Sugarbeet Growth, Yield Components, Quality and Nitrogen Use Efficiency as Influenced by Sources and Rates of Nitrogen Fertilizer
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ABSTRACT
Two split trials with four replications were conducted at the Bangar El- Sukar region, Burg El- Arab, Alex. Governorate, Egypt during 2018/19 and 2019/20 seasons to study the effect of two nitrogen sources fertilizers (ammonium sulphate 20.6% and urea 46%) with three rates (80, 100 and 120 Kg N/ fed.) on growth, yield components and quality characters and nitrogen use efficiency of sugarbeet grow on a clay loam soil. Results showed that significant differences were reported between sources of nitrogen fertilizer in the most plant growth characters, yield components, quality parameters and impurity parameters as well as nitrogen use efficiency (NUE) in the two seasons. Beet plants fertilized with ammonium sulphate as compared with urea significantly exceeded root and top fresh weight, root length, root diameter, leaf area index and total dry matter accumulation per plant as growth parameters, roots, top, gross sugar and white sugar as yield components, percentage of gross sugar, white sugar, quality index as quality parameters and NUE for yields of roots, gross sugar, white sugar and loss sugar in both seasons, and chlorophyll “a” in first season only. On contrary, also, ammonium sulphate significantly decreased concentrations of K, Na, α- amino-N as impurities and loss sugar% as compared with urea in both seasons. Application of different rates of nitrogen fertilizer in the two seasons, significantly affected all tested traits, except loss sugar yield and quality index in the first season only. Application of 120 Kg N/fed. rate recorded the highest values of all tested plant characters, photosynthetic contents, yield components, quality parameters and NUE for gross sugar and white sugar yields. In addition, the same nitrogen rate produced the lowest values for all impurity parameters measured (K, Na, α- amino-N and AC), loss sugar percent, NUE for roots and loss sugar yields in the both seasons. The interaction between sources and rates of nitrogen fertilizer were significant effect on root length and fresh weight/plant in first season only, root diameter, chlorophyll “b”, gross sugar yield/ fed., all quality parameters and NUE for loss sugar yield in the second season only. However, in the two seasons, roots, top and white sugar yields/ fed. and all impurities as well as NUE for roots, gross sugar and white sugar yields were significantly affected by the interaction between sources and rates of nitrogen fertilizer. In general, application ammonium sulphate fertilizer at the rate of 120 Kg N/ fed. was recommended because it recorded the highest root characterise, chlorophyll “b”, most yield components and quality traits as well as NUE for gross sugar and white sugar yields, and the lowest loss sugar yield, loss sugar%, NUE for roots yield and all impurities traits.

Key words: Sugarbeet, Nitrogen sources, rates, quality, yield, Growth, Use efficiency.

INTRODUCTION
In Egypt, nowadays, sugarbeet (Beta vulgaris L.), is the first source of sugar production. The production of sugar from sugarbeet reached 58.9% according to Sugar Crops Council, 2020.

Nitrogen is one of the most abundant elements on earth. It accounts for 78% of the earth’s atmosphere in the form of N2. Plants require nitrogen for their metabolic processes as well as growth. It is key component of amino acids, the building blocks of proteins, as well as chlorophyll. Primary cells are found to have about 5% of nitrogen. It plays a vital role in various metabolic activities. It helps in harvesting solar energy through chlorophyll, in energy transformation through phosphorylated components, in transfer of genetic information through nucleic acids. Moreover, it is essential in cellular and protein metabolism and acts as biological catalyst (Naresh, 2020).

Nitrogen is a major nutrient element for sugarbeet and it’s needed to large amount for high yield of sugarbeet and it considered the most factor affecting the growth and productivity of sugarbeet. Source of nitrogen application is important management tools in this respect because maximum nitrogen efficiency is obtained when nitrogen is applied in the form which is available for uptake by plant needed.

It is very important to use adequate rates and sources of nitrogen, for it successful implementation. Such proposal not only increases yield but also reduce production cost and environmental pollution. The main of this study was to evaluate the effect of two sources and three rates of nitrogen fertilizer on growth, yield components and quality of sugarbeet. In addition, use efficiency of the tested previous factors on roots and sugar yields in clay loam soil.

