect of biofertilizers (Rhizobacterin and Cerialine) may be due to its role in enhancing growth of sugar beet plants. Moreover, to the effect of nitrogen which produced via bacteria in addition to GA<sub>3</sub> and IAA that stimulate vegetative growth and consequently top yield per faddan. A positive association between biofertilization treatments and top yield per faddan has been reported by Abo EL-Goud (2000), Bassal *et al.* (2001), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase top yield from 6.042 to 8.151, 10.449 and 10.983 t/fad as average during the three seasons, respectively. Similar trend was established by Attia *et al.* (1999), EL-Hawary (1999), Abd EL-Moneim (2000), Sohier, Ouda (2001), Kandil *et al.* (2002 c), Nemeat Alla *et al.* (2002) and Ramadan *et al.* (2003).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase top yield from 8.282 to 9.531 t/fad as average in the three seasons. EL-Moursy *et al.* (1998), Selim and EL-Ghinbihi (1999), EL-Zayat (2000), Sohier, Ouda (2001) and Kandil *et al.* (2002 a) came to like trend.

As shown from tabulated data in Table 34, nitrogen and potassium combination levels exhibited remarkable differences on top yield (t/fad) in the three seasons. The highest level of nitrogen and potassium combination (80 kg N + 48 kg K<sub>2</sub>O/fad) led to record the greatest means of top yield, which were 11.533, 11.419 and 11.568 t/fad in the first, second and third seasons, respectively. The best application followed by previous level was fertilizing beet plant with 60 kg N + 48 kg K<sub>2</sub>O/fad, which the differences between them were fewer than those among other levels in all growing seasons of this study. Whereas, application of 20 kg N + 24 kg K<sub>2</sub>O/fad resulted in the lowest values of this trait, 6.560, 4.764 and 5.364 in the first, second and third seasons, respectively. Further addition of nitrogen and potassium stimulates top growth and cause canopy regeneration to continuous late into the season and directs photosynthates into top production rather than root storage. Also it is well known that nitrogen and potassium fertilizers increase dry matter accumulation as previously mentioned. These findings are in great accordance with those confirmed

by EL-Hawary (1999), Sultan *et al.* (1999), EL-Shafai (2000) and EL-Harriri and Mirvat, Gobarh (2001).

### **Effect of interactions:**

The response of top yield to the interaction between planting dates X biofertilization treatments was significant in the three seasons of this study (Table 39). It can be considered that the highest values of top yield were obtained due to planting on 1<sup>st</sup> October (in the first season) or on 1<sup>st</sup> September (in the second season) or on 1<sup>st</sup> November (in the third season) in addition to the usage of Rhizobacterin biofertilizer, where they were 10.300, 9.375 and 9.915 t/fad in the first, second and third seasons, respectively. These findings are in line with those stated by Kandil *et al.* (2002 c).

The interaction between planting dates X nitrogen and potassium combination levels showed significant effect on top yield in the three seasons (Table 40). It can be stated that the highest values of top yield (12.100, 11.558 and 11.984 t/fad) produced from planting on 1<sup>st</sup> October (in the first and second seasons) or on 1<sup>st</sup> November (in the third season) and application of 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. These findings are in line with those stated by Badawi *et al.* (1995), Azzazy (1998) and Kandil *et al.* (2002 c).

The response of sugar beet top yield to the interaction between biofertilization treatments X nitrogen and potassium combination levels was significant in the three seasons (Table 41). The highest values of top yield were recorded due to usage of Rhizobacterin treatment and addition of 80 kg N + 48 kg K<sub>2</sub>O/fad, where they were 12.333, 11.956 and 12.456 t/fad in the first, second and third seasons, respectively. However, application of Rhizobacterin + 60 kg N + 48 kg K<sub>2</sub>O/fad combination treatment induced the preferable results subsequent to the aforementioned treatment with fewer differences between them. These findings are in line with those stated by Sultan *et al.* (1999), Bassal *et al.* (2001), Kandil *et al.* (2002 c), Soha, Khalil (2002) and Ramadan *et al.* (2003).

The effect of the interaction among all factors under study on top yield was significant in the three seasons. It can be concluded that from data illustrated in Table 42, the highest values of top yield (12.467, 12.303 and 13.033 t/fad in the first, second and third seasons, respectively) were produced from planting on the first of October (in the first season) or September (in the second season) or November (in the third season) in addition to utilization of Rhizobacterin biofertilizer + 80 kg N + 48 kg K<sub>2</sub>O/fad. Abdou (2001) obtained results parallel with those reported in this study.

**Table 39:** Averages of top yield (t/fad) as affected by planting dates and biofertilization treatments during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates Biofertilization treatments	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Without</b>	8.958	8.104	7.771	8.283	7.942	7.509	8.543	8.717
<b>Rhizobacterin</b>	10.300	9.154	9.375	9.304	8.904	9.513	9.313	9.915
<b>Cerialine</b>	9.260	8.383	8.654	8.917	8.404	8.268	8.790	9.195
<b>Rhizobacterin+Cerialine</b>	9.859	8.617	9.050	9.125	8.625	9.061	9.029	9.465
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.093		0.161			0.080		