MATERIALS AND METHODS
Two split plot field trials with four replications were conducted at the Bangar El- Sukar region, Burg El- Arab, Alex. Governorate, Egypt during 2018/ 19 and

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2019/2020 seasons to study the effect of two nitrogen fertilizer sources (ammonium sulphate 20.6% and urea 46%) with three rates (80, 100 and 120 Kg N/fed.) on plant characters, photosynthetic pigment contents, yield components, quality parameters and concentrations of impurities in juice roots of sugar beet cultivar, Heba (polygerm) in clay loam soil. Physical properties of the experimental soil were analysis using the procedure described by Black et al. (1981). Soil chemical analysis was determined according to the methods of Jackson (1973). The physical and chemical analysis of experimental soil (at 30 cm depth) were tabulated in Table (1). Sources and rates of nitrogen fertilizer were randomly allocated in main and sub-plot, respectively. The experimental unit was 18 m² including 5 rides of 6 m in length and 60 cm in width, with 20 cm between hills. The soil was ploughed triple, settled, ridged and divided into plots. The recommended dose of phosphorus fertilizer was applied at a rate of 100 Kg calcium super phosphate/ fed. (15.5% P₂O₅) during soil preparation. Two- three of sugarbeet seeds cv. Heba were sown in hill on one side of ridge on September 10 and 15 in the first and second seasons, respectively. Plots were flooded irrigated immediately after sowing. Potassium in the form of potassium sulphate (48% K₂O) was added at rate 100 Kg K₂O/ fed. in two equal portions after thinning (4-6 true-leaf stage) and 30 days later, respectively. Nitrogen fertilizer was applied in three equal portions, the first was applied after thinning and the 2nd and 3rd portions were added at two weeks intervals after the first one, respectively. Other agricultural practices were kept the same as normally practiced in growing sugarbeet fields.

The recorded data:

After 150 days from sowing, a representative sample of ten plants was randomly taken from the guard ridges of each sub-plot to determine the following:

- Leaf area index (LAI), which was determined as described by Watson (1958) using the following equation:

\[ \text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{plant ground area (cm}^2\text{)}} \]

Where: plant leaf area was determined using the "disk method" in 50 leaf disks of 1.0 cm diameter.

- Photosynthetic pigments (mg/ g) were determined in the fresh leaves as mentioned by Grodzinsky and Grodzinsky (1973). Chlorophyll a and b concentrations in mg per gm leaves were calculated as follows:

\[ \text{Ca} = (12.7 \times \text{Ob.}^* \text{ at 663} - 2.69 \times \text{Ob. At 645}) \times 0.2** \\
\text{Cb} = (22.9 \times \text{Ob.}^* \text{ at 645} - 4.68 \times \text{Ob. At 663}) \times 0.2** \\
\text{Ob.} = \text{absorption} \\
\text{0.2} = 1/ [\text{weight of leaves sample (250 mg)/volume of aceton (50 m}]

- Total dry matter accumulation:

Each sample was separated into blades, petioles and roots. The roots of each sample were cut to small pieces. All plant fractions were air-dried then oven dried to constant weight for 48 hours at 90°C. The sum of dried plant fractions was used to calculate the total dry matter accumulation per plant.

Table 1. Physical and chemical analysis of experimental soil during 2018/19 and 2019/20 seasons

| Seasons | Sand (%) | Silt (%) | Clay (%) | Soil texture | Bulk density g/cm³ | Saturation % |
|---------|----------|----------|----------|--------------|--------------------|-------------|
| 2018/19 | 32.70    | 22.30    | 36.51    | Clay loam    | 1.31               | 30.74       |
| 2019/20 | 31.71    | 25.40    | 35.71    | Clay loam    | 1.26               | 28.11       |

| seasons | Soluble anions (Meq/L) | Soluble cations (Meq/L) | Available nutrients (mg/Kg soil) | CaCO₃ | Organic Matter | Ec (ds/m) | pH   |
|---------|------------------------|-------------------------|---------------------------------|-------|---------------|----------|------|
|         | CO₂⁻ | HCO₃⁻ | Cl⁻ | SO₄²⁻ | Ca⁺ | K⁺ | Mg²⁺ | Na⁺ | K | N | P | B |       |       |     |
| 2018/19 | 0.00 | 3.11  | 5.30 | 4.25  | 2.52 | 0.51 | 3.62 | 4.40 | 70.15 | 21.96 | 6.18 | 0.13 | 4.91 | 1.18 | 1.32 | 8.3 |
| 2019/20 | 0.00 | 3.55  | 5.57 | 4.43  | 2.96 | 0.92 | 3.20 | 6.10 | 67.29 | 20.86 | 5.18 | 0.11 | 4.50 | 1.24 | 1.15 | 8.1 |
At harvest, plants in the three inner ridge of each plot were collected and cleaned, therefore roots and top were separated and weighted in kilogram and converted to estimate roots and top yields (tons/ fed.). A sample of ten plants was randomly taken from each plot to determine root length, root diameter (cm) and fresh weights of root and top (gm) per plant. Also, a random sample of 10 Kg roots was taken from each plot and sent to Beet Laboratory Nil Sugar Factory to determine, Alpha amino nitrogen (α- amino- N), sodium (Na) and potassium (K) concentrations (expressed as milliequivalents/ 100 g beet) were estimated according to the procedure of Sugar Company by Euto Analyzer described by Cooke and Scott (1993). Sucrose% (expressed as pol%) was estimated in fresh samples of sugar beet roots by using Saccharometer according to the method described by A.O.A.C. (1995). Sugar loss% was calculated using the following formula:

\[
\text{Loss sugar\%} = \frac{\text{Loss sugar\%}}{\text{Roots yield (tons/ fed.)}} \times 100
\]

* Sugar recovery (white sugar\%) was calculated using the following equation:

\[
\text{White sugar\%} = \text{Sucrose\% - loss sugar\%}
\]

* White sugar yield (tons/ fed.) = White sugar\% \times roots yield (tons/ fed.).

* Quality index was calculated as (White sugar \times 100)/ Sucrose%.

* Gross sugar yield (tons/ fed.) = roots yield (tons/ fed.) \times Sucrose%.

* Loss sugar yield (tons/ fed.) = roots yield (tons/ fed.) \times Loss sugar%. 

\[
\text{K% + Na\%} = \alpha - N
\]

* Alkalinity coefficient (AC) = \text{K% + Na\%}

Nitrogen utilization efficiency (NUE) for roots and sugar yields (Kg/ Kg N) was calculated as:

* NUE for roots yield= Roots yield at N\_x rate , Kg roots/ K N

\[
N_x \text{ rate}
\]

* NUE for sugar yield= Sugar yield at N\_x rate , Kg sugar/ K N

\[
N_x \text{ rate}
\]

Where: N\_x = roots or sugar yields at the nitrogen rate of 80 or 100 or 120 Kg N/ fed.

The analysis of variance of split plot experiments was carried out using COSTAT computer software for both seasons were done- Least Significant Difference (L.S.D) method was used to test the differences between treatment means at 5% level of probability.

### RESULTS AND DISCUSSION

#### I-Plant characters:

Results of the effect of sources and rates of nitrogen fertilizer on plant characters, root and top fresh weight/ plant, root length, root diameter and total dry matter accumulation of sugarbeet are shown in Table (2). The results indicated that all the previously mentioned traits were significantly affected by nitrogen sources in the two seasons. In general, applying ammonium sulphate fertilizer significantly increased root and top fresh weight/ plant, root length and root diameter as well as total dry matter accumulation/ plant, compared with urea fertilizer in the two seasons. In this concern, Khedr and Nemeat- Alla (2006); El- Sheref (2007); Bou-Shady et al. (2008) and Allam (2009), they found that fertilized sugar beet by all nitrogen sources (ammonium nitrate, ammonium sulphate and urea) gave the highest values of root length and root fresh weight. Concerning between ammonium sulphate and urea, El- Sonbaty et al. (2012) reported that no significant difference between ammonium sulphate and urea on root length and root weight. Also, no significant difference between ammonium sulphate and urea in root diameter, root length and root fresh weight (Hozayn et al. 2014). On the other hand, in the most plant characters of sugar beet, application of ammonium sulphate was superior affected in compared with urea (Attia and Khalifa, 2015).

The results in the same Table, also, revealed that the previously mentioned plant characters were significantly affected by nitrogen rates in both seasons. These characters were increased significantly by increasing nitrogen rate from 80 up to 120 Kg N/ fed. in the two seasons. Application of 120 Kg N/ fed. rate gives the highest root fresh weight (1125.71 & 1034.72 gm), top fresh weight (431.15 & 444.08 gm), root length (33.36 & 30.65 cm), root diameter (12.59 & 12.41 cm) and total dry matter (121.68 & 111.15 gm) in the first and the second seasons, respectively as shown in Table (2). A positive effect of increasing nitrogen rate on root size, fresh weight of root and top/ plant may be due to role of nitrogen in development and survival of new tillers through synthesis of nucleic acids and other organelles (Allam, 2003). In this respect, increasing rate up to 120 Kg N/ fed. significantly increased length and perimeter of root and fresh weight of root and leaves/ plant (Maareg et al., 2005 a & b; Abou El- Ghaita and Mohamoud, 2005; Osman, 2011; Sarhan, 2012; Abdou et al., 2014 and El- Geddawy and Makhlouf, 2015).

The interaction between nitrogen and application rates was significant for root fresh weight/ plant (in both seasons), for root length (in the first season) and root...
diameter (in the second season). Applying ammonium sulphate fertilizer at the rate of 120 Kg N/ fed. gave the maximum values of root fresh weight/ plant, root length and root diameter, while, the minimum ones were obtained by applying urea at the rate of 80 Kg N/ fed. This results may be ammonium sulphate is a source of NH\(^{4}\) which is more readily taken up by plants than urea from soil or the inferiority of urea may be due to a considerable loss of N- urea out root zone either by leach or volatilization (Ismail and Abo El- Ghait, 2005 and Hozayn et al., 2014).

II- Leaf area index and photosynthetic pigment contents:

Leaf area (LAI) is the main character that has a direct relation with the processes of light interception and competition in plant communities. Chlorophylls "a" and "b" are the main pigments needed for light energy absorption, and both pigment synthesis requires Mg. A normal response to the Mg deficiency is a reduction in chlorophyll concentrations (Mengutary et al., 2013; Faust, 2016 and Trankner et al., 2016).