**Table 40:** Averages of top yield (t/fad) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
Planting dates NK levels	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	6.821	5.700	4.792	5.108	4.392	5.181	4.911	6.000
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	7.650	6.567	6.267	6.542	6.033	6.199	6.483	6.740
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	8.400	7.350	7.050	7.412	6.825	7.684	7.573	8.030
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	9.042	8.267	8.508	8.750	8.633	8.403	9.085	9.174
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	9.983	9.008	9.225	10.117	9.625	9.252	9.914	10.021
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	11.842	10.725	11.400	11.258	10.875	10.754	11.550	11.758
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	10.918	9.933	10.900	10.508	10.225	10.192	10.149	10.876
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	12.100	10.967	11.558	11.558	11.142	11.037	11.683	11.984
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.116		0.140			0.123		

**Table 41:** Averages of top yield (t/fad) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	5.867	6.683	6.158	6.333
20 kg N + 48 kg K <sub>2</sub> O/fad	6.733	7.600	6.933	7.167
40 kg N + 24 kg K <sub>2</sub> O/fad	7.317	8.517	7.717	7.950
40 kg N + 48 kg K <sub>2</sub> O/fad	7.917	9.350	8.483	8.867
60 kg N + 24 kg K <sub>2</sub> O/fad	8.583	10.100	9.333	9.967
60 kg N + 48 kg K <sub>2</sub> O/fad	10.833	12.067	10.850	11.383
80 kg N + 24 kg K <sub>2</sub> O/fad	9.867	11.168	10.000	10.668
80 kg N + 48 kg K <sub>2</sub> O/fad	11.133	12.333	11.100	11.567
F. test	*			
LSD 5 %	0.164			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	4.300	5.111	4.678	4.967
20 kg N + 48 kg K <sub>2</sub> O/fad	5.911	6.522	6.256	6.433
40 kg N + 24 kg K <sub>2</sub> O/fad	6.467	7.522	7.111	7.289
40 kg N + 48 kg K <sub>2</sub> O/fad	7.533	9.622	8.533	8.833
60 kg N + 24 kg K <sub>2</sub> O/fad	8.611	10.222	9.722	10.067
60 kg N + 48 kg K <sub>2</sub> O/fad	10.533	11.633	11.100	11.444
80 kg N + 24 kg K <sub>2</sub> O/fad	9.800	10.967	10.611	10.800
80 kg N + 48 kg K <sub>2</sub> O/fad	10.833	11.956	11.256	11.633
F. test	*			
LSD 5 %	0.160			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	4.909	5.787	5.258	5.502
20 kg N + 48 kg K <sub>2</sub> O/fad	6.118	6.743	6.423	6.612
40 kg N + 24 kg K <sub>2</sub> O/fad	7.128	8.348	7.626	7.949
40 kg N + 48 kg K <sub>2</sub> O/fad	8.393	9.472	8.626	9.059
60 kg N + 24 kg K <sub>2</sub> O/fad	9.066	10.311	9.682	9.857
60 kg N + 48 kg K <sub>2</sub> O/fad	10.341	12.293	10.996	11.786
80 kg N + 24 kg K <sub>2</sub> O/fad	9.496	11.236	10.199	10.693
80 kg N + 48 kg K <sub>2</sub> O/fad	10.600	12.456	11.198	12.020
F. test	*			
LSD 5 %	0.140			