The effect of sources and rates of nitrogen fertilizer on LAI per plant and photosynthetic pigment contents, chlorophylls "a" and "b" as well as total chlorophylls "a + b" in leaves of sugarbeet plant mg/ gm fresh weight is shown in Table (3).

Results in this Table, nitrogen sources (ammonium sulphate and urea) significantly affected LAI in the two seasons. Application nitrogen fertilizer in form ammonium sulphate significantly exceeded LAI as compared with urea fertilizer in both seasons. On the other hand, chlorophylls "a", "b" and total chlorophylls were insignificantly affected by nitrogen sources in both seasons.

Form the same Table, nitrogen rates exerted significant effect on LAI and photosynthetic contents, chlorophyll "a", "b" and total chlorophylls in beet leaves in the two seasons. Nitrogen fertilization significantly increased LAI, chlorophylls "a", "b" and total chlorophylls and any increase in nitrogen rate applied was always followed by a significant increase in values of all previously mentioned traits in the both seasons. The highest values of LAI (5.19 & 5.00), chlorophyll "a" (36.39 & 35.71), chlorophyll "b" (19.40 & 19.49) and total chlorophylls (55.79 & 55.20 mg / gm beet leaves) were obtained with added nitrogen at the rate of 120 Kg N/ fed. in both seasons, respectively. Also, increasing nitrogen rate up to 120 Kg N/ fed. significantly increased LAI (El- Kady, 2015). On the other hand, low- N stress significantly decreased chlorophyll contents in sugarbeet leaves (Wu et al., 2012). However, Fei et al. (2020) found that chlorophyll parameters varied significantly at different nitrogen levels.

The interaction between sources, and rates of nitrogen fertilizer on LAI and photosynthetic contents was not significant in both seasons except, chlorophyll "b" was significant in the second season, only. The greatest (19.67) and lowest (17.43 mg/ g leaves) values of chlorophyll "b" were obtained by applying ammonium sulphate at the rates of 120 and 80 Kg N/ fed. (Table, 3).

| Treatments               | N Rates | 2018/19                   | 2019/20                   |
|--------------------------|---------|---------------------------|---------------------------|
|                          |         | Root weight               | Top weight                | Root length   | Root diameter | Total dry matter | Root weight | Top weight | Root length | Root diameter | Total dry matter |
| Ammonium sulphate        | 80      | 671.12                    | 263.73                    | 24.75          | 9.59          | 91.53          | 587.61       | 293.12      | 22.93       | 7.83          | 87.74          |
|                          | 100     | 853.38                    | 314.97                    | 27.18          | 11.31         | 99.84          | 768.40       | 346.36      | 25.98       | 10.75         | 93.11          |
|                          | 120     | 1098.11                   | 398.98                    | 32.19          | 12.89         | 111.63         | 997.73       | 411.91      | 29.21       | 11.91         | 99.89          |
| Urea 46%                 | 80      | 699.71                    | 307.67                    | 26.14          | 9.98          | 105.41         | 636.51       | 329.89      | 24.35       | 9.13          | 99.23          |
|                          | 100     | 989.30                    | 367.25                    | 30.10          | 11.91         | 122.97         | 893.93       | 383.79      | 27.58       | 10.68         | 109.99         |
|                          | 120     | 1153.31                   | 463.32                    | 34.53          | 12.89         | 131.73         | 1071.71      | 476.24      | 32.09       | 12.91         | 122.41         |
| 20.6%                    |         |                           |                           |               |              |                |              |             |             |               |               |
| LSD\(_{0.05}\)            |         | 33.42                     | ns                        | 0.39          | ns           | 0.39          | 5.89         | 0.12        | 0.80        | 0.52          | 5.37           |
| N/Fed                    | 80      | 685.42                    | 285.70                    | 25.45          | 9.79          | 98.47          | 612.06       | 311.51      | 23.64       | 8.48          | 93.49          |
|                          | 100     | 921.34                    | 341.11                    | 28.64          | 11.61         | 111.41         | 831.17       | 365.08      | 26.78       | 10.72         | 101.55         |
|                          | 120     | 1125.71                   | 431.15                    | 33.36          | 12.89         | 121.68         | 1034.72      | 444.08      | 30.65       | 12.41         | 111.15         |
| LSD\(_{0.05}\)            |         | 23.59                     | 16.49                     | 0.27           | 0.33          | 5.89           | 0.12         | 0.80        | 0.52        | 5.37           |
| Sources                  |         |                           |                           |               |              |                |              |             |             |               |               |
| Ammonium sulphate        | 874.20  | 325.89                    | 28.04                      | 11.26          | 101.00        | 784.58         | 350.46       | 26.04       | 10.16       | 93.58          |
| Urea 46%                 | 947.44  | 379.41                    | 30.26                      | 11.59          | 120.04        | 867.38         | 396.64       | 28.01       | 10.91       | 110.54         |
| Ammonium sulphate 20.6%  |         | 11.28                     | 31.16                      | 0.84           | 0.017         | 5.66           | 0.31         | 5.51        | 0.68        | 0.39          | 13.14          |
Table 3. Effect of the two sources and three rates of nitrogen fertilizer on leaf area index and photosynthetic pigment contents in leaves of sugarbeet plants during 2018/19 and 2019/20 seasons

| Treatments               | N Rates | 2018/19 |          |          |          | 2019/20 |          |          |          |
|--------------------------|---------|---------|----------|----------|----------|---------|----------|----------|----------|
|                          |         | LAI     | Chl. a    | Chl. b   | Chl. T   | LAI     | Chl. a    | Chl. b   | Chl. T   |
| Urea 46%                 | 80      | 3.90    | 33.31     | 18.03    | 51.34    | 3.57    | 33.82     | 17.89    | 51.71    |
|                          | 100     | 4.17    | 34.54     | 18.77    | 53.31    | 4.00    | 34.65     | 18.68    | 53.33    |
|                          | 120     | 5.04    | 35.95     | 19.29    | 55.24    | 4.81    | 36.10     | 19.31    | 55.41    |
| Ammonium sulphate        | 80      | 4.13    | 34.31     | 18.61    | 52.92    | 4.09    | 33.13     | 17.43    | 50.56    |
|                          | 100     | 4.61    | 35.71     | 19.01    | 54.72    | 4.47    | 34.45     | 18.37    | 52.82    |
|                          | 20.6%   | 120     | 5.35      | 36.83    | 19.51    | 56.34    | 5.18      | 35.31    | 19.67    | 54.98    |

| N/Fed        |         | LSD<sub>0.05</sub> |     |     |     |     |         |         |     |
|--------------|---------|---------------------|-----|-----|-----|-----|---------|---------|-----|
| 80           | 0.12    | 5.89                | 0.35| 1.01| 0.30| 0.24| 0.81    |         |
| 100          |         |                     |     |     |     |     |         |         |     |
| 120          |         |                     |     |     |     |     |         |         |     |

| Sources       |         | LSD<sub>0.05</sub> |     |     |     |     |         |         |     |
|---------------|---------|---------------------|-----|-----|-----|-----|---------|---------|-----|
| Urea 46%      | 0.31    | 5.66                |     |     |     |     |         |         |     |
| Ammonium      |         |                     |     |     |     |     |         |         |     |
| sulphate      |         |                     |     |     |     |     |         |         |     |
| 20.6%         |         |                     |     |     |     |     |         |         |     |

II1-Yield components:

Data in Table 4 showed that nitrogen fertilizer sources exerted significant effect on roots, top, gross sugar and white sugar yields/ fed. in the two seasons. However, nitrogen sources did not attributed any significant difference in loss sugar yield in both seasons. Beet plants were fertilized with ammonium sulphate fertilizer significantly exceeded than those fertilized with urea fertilizer. This excess represented (14.91 & 20.2), (31.75 & 46.43), (21.74 & 22.14) and (26.06 & 23.40%) on roots, top gross sugar and white sugar yields in the first and the second seasons, respectively. In this respect, El- Sonbaty et al. (2012) reported that urea fertilizer significantly increased roots and sugar yields as compared with ammonium sulphate. However, Hozayn et al. (2014) found that no significant difference between ammonium sulphate and urea in yield components, roots, top, gross sugar, white sugar and loss sugar tons/ fed. On the other hand, Attia and Khalifa (2015) reported that the application nitrogen fertilizer in the form of ammonium sulphate significantly increased most yield components in compared with urea fertilizer.

Also, nitrogenous fertilization exhibited significant differences for all yield components in both seasons. Nitrogenous fertilization significantly increased the roots yield, top yield, gross sugar yield and white sugar yield (tons/ fed.) and any increase in nitrogen applied was followed by a respective increase in these yields. However, loss sugar yield was gradually increased by increasing nitrogen rate from 80 up to 100 and 120 Kg N/ fed., without significant difference between 100 and 120 Kg N/ fed. rates applications (Table 4).

Application of 120 Kg N/ fed. rate gave the highest values (29.51 & 25.29), (9.51 & 8.72), (5.73 & 5.47), (4.91 & 4.86) and (0.87 & 0.61 tons/ fed.) for roots, top, gross sugar, and white sugar and loss sugar yields in the first and the second seasons, respectively. In the contrary, the rate of 80 Kg/ fed. gained the lowest ones. This is due to the increase in the accumulation of total dry matter in the root as a result of higher LAI, root size, as well as weight accompanying nitrogen application in three equal portions.