**Table 42:** Averages of top yield (t/fad) as affected by planting dates, biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Planting dates	1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.							
	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine				
Biofertilization Treatments												
Nitrogen & potassium levels												
<b>2000/2001</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	6.333	7.333	6.717	6.900	5.400	6.033	5.600	5.767				
20 kg N + 48 kg K <sub>2</sub> O/fad	6.967	8.400	7.533	7.700	6.500	6.800	6.333	6.633				
40 kg N + 24 kg K <sub>2</sub> O/fad	7.600	9.500	8.000	8.500	7.033	7.533	7.433	7.400				
40 kg N + 48 kg K <sub>2</sub> O/fad	8.067	10.233	8.500	9.367	7.767	8.467	8.467	8.367				
60 kg N + 24 kg K <sub>2</sub> O/fad	8.633	10.800	9.633	10.867	8.533	9.400	9.033	9.067				
60 kg N + 48 kg K <sub>2</sub> O/fad	11.767	12.200	11.433	11.967	9.900	11.933	10.267	10.800				
80 kg N + 24 kg K <sub>2</sub> O/fad	10.300	11.470	10.500	11.403	9.433	10.867	9.500	9.933				
80 kg N + 48 kg K <sub>2</sub> O/fad	12.000	12.467	11.767	12.167	10.267	12.200	10.433	10.967				
F. test	*											
LSD 5 %	0.232											
Planting dates	1 <sup>st</sup> Sep.				1 <sup>st</sup> Oct.				1 <sup>st</sup> Nov.			
	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
Biofertilization Treatments												
Nitrogen & potassium levels												
<b>2001/2002</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	4.400	5.100	4.767	4.900	4.700	5.333	5.100	5.300	3.800	4.900	4.167	4.700
20 kg N + 48 kg K <sub>2</sub> O/fad	5.933	6.467	6.300	6.367	6.067	6.900	6.467	6.733	5.733	6.200	6.000	6.200
40 kg N + 24 kg K <sub>2</sub> O/fad	6.367	7.733	6.933	7.167	6.733	7.667	7.500	7.767	6.300	7.167	6.900	6.933
40 kg N + 48 kg K <sub>2</sub> O/fad	7.033	9.767	8.367	8.867	7.800	9.433	8.800	8.967	7.767	9.667	8.433	8.667
60 kg N + 24 kg K <sub>2</sub> O/fad	7.467	10.133	9.267	10.033	9.267	10.533	10.267	10.400	9.100	10.000	9.633	9.767
60 kg N + 48 kg K <sub>2</sub> O/fad	10.403	11.967	11.433	11.800	10.833	11.700	11.067	11.433	10.367	11.233	10.800	11.100
80 kg N + 24 kg K <sub>2</sub> O/fad	9.93	11.533	10.833	11.300	9.700	10.900	10.700	10.733	9.767	10.467	10.300	10.367
80 kg N + 48 kg K <sub>2</sub> O/fad	10.633	12.303	11.333	11.967	11.167	11.967	11.433	11.667	10.700	11.600	11.000	11.267
F. test	*											
LSD 5 %	0.280											
<b>2002/2003</b>												
20 kg N + 24 kg K <sub>2</sub> O/fad	4.657	5.687	5.017	5.363	4.640	5.103	4.840	5.060	5.430	6.570	5.917	6.083
20 kg N + 48 kg K <sub>2</sub> O/fad	5.693	6.420	6.127	6.557	6.123	6.793	6.420	6.597	6.537	7.017	6.723	6.683
40 kg N + 24 kg K <sub>2</sub> O/fad	6.543	8.803	7.473	7.917	7.167	7.963	7.363	7.800	7.673	8.277	8.040	8.130
40 kg N + 48 kg K <sub>2</sub> O/fad	7.397	9.453	7.830	8.933	8.847	9.637	8.897	8.960	8.937	9.327	9.150	9.283
60 kg N + 24 kg K <sub>2</sub> O/fad	8.143	10.463	8.957	9.443	9.530	10.120	10.030	9.977	9.523	10.350	10.060	10.150
60 kg N + 48 kg K <sub>2</sub> O/fad	9.200	11.937	10.297	11.583	11.073	12.160	11.260	11.707	10.750	12.783	11.430	12.067
80 kg N + 24 kg K <sub>2</sub> O/fad	8.833	11.257	9.910	10.770	9.733	10.483	10.087	10.293	9.920	11.967	10.600	11.017
80 kg N + 48 kg K <sub>2</sub> O/fad	9.607	12.087	10.537	11.920	11.230	12.247	11.420	11.837	10.963	13.033	11.637	12.303
F. test	*											
LSD 5 %	0.246											

### **4.3- Sugar yield (t/fad):**

Means of sugar yield (t/fad) in response to planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels in the three seasons are presented in Table 43.

#### **Effect of planting dates:**

Significant differences between planting dates of sugar beet were found in the three seasons of study (Table 43). It can be considered that, the optimum planting date which gave the highest means of sugar yield i.e. 2.975, 4.111 and 4.035 t/fad in the first, second and third seasons, respectively were recorded from planting beets on 1<sup>st</sup> October. Inversely, planting sugar beet on 1<sup>st</sup> November resulted in the lowest values of this trait, where results were 2.754, 3.840 and 3.603 t/fad in the first, second and third seasons, respectively. This achievement in sugar yield (t/fad) may be backed to the positive effect of planting sugar beet during the first October on fresh weight/plant, root yield and sucrose %, which greatly affected sugar production per unit area. These results like to those reported by Badawi (1985), EL-Kassaby and Leilah (1992 b), Badawi *et al.* (1995), Abd EL-Gawad *et al.* (2000), Abdou (2000), Abo-Salama and EL-Sayiad (2000) and Kandil *et al.* (2002 c).

#### **Effect of biofertilization treatments:**

Concerning the effect of biofertilization treatments on sugar yield per faddan, it was significant in all growing seasons as shown in Table 43. It was noticeable that, inoculation soil of sugar beet field with Rhizobacterin was the most favorable biofertilization treatment and produced the highest averages of sugar yield per unit area. The corresponding data, with respect to the control treatment were 3.127, 4.263 and 4.179 t/fad in the first, second and third seasons, respectively. On the contrary, left soil without inoculation with biofertilizers (control treatment) had the opposite direction, which resulted in the lowest values of this character, 2.63, 3.467 and 3.434 t/fad in the first, second and third seasons, respectively. It was worthy to mention that, Rhizobacterin + Cerialine treatment came in the second rank, and then Cerialine treatment with regard to their effect on sugar yield in all growing seasons of this work. The trend of these results may be reflected to the considerable increase in root weight/plant, root yield/fad and sucrose % by biofertilization treatments (Rhizobacterin and Cerialine) as mentioned before. Similar trend of sugar yield per unit area was suggested by EL-Badry and EL-Bassel (1993), Cakmakci *et al.* (1999), Kandil *et al.* (2002 c) and Ramadan *et al.* (2003).

#### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40 and 60 kg N/fad tended to increase sugar yield from 2.388 to 3.353 and 4.308 t/fad as average of the three seasons, respectively. However, increasing nitrogen levels from 60 to 80 kg N/fad tended to decrease sugar yield from 4.308 to 4.123 t/fad as average over seasons. These results agree with those suggested by Attia *et al.* (1999),

**Table 43:** Averages of sugar yield (t/fad) and harvest index (HI) as affected by planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels during 2000/2001, 2001/2002 and 2002/2003 seasons.