The interaction between nitrogen sources and their rates significantly affected sugar beet yield components, except, loss sugar yield in both seasons. The highest values of roots, (31.50 & 30.60), top, (10.31 & 10.19), gross sugar, (6.38 & 6.06) and white sugar, (5.60 & 5.42 tons/ fed.) were obtained by adding ammonium sulphate at 120 Kg N/ fed. rate in the first and second seasons, respectively. On the other hand, the lowest ones were reported at 80 Kg N/ fed. rate of urea in the two seasons.

Many investigators study the effect of nitrogen rates of nitrogen fertilizer on sugar beet yield components. They concluded that the maximum roots, gross sugar, top and biological yields achieved when nitrogen application at 80 Kg N/ fed. (Agami, 2005), and adding 90 Kg N/ fed. gave only the highest gross sugar yields (Osman et al., 2010), roots, top and gross sugar yields (Gharib and El- Hanawy, 2011) and roots only (Soliman et al., 2013). However, nitrogen at the rates of 100- 110 Kg N/fed. recorded the maximum top,
roots and gross sugar tons/ fed. (Abd- El- Kader, 2011 and Gomea et al., 2017), yields of roots and gross sugar (Moustafa et al., 2011 and Shaban et al., 2014), and only roots yield (Kandil et al., 2016). Increasing nitrogen rate up to 120 Kg N/ fed. significantly increased top, roots and gross sugar yields (Maareg et al., 2005 a& b; El- Sarag, 2008 and El- Geddawy and Makhlof, 2015), roots and sugar yields (Ibrahim et al., 2005 and Sarhan, 2012), yields of roots and top, but gross sugar yield decreased (Osman, 2011 and El- Sayed, 2013), yields of roots, top, gross sugar, white sugar and loss sugar (Abdou et al., 2014), and roots and white sugar yields only (El- Kady, 2015). On the other hand, increasing nitrogen rate up to 140 Kg N/ fed. significantly increased roots and gross sugar, tons/ fed. (Abdou, 2013 in addition to roots, top, biological, gross sugar, white sugar and loss sugar yields (Mekdad, 2015) and Maareg et al. (2020).

Table 4. Effect of the two sources and three rates of nitrogen fertilizer on sugarbeet yield components (tons/fed.) during 2018/ 19 and 2019/ 20 seasons

| Treatments | N Rates | 2018/19 | | | 2019/20 | | |
|---|---|---|---|---|---|---|---|
| | | Roots Yield | Top Yield | Gross Sugar Yield | White Sugar Yield | Loss Sugar Yield | Roots Yield | Top Yield | Gross Sugar Yield | White Sugar Yield | Loss Sugar Yield | | |
| Urea 46% | 80 | 19.80 | 5.62 | 3.44 | 2.76 | 0.68 | 17.16 | 4.73 | 3.05 | 2.58 | 0.47 |
| | 100 | 25.15 | 6.92 | 4.46 | 3.61 | 0.85 | 21.19 | 5.65 | 3.87 | 3.35 | 0.51 |
| | 120 | 27.51 | 8.71 | 5.08 | 4.21 | 0.87 | 25.97 | 7.25 | 4.88 | 4.29 | 0.58 |
| Ammonium sulphate | 80 | 23.45 | 8.50 | 4.13 | 3.31 | 0.78 | 19.83 | 6.91 | 3.44 | 2.92 | 0.52 |
| | 100 | 28.31 | 9.17 | 5.30 | 4.44 | 0.82 | 26.87 | 8.74 | 4.91 | 4.27 | 0.64 |
| | 20.6% | 120 | 31.50 | 10.31 | 6.38 | 5.60 | 0.86 | 30.60 | 10.19 | 6.06 | 5.42 | 0.64 |
| LSD<sub>0.05</sub> | 0.23 | 0.19 | ns | 0.14 | ns | 0.98 | 0.22 | 0.33 | 0.29 | ns |
| N/Fed | 80 | 21.63 | 7.06 | 3.79 | 3.03 | 0.73 | 18.50 | 5.82 | 3.25 | 2.75 | 0.49 |
| | 100 | 26.73 | 8.05 | 4.88 | 4.03 | 0.84 | 24.03 | 7.20 | 4.39 | 3.81 | 0.58 |
| | 120 | 29.51 | 9.51 | 5.73 | 4.91 | 0.87 | 28.29 | 8.72 | 5.47 | 4.86 | 0.61 |
| LSD<sub>0.05</sub> | 0.16 | 0.13 | 0.34 | 0.10 | ns | 0.69 | 0.15 | 0.23 | 0.21 | 0.04 |
| Sources | | | | | | | | | | | |
| Urea 46% | 24.15 | 7.08 | 4.33 | 3.53 | 0.80 | 21.44 | 5.88 | 3.93 | 3.41 | 0.52 |
| Ammonium sulphate | 27.75 | 9.33 | 5.27 | 4.45 | 0.82 | 25.77 | 8.61 | 4.80 | 4.21 | 0.60 |
| 20.6% | LSD<sub>0.05</sub> | 0.12 | 0.41 | 0.42 | 0.12 | ns | 1.46 | 0.45 | 0.36 | 0.27 | ns |

Table 5. Effect of two sources and three rates of nitrogen fertilizer on sugarbeet quality during 2018/ 19 and 2019/ 20 seasons

| Treatments | N Rates | 2018/19 | | | 2019/20 | | |
|---|---|---|---|---|---|---|---|
| | | Gross Sugar% | White sugar% | Loss sugar% | Quality index% | Gross Sugar% | White sugar% | Loss sugar% | Quality index% | | |
| Urea 46% | 80 | 17.38 | 13.92 | 3.46 | 86.24 | 17.78 | 14.34 | 3.44 | 85.94 |
| | 100 | 17.73 | 14.34 | 3.39 | 82.47 | 18.23 | 15.16 | 3.07 | 84.26 |
| | 120 | 18.45 | 15.30 | 3.37 | 82.80 | 18.76 | 15.86 | 2.90 | 85.41 |
| Ammonium sulphate | 80 | 17.59 | 14.11 | 3.48 | 84.24 | 17.33 | 14.04 | 3.29 | 84.97 |
| | 100 | 18.72 | 15.69 | 3.03 | 85.02 | 18.28 | 15.29 | 2.99 | 85.18 |
| | 20.6% | 120 | 20.23 | 17.78 | 2.45 | 87.48 | 19.76 | 17.07 | 2.69 | 87.62 |
| LSD<sub>0.05</sub> | 0.44 | 0.53 | 0.53 | 1.19 | ns | | | | | |
| N/Fed | 80 | 17.49 | 14.01 | 3.47 | 85.24 | 17.56 | 14.19 | 3.37 | 85.46 |
| | 100 | 18.23 | 15.01 | 3.21 | 83.75 | 18.26 | 15.23 | 3.03 | 84.72 |
| | 120 | 19.34 | 16.54 | 2.91 | 85.14 | 19.26 | 16.46 | 2.80 | 86.52 |
| LSD<sub>0.05</sub> | 0.25 | 0.24 | 0.29 | ns | 0.31 | 0.37 | 0.37 | 0.84 | |
| Sources | | | | | | | | | | |
| Urea 46% | 17.85 | 14.52 | 3.41 | 83.84 | 18.26 | 15.12 | 3.14 | 85.20 |
| Ammonium sulphate | 18.85 | 15.86 | 2.99 | 85.58 | 18.46 | 15.46 | 2.99 | 85.92 |
| 20.6% | LSD<sub>0.05</sub> | 0.53 | 1.18 | 1.18 | 0.31 | 0.01 | 0.09 | 0.09 | 0.42 |
IV- Quality parameters:

Data in Table, (5) showed that nitrogen sources had a significant effect on all tested quality traits in both seasons. In generally, beet received ammonium sulphate produced the highest gross sugar, white sugar and quality index%, while, those received urea produced the lowest ones in the two seasons. On contrary, loss sugar% was high with urea, and low with ammonium sulphate in both seasons.

Nitrogen rates exerted significant effect on quality parameters, gross sugar, white sugar and loss sugar in the two seasons, and on quality index% in the second season only. Increasing nitrogen rate from 80Kg N/fed. to 120 Kg N/fed. increasing significantly increased gross sugar and white sugar%, and any increase in nitrogen rate was always followed by a significant increase in these traits. However, increasing nitrogen rate from 80 to 100 and 120Kg N/fed. gradually decreasing loss sugar% without significent difference between 80 and 100 Kg N/fed. rates of application in both seasons. Application of 120Kg N/fed. rate recorded the highest values of gross sugar and white sugar% (in both seasons) and quality index (in the second season only), and the lowest values of loss sugar% in both seasons.

The interaction between sources and rates of nitrogen fertilizer was significant on gross sugar, white sugar and quality index% in the second season only. In this season, results indicated that ammonium sulphate at the application rate of 120 Kg N/ fed. recorded the highest gross sugar% (19.76%), white sugar% (17.07) and quality index% (87.62), while, application ammonium sulphate at the rate of 80 Kg N/fed. recorded the lowest gross sugar% (17.33) and white sugar% (14.74). Conversely, the lowest quality index% (84.26) was recorded with urea at rate of 100 Kg N/ fed. as shown in Table (5).

V- Impurity parameters:

The soluble non-sugar, potassium (K), sodium (Na), alpha- amino N (α-amino N) in the beet roots are regarded as impurities because they interfere with sugar extraction. Results of these impurities and alkalinity coefficient (\{(K + Na)/ α-N\}) as affected by sources and rates of nitrogen fertilizer were presented in Table (6).