Characters	Sugar yield (t/fad)			Harvest Index (HI)		
	2000/2001	2001/2002	2002/2003	2000/2001	2001/2002	2002/2003
<b>A: Planting dates:</b>						
1 <sup>st</sup> September	-	3.851	3.850	-	0.703	0.703
1 <sup>st</sup> October	2.975	4.111	4.035	0.614	0.706	0.704
1 <sup>st</sup> November	2.754	3.840	3.603	0.627	0.709	0.671
F. test	*	*	*	*	NS	*
LSD 5%		0.028	0.086		-	0.008
<b>B: Biofertilization treatments:</b>						
Without	2.630	3.467	3.434	0.620	0.700	0.689
Rhizobacterin	3.127	4.263	4.179	0.621	0.709	0.694
Cerialine	2.799	3.884	3.781	0.622	0.706	0.694
Rhizobacterin+Cerialine	2.901	4.122	3.924	0.620	0.710	0.694
F. test	*	*	*	NS	*	NS
LSD 5%	0.046	0.037	0.068	-	0.002	-
<b>C: Nitrogen and potassium combination levels:</b>						
20 kg N + 24 kg K <sub>2</sub> O/fad	1.889	2.258	2.193	0.596	0.704	0.674
20 kg N + 48 kg K <sub>2</sub> O/fad	2.255	2.904	2.829	0.601	0.691	0.681
40 kg N + 24 kg K <sub>2</sub> O/fad	2.426	3.327	3.299	0.612	0.709	0.689
40 kg N + 48 kg K <sub>2</sub> O/fad	2.875	4.196	3.989	0.622	0.711	0.694
60 kg N + 24 kg K <sub>2</sub> O/fad	3.069	4.558	4.332	0.633	0.718	0.706
60 kg N + 48 kg K <sub>2</sub> O/fad	3.749	5.132	5.006	0.632	0.705	0.699
80 kg N + 24 kg K <sub>2</sub> O/fad	3.156	4.345	4.255	0.637	0.709	0.702
80 kg N + 48 kg K <sub>2</sub> O/fad	3.499	4.752	4.733	0.630	0.704	0.697
F. test	*	*	*	*	*	*
LSD 5%	0.035	0.031	0.058	0.003	0.003	0.004

EL-Hawary (1999), Mahasen, Fahmi (1999), Abd EL-Moneim (2000), EL-Shahawy *et al.* (2002) and Ramadan *et al.* (2003).

Concerning the effect of potassium fertilizer levels, increasing its levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase sugar yield from 3.259 to 3.827 t/fad as average during the three seasons. This trend is in line with those supported by EL-Moursy *et al.* (1998), Selim and EL-Ghinbihi (1999), EL-Zayat (2000), Sohier, Ouda (2001) and Kandil *et al.* (2002 a).

From data in Table 43, it can be clearly seen that gross sugar yield (t/fad) was significantly affected by nitrogen and potassium combination levels in the three seasons. Remarkable increases in sugar yield were noticed as a results of raising nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 60 kg N + 48 kg K<sub>2</sub>O/fad in all seasons. The optimum nitrogen and potassium combination levels, which produced the greatest values of sugar yield was 60 kg N + 48 kg K<sub>2</sub>O/fad, where gave 3.749, 5.132 and 5.006 t/fad in the first, second and third seasons, respectively. Moreover, this combination increased sugar yield by 98.46, 127.28 and 128.27 % over application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. In other words, excess nitrogen application did not desirable, because it reduced the most quality parameters and sugar yield per unit area along with its critical effect in increasing environmental pollution. The increase in gross sugar yield per unit area due to application of nitrogen and potassium fertilizers can be explained through the fact that nitrogen and potassium has a vital role in improving all growth attributes and root weight per plant and per faddan as well as sucrose %, consequently increasing gross sugar yield per unit area. These results agree with those stated by Badawi *et al.* (1995), Samia, EL-Maghraby *et al.* (1998), EL-Hawary (1999), Sultan *et al.* (1999) and EL-Zayat (2000).

#### **Effect of interactions:**

With regard to the effect of interaction between planting dates X nitrogen and potassium combination level on sugar yield, it exerted significant response in the three seasons (Table 44). The highest values could be obtained for sugar yield (3.921, 5.275 and 5.172 t/fad) were produced as result of planting on 1<sup>st</sup> October and application of 60 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. On the other hand, the lowest ones (1.852, 2.144 and 2.004 t/fad) were resulted from planting on 1<sup>st</sup> November and application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. Kandil *et al.* (2002 c) confirmed these results.

A significant interaction between biofertilization treatments X nitrogen and potassium combination levels over planting dates on sugar yield t/fad is illustrated in Table 45 during the three seasons. The highest final yields of sugar which intend producer were obtained from inoculation soil with Rhizobacterin along with application of 60 kg N + 48 kg K<sub>2</sub>O/fad, where they were 4.134, 5.564 and 5.444 t/fad in the first, second and third seasons, respectively. It also considers that

**Table 44:** Averages of sugar yield (t/fad) as affected by planting dates and nitrogen & potassium fertilizer levels during the three seasons.

Seasons	2000/2001		2001/2002			2002/2003		
	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.	1 <sup>st</sup> Sept.	1 <sup>st</sup> Oct.	1 <sup>st</sup> Nov.
<b>Planting dates</b>								
<b>NK levels</b>								
<b>20 kg N + 24 kg K<sub>2</sub>O/fad</b>	1.926	1.852	2.253	2.378	2.144	2.242	2.332	2.004
<b>20 kg N + 48 kg K<sub>2</sub>O/fad</b>	2.267	2.242	2.870	3.030	2.811	2.867	2.987	2.634
<b>40 kg N + 24 kg K<sub>2</sub>O/fad</b>	2.475	2.377	3.265	3.573	3.144	3.313	3.482	3.102
<b>40 kg N + 48 kg K<sub>2</sub>O/fad</b>	2.986	2.763	4.004	4.462	4.121	3.938	4.277	3.753
<b>60 kg N + 24 kg K<sub>2</sub>O/fad</b>	3.256	2.881	4.471	4.661	4.540	4.415	4.452	4.130
<b>60 kg N + 48 kg K<sub>2</sub>O/fad</b>	3.921	3.577	5.067	5.275	5.054	5.139	5.172	4.705
<b>80 kg N + 24 kg K<sub>2</sub>O/fad</b>	3.283	3.022	4.273	4.506	4.260	4.149	4.550	4.065
<b>80 kg N + 48 kg K<sub>2</sub>O/fad</b>	3.682	3.326	4.604	5.007	4.644	4.740	5.026	4.434
<b>F. test</b>	*		*			*		
<b>LSD 5 %</b>	0.050		0.054			0.102		

**Table 45:** Averages of sugar yield (t/fad) as affected by biofertilization treatments and nitrogen & potassium fertilizer levels during the three seasons.

Biofertilization treatments NK levels	Without	Rhizobacterin	Cerialine	Rhizobacterin + Cerialine
<b>2000/2001</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	1.762	2.014	1.855	1.926
20 kg N + 48 kg K <sub>2</sub> O/fad	2.062	2.461	2.159	2.337
40 kg N + 24 kg K <sub>2</sub> O/fad	2.248	2.577	2.455	2.425
40 kg N + 48 kg K <sub>2</sub> O/fad	2.669	3.059	2.795	2.975
60 kg N + 24 kg K <sub>2</sub> O/fad	2.831	3.477	2.927	3.039
60 kg N + 48 kg K <sub>2</sub> O/fad	3.444	4.134	3.646	3.772
80 kg N + 24 kg K <sub>2</sub> O/fad	2.833	3.448	3.117	3.225
80 kg N + 48 kg K <sub>2</sub> O/fad	3.191	3.850	3.442	3.512
F. test	*			
LSD 5 %	0.071			
<b>2001/2002</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	2.021	2.564	2.128	2.321
20 kg N + 48 kg K <sub>2</sub> O/fad	2.582	3.143	2.824	3.065
40 kg N + 24 kg K <sub>2</sub> O/fad	2.895	3.576	3.342	3.497
40 kg N + 48 kg K <sub>2</sub> O/fad	3.634	4.489	4.142	4.519
60 kg N + 24 kg K <sub>2</sub> O/fad	4.000	4.944	4.477	4.810
60 kg N + 48 kg K <sub>2</sub> O/fad	4.573	5.564	5.122	5.269
80 kg N + 24 kg K <sub>2</sub> O/fad	3.796	4.696	4.343	4.547
80 kg N + 48 kg K <sub>2</sub> O/fad	4.232	5.130	4.694	4.952
F. test	*			
LSD 5 %	0.063			
<b>2002/2003</b>				
20 kg N + 24 kg K <sub>2</sub> O/fad	1.946	2.443	2.098	2.285
20 kg N + 48 kg K <sub>2</sub> O/fad	2.632	3.041	2.744	2.901
40 kg N + 24 kg K <sub>2</sub> O/fad	2.915	3.656	3.209	3.416
40 kg N + 48 kg K <sub>2</sub> O/fad	3.554	4.389	3.914	4.101
60 kg N + 24 kg K <sub>2</sub> O/fad	3.941	4.692	4.349	4.346
60 kg N + 48 kg K <sub>2</sub> O/fad	4.497	5.444	5.029	5.052
80 kg N + 24 kg K <sub>2</sub> O/fad	3.736	4.664	4.203	4.416
80 kg N + 48 kg K <sub>2</sub> O/fad	4.255	5.102	4.703	4.873
F. test	**			
LSD 5 %	0.117			

raising nitrogen level upon 60 kg N/fad caused significant decrease in sugar yield in all seasons. These results are accomplished with those reported by Sultan *et al.* (1999), Bassal *et al.* (2001), Soha, Khalil (2002) and Ramadan *et al.* (2003).

#### **4.4- Harvest index (HI):**

Data collected in Table 43 clear the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels on harvest index during 2000/2001, 2001/2002 and 2002/2003 seasons.

##### **Effect of planting dates:**

Planting dates manifested significant effect on harvest index in the first and third seasons only. As shown from data presented in Table 43, the highest means of harvest index (0.627, 0.709 and 0.704 in the first, second and third seasons, respectively) were obtained due to planting beets on 1<sup>st</sup> November in the first and second season, and on 1<sup>st</sup> October in the third season. It can be also noticed that, the differences between planting on 1<sup>st</sup> September or 1<sup>st</sup> October did not reach the level of significance in the second and third seasons.

##### **Effect of biofertilization treatments:**

The statistical analysis of obtained data show that biofertilization treatments had significant effect on harvest index in the second season only. It is prominent from data listed in Table 43 that biofertilization treatments caused a progressively increase in harvest index over than chick treatment (without biofertilization) in the second and third season only. The highest values of harvest index were achieved due to Cerialine treatment in the first season and from Rhizobacterin + Cerialine treatment in the second and third seasons, where results were 0.622, 0.710 and 0.694 in the first, second and third seasons, respectively. Generally, the differences among biofertilization treatments with concern harvest index were insignificant in the first and third seasons of this study. Such increase in harvest index by this factor certainly attributed to its desirable effect on root and top yields as discussion previously.

##### **Effect of nitrogen and potassium combination levels:**

Increasing nitrogen fertilizer levels from 20 to 40 and 60 kg N/fad tended to increase HI from 0.658 to 0.673 and 0.682 as average of the three seasons. But, increasing nitrogen levels from 60 to 80 kg N/fad tended to decrease HI from 0.682 to 0.680 as average over the three seasons. Similar findings were established by other workers including Attia *et al.* (1999).

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to decrease HI from 0.674 to 0.672 as average of the three seasons.

Referring to the effect of nitrogen and potassium combination levels on harvest index, it was significant in the three seasons (Table 43). It can be consider that the highest means of this character (0.633, 0.718 and 0.706) were recorded by application of 60 kg N + 24 kg K<sub>2</sub>O/fad in the first,

second and third seasons, respectively. On the other side, the lowest ones (0.596, 0.691 and 0.674 in the first, second and third seasons, respectively) were obtained from fertilizing with 20 kg N + 24 kg K<sub>2</sub>O/fad in the first and third season, but from application of 20 kg N + 48 kg K<sub>2</sub>O/fad in the second season. In general, excess nitrogen and potassium combination levels upon 60 kg N + 24 kg K<sub>2</sub>O/fad caused gradual decrease in harvest index over all seasons. This preferable effect of nitrogen and potassium fertilization on harvest index may be due to the obvious effect of this factor on root and biological yields.

### **ECONOMIC EVALUATION:**

Total cultivated area of sugar beet in Egypt exceeded 131200 fad produce about 2.43 million ton root and 0.347 million ton sugar annually, which equal approximately 24 % of total local sugar production.

Studying economic evaluation of treatments under study, its show that planting sugar beet in the first of October led to increase root yield by 1.214 t/fad (as an average in the three seasons under study) as compared with delaying planting to the first of November, moreover its monetary value reached 125 L.E. (based on the price of ton beet root about 102.93 L.E.).

Furthermore, application of Rhizobacterin as biofertilizers in addition mineral fertilization with 80 kg N + 48 kg K<sub>2</sub>O/fad caused an increase in root yield amounted 3.717 t/fad (as an average in the three seasons under study) and its cash value was 382.6 L.E. as compared with the treatments of without biofertilization and usage of 80 kg N + 48 kg K<sub>2</sub>O/fad.

It was worthy to mentioned that this research aimed to reducing amount of mineral nitrogen fertilizer that applying in sugar beet fields and exchange its with biofertilization in order to minimize pollution rate and maintenance of environment that consider as national goal. It can be concluded that, the same root yield could be obtained by reducing mineral nitrogen fertilizer levels from 80 to 60 kg N/fad and the difference was 293 kg/fad only (as an average in the three seasons under study) with monetary value about 30 L.E., whereas the price of nitrogen amount reduced (20 kg N/fad) reached to 40 L.E.

## SUMMARY

Three field experiments were carried out at the Experimental Station, Fac. of Agric., Mansoura Univ. during the three successive growing seasons of 2000/2001, 2001/2002 and 2002/2003. This study aimed to investigate the effect of planting dates, biofertilization treatments, nitrogen and potassium fertilizer levels as well as their interactions on growth, yield and yield components as well as quality of sugar beet (*Beta vulgaris* var. *altissima*, L.) cv. Beta Poly 4.

The experiments were laid-out in a split-split plot design with three replications. The main plots were assigned to planting dates as follows: two planting dates only in the first season (1<sup>st</sup> Oct. and 1<sup>st</sup> Nov.) and three planting dates in the second and third seasons (1<sup>st</sup> Sept., 1<sup>st</sup> Oct. and 1<sup>st</sup> Nov.).

The sub-plots were allocated with the following four biofertilization treatments:

B<sub>0</sub> - Without biofertilization (control).

B<sub>1</sub> - Treated soil with Rhizobacterin (450 g/fad).

B<sub>2</sub> - Treated soil with Cerialine (450 g/fad).

B<sub>3</sub> - Treated soil with Rhizobacterin + Cerialine (225+225 g/fad, respectively).

The sub sub-plots were occupied with the following eight combinations of nitrogen and potassium fertilizer levels:

1- 20 kg N + 24 kg K<sub>2</sub>O/fad.

2- 20 kg N + 48 kg K<sub>2</sub>O/fad.

3- 40 kg N + 24 kg K<sub>2</sub>O/fad.

4- 40 kg N + 48 kg K<sub>2</sub>O/fad.

5- 60 kg N + 24 kg K<sub>2</sub>O/fad.

6- 60 kg N + 48 kg K<sub>2</sub>O/fad.

7- 80 kg N + 24 kg K<sub>2</sub>O/fad.

8- 80 kg N + 48 kg K<sub>2</sub>O/fad.

- *The most important results obtained from this investigation can be summarized as follows:*

### **I- EFFECT OF PLANTING DATES:**

The statistical analysis of obtained results manifest that all growth attributes which estimated at 120 and 150 days after planting *i.e.* root fresh and dry weight, foliage fresh and dry weight, leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) exhibited significant effect due to planting dates in the three growing seasons. Excluding of that root fresh and dry weight (at 120 and 150 days from planting in the first season), foliage fresh weight (at 120 days from planting in the second season), LAI (at 120 days from planting in the first and second seasons and also at 150 days after sowing in the second season), CGR (in the third season), RGR and NAR (in the first season). Noteworthy, planting sugar beet on 1<sup>st</sup> October resulted in the highest values of root fresh and dry weight, foliage fresh and dry weight, LAI and NAR, except foliage dry weight (at 150 days after planting in the second season), LAI (at 150 days after sowing in the second season and NAR (in the second season), which the

highest ones were followed from planting on 1<sup>st</sup> November for foliage dry weight and on 1<sup>st</sup> September for LAI and NAR. With respect CGR and RGR, the highest means were produced from planting on 1<sup>st</sup> November in the first season or planting on 1<sup>st</sup> September in the second and third seasons.

From data explained previously, all yield components (root and foliage fresh weight, root/top ratio and root length and diameter) had significant effect owing to different planting dates in the three seasons, except root fresh weight (in the first season), root/top ratio and root length (in the second season) and root diameter (in the first and second seasons). It can be also statement that in the three growing seasons, planting on 1<sup>st</sup> October gave the highest values of root and foliage fresh weight as well as root length and diameter, exclusion root length in the first season only, which resulted from planting on 1<sup>st</sup> November. While, root/top ratio has varied trend, which the highest means resulted from planting on 1<sup>st</sup> November (in the first season) or from planting on 1<sup>st</sup> September (in the second and third seasons).

Planting dates treatments showed significant effect of most quality parameters *i.e.* TSS, sucrose and purity percentages, except TSS % (in the first and second seasons), sucrose % (in the first season) and purity % (in the first and second seasons). The highest values of these parameters were achieved with planting beets on 1<sup>st</sup> October, excluding TSS % in the second season (1<sup>st</sup> November) and in the third season (1<sup>st</sup> September).

From obtained results, all yield characters (root, top and sugar yields/fad and harvest index) significantly affected by planting dates, this comment was mostly true in the three seasons of study, except HI in the second season only. The optimum planting date that yielded the highest values of root, top and sugar yields/fad was planting on the first of October, except top yield in the third season, which resulted from planting on 1<sup>st</sup> November. The corresponding data were 15.500, 21.596 and 21.278 ton roots/fad, 9.594, 8.907 and 9.323 ton top/fad and 2.975, 4.111 and 4.035 ton sugar/fad in the first, second and third seasons, respectively. The highest means of HI (0.627, 0.709 and 0.704 in the first, second and third seasons, respectively) were followed from planting on 1<sup>st</sup> November in the first and second seasons and from planting on 1<sup>st</sup> October in the third season.

## **II- EFFECT OF BIOFERTILIZATION TREATMENTS:**

Application of biofertilization treatments (Rhizobacterin, Cerialine and the mixture of Rhizobacterin + Cerialine) were associated with significant effect on root and foliage fresh and dry weight, LAI at age 120 and 150 days from sowing (in the three seasons), CGR (in the first season only), RGR and NAR (in the second and third seasons. Inoculation soil with Rhizobacterin biofertilizer significantly improved most growth measurements and induced the highest values in the three growing seasons, with exception CGR and NAR in the second and third seasons only. On contrary, the lowest ones were accomplished from control treatment, except CGR (in the third

season) and NAR (in the second season). It worthy to mentioned that application of the mixture of Rhizobacterin + Cerialine arranged in the second rank, then followed by Cerialine treatment with regard to its influence on most growth attributes at both samples in the three seasons.

Root and foliage fresh weight as well as root length and diameter were significantly affected by biofertilization treatment in the three growing seasons. With respect to root/top ratio, it had insignificant effect as a result of biofertilization treatments in all seasons of study. The highest values could be obtained for all yield components were achieved when treated soil with Rhizobacterin treatment in the three growing seasons, except root/top ratio in the first season only. On the other hand, the minimum values for whole these characters were resulted from control treatment (without biofertilization). The trend of other biofertilization treatments was similar to that mentioned formerly with concern growth attributes.

Biofertilization treatments caused a significant effect on TSS % (in the second season), sucrose % (in the three seasons) and apparent purity % (in the third season). Rhizobacterin treatment induced the highest values of yield quality parameters, excluding TSS % (in the first and third seasons) and purity % (in the second season). Generally, it can be observed that biofertilization treatments led to gradual tendency to improve all yield quality determinations in all growing seasons.

All yield characters under study *i.e.* root, top and sugar yields/fad as well as harvest index (HI) were significantly responded due to biofertilization treatments in the three seasons, except HI in the first and third seasons. Noteworthy, application of Rhizobacterin biofertilizer yielded the highest values of root yield (16.127, 22.485 and 21.887 t/fad), top yield (9.727, 9.194 and 9.581 t/fad) and sugar yield (3.127, 4.263 and 4.179 t/fad) in the first, second and third seasons, respectively. Concerning application of the mixture of Rhizobacterin + Cerialine and Cerialine biofertilizer, its ranked after Rhizobacterin treatment, respectively with respecting their effect on root, top and sugar yields/fad in the three season. On the other hand, chick treatment (without biofertilization) resulted in the lowest means ones.

### **III- EFFECT OF NITROGEN FERTILIZER LEVELS:**

Increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to increase all growth attributes, yield and its components under study in the three seasons. Concerning TSS % and HI, increasing nitrogen fertilizer levels from 20 to 40 and 60 kg N/fad tended to increase its means, but increasing nitrogen fertilizer levels from 60 to 80 kg N/fad tended to decrease its means in all seasons. Respecting sucrose and purity percentages, increasing nitrogen fertilizer levels from 20 to 40, 60 and 80 kg N/fad tended to decrease its averages in the three growing seasons.

#### **IV- EFFECT OF POTASSIUM FERTILIZER LEVELS:**

Increasing potassium fertilizer levels from 24 to 48 kg K<sub>2</sub>O/fad tended to increase all studied character with exception HI only in the three seasons.

#### **V- EFFECT OF NITROGEN AND POTASSIUM COMBINATION LEVELS:**

Nitrogen and potassium combination levels significantly affected all growth attributes under study at 120 and 150 days from sowing in the three seasons. It can be easily consider that raising nitrogen and potassium combination levels accompanied with obvious increase in all growth measurements at two samples in the three seasons. Application of 80 kg N + 48 kg K<sub>2</sub>O/fad resulted in the highest values of root and foliage fresh weight at 120 and 150 days after planting (in the three seasons), root and foliage dry weight at 120 and 150 days after planting (in the first season), LAI at 120 and 150 days after planting (in the second and third seasons), CGR and RGR (in the first season) and NAR (in the first and second seasons). In addition, application of 60 kg N + 48 kg K<sub>2</sub>O/fad produced the best results after aforementioned combination level and characters, moreover it gave the highest values of root and foliage dry weight at 120 and 150 days from sowing (in the second and third seasons), LAI at 120 and 150 days from sowing (in the first season) and CGR as well as RGR (in the second and third seasons). On contrast, the lowest ones were resulted from application of 20 kg N + 24 kg K<sub>2</sub>O/fad in the three seasons.

All yield components (root and foliage fresh weight, root/top ratio and root length and diameter) significantly increased as a result of increasing nitrogen and potassium combination levels from 20 kg N + 24 kg K<sub>2</sub>O/fad to 80 kg N + 48 kg K<sub>2</sub>O/fad in all seasons. Fertilizing with 80 kg N + 48 kg K<sub>2</sub>O/fad produced the highest values of all yield components in the three seasons, except root/top ratio which results from application of 60 kg N + 24 kg K<sub>2</sub>O/fad in all seasons. Worthy mentioning, application of 60 kg N + 48 kg K<sub>2</sub>O/fad resulted in the best findings after the highest combination level with minimum differences comparison with other combinations. While, the lowest ones were obtained due to application 20 kg N + 24 kg K<sub>2</sub>O/fad in the three seasons.

Significant differences in all yield quality determinations were noticed due to nitrogen and potassium combination levels in all growing seasons. The highest values of TSS % were obtained by application of 60 kg N + 24 kg K<sub>2</sub>O/fad (in the first season) or 60 kg N + 48 kg K<sub>2</sub>O/fad (in the second and third seasons). However, the highest means of sucrose % and apparent purity % were resulted from application of 20 kg N + 48 kg K<sub>2</sub>O/fad in the three growing seasons, except purity % in the first season only.

Nitrogen and potassium combination levels caused significant effect on all yield characters in the three seasons. The highest values of root and top yields (19.637, 27.158 and 26.637 t/fad) and (11.533, 11.419 and 11.568 t/fad) were produced from fertilizing beet plants with 80 kg N + 48 kg K<sub>2</sub>O/fad in the first, second and third seasons, respectively. However, application of 60 kg N + 48

kg K<sub>2</sub>O/fad resulted in the maximum sugar yields (3.749, 5.132 and 5.006 t/fad in the first, second and third seasons, respectively), in addition to induced the best root and top yields/fad after formerly combination level. Referencing to the highest means of harvest index, its achieved by application of 60 kg N + 24 kg K<sub>2</sub>O/fad in the three growing seasons. The lowest values of all yield measurements were obtained from application 20 kg N + 24 kg K<sub>2</sub>O/fad in the three seasons, except harvest index in the second season.

#### **VI- EFFECT OF INTERACTIONS:**

The interaction between planting dates X biofertilization treatments exhibited significant effect on sucrose %, root and top yields/fad in all seasons.

Respecting the effect of the interaction between planting dates X nitrogen and potassium combination level, it showed significant effect on root and foliage fresh weight (at 120 and 150 days after sowing), LAI (at 120 and 150 days from planting in the first and third seasons), CGR, root and foliage fresh weight, root length and diameter, TSS %, sucrose % , purity %, root, top and sugar yields/fad in the three seasons.

The interaction between biofertilization treatments X nitrogen and potassium combination levels exhibited significant effect on root and foliage fresh weight (at 120 and 150 days after sowing), LAI (at 120 and 150 days from planting in the first and third seasons), root and foliage fresh weight, root length and diameter, sucrose %, root, top and sugar yields/fad in the three seasons.

As regards the interaction among planting dates X biofertilization treatments X nitrogen and potassium combination levels, it revealed that significant effect on sucrose %, root and top yields/fad in the three seasons.

#### **CONCLUSION**

*From obtained data in this study, it can be concluded that in order to maximizing sugar beet productivity planting it on the first of October and inoculation soil with Rhizobacterin as biofertilizer in addition to application of 60 or 80 kg N + 48 kg K<sub>2</sub>O/fad under the environment conditions of Mansoura region.*

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