From the same Table, alpha- amino N (α-amino N) concentration was significantly influence by nitrogen sources in the both seasons. However, K and Na concentrations were significantly affected by nitrogen sources in the first and the second seasons, respectively. On the other hand, alkalinity coefficient (AC) was not significant influenced by nitrogen sources in both seasons. In general, urea fertilizer significantly increased K, Na and α- amino N as impurities as compared with ammonium sulphate fertilizer.

The results in this study revealed that nitrogen sources had a significant effect on all tested quality and impurity traits. Application of ammonium sulphate significantly increased quality parameters and decreased impurity concentrations in roots of sugarbeet. In this concern, Ismail and Abo El- Hgait (2005) reported that ammonium sulphate application recorded the lowest sucrose, white sugar and purity% as quality percentages, and the highest K and α- amino- N concentrations in compared with urea, however, El- Sombaty et al. (2012) found that application ammonium sulphate significantly increased in most quality percentages and quantity of sugarbeet as compared with urea. On the other hand, no significant difference between ammonium sulphate and urea fertilizers in the quality and impurity parameters, except, loss sugar% and K- concentration (Hozayn et al., 2014). While, source nitrogen fertilizer as ammonium sulphate exhibited a significant increase in all quality percentages as compared with urea fertilizer (Attia and Khalifa 2015).

Nitrogen fertilization exerted significant effect on concentrations of K, Na, α-amino N and AC in beet roots in the two seasons. Increasing nitrogen from 80 to 120 Kg N/ fed. significantly decreased K, Na and α-amino N concentrations, and in the two seasons, any rise in nitrogen rate was often accompanied by a substantial decrease in these listed traits. With regard to AC, application of 80 and 120 nitrogen rates significantly decreased its value as compared to 100 Kg N/ fed. rate in the two seasons.

The interaction between nitrogen sources and application rates was significant for K, Na, α-amino- N and AC in both seasons. The lowest values of the mentioned impurities (K, Na, α-amino- N) were obtained with application of ammonium sulphate at the rate of 120 Kg N/ fed. in both seasons. However, the lowest value of AC was record with ammonium sulphate at 120 and 80 Kg N/ fed. rates in the first and second seasons, respectively.

In this respect, several workers revealed that the effect of nitrogen fertilizer at 120 Kg N/ fed. on Na, K, α-N and alkalinity coefficient (Ac) were no significant (Nemeat Alla, 2009). However, increasing N rate up to 120 Kg N/ fed. significantly increased juice impurities i.e. Na, K and α- N contents, whereas, gross sugar, white sugar content and purity% were decreased (El-Sayed, 2013). Also, fertilizing sugarbeet plants with 120 Kg N/ fed. produced the highest T.S.S%, however, the highest gross sugar and purity% were resulted from control treatment (Sarhan, 2012 and Abdelaal & Tawfik, 2015). On the other hand, increasing N rate up
to 120 Kg N/ fed. significantly increased loss sugar\%., on contrary, it significantly decreased gross sugar and white sugar contents (Abdou et al., 2014). Also, increasing N rate up to 120 Kg N/ fed. significantly increased impurities, K, Na and α-N, whereas, insignificant on white sugar and purity\% (El- Kady, 2015).

VI- Nitrogen utilization efficiency (NUE) for sugarbeet yields (Kg/ Kg N).

Data of NUE for roots and sugar yield components as affected by sources and rates of nitrogen fertilizer are presented in Table (7). Nitrogen sources had a significant effect on NUE for roots, gross sugar and white sugar yields in the two seasons, and only on loss sugar yield in the first season only. Beet plants received ammonium sulphate fertilizer significantly exceeded those received urea fertilizer in the NUE values for previously mentioned yield components in both seasons. These excess were about (15.17 & 20.03), (21.37 & 21.43), (25.38 & 22.53) and (3.95 & 14.37\%) in NUE for roots, gross sugar, white sugar and loss sugar yields in the first and the second seasons, respectively.

Nitrogen fertilization exerted significant effect on NUE for roots, gross sugar, white sugar and loss sugar yields in both seasons. The values of NUE for gross sugar yield (in the first season only), and white sugar yield (in the both seasons) gradually increased by increasing nitrogen from 80 to 120 Kg N/ fed. On contrary, increasing nitrogen rate from 80 to 120 Kg N/fed. significantly decreased values of NUE for roots yield (in the first season only) and loss sugar yield (in the two seasons). On the other hand, the highest values of NUE for gross sugar yield (48.82 Kg/ Kg N) in the first season and NUE for roots yield (240.3 Kg/ Kg N) in the second season were recorded with application nitrogen fertilizer at the rate of 100 Kg N/ fed.

Regarding the interaction between nitrogen sources and its rates was significant for NUE for roots yield, gross sugar yield and white sugar yield in the two seasons and for loss sugar yield in the second season only. Generally, application of ammonium sulphate with 120 Kg N/ fed. gave the highest values of NUE for gross sugar and white sugar yields in both seasons. While, application the same fertilizer at the rate of 80 Kg N/ fed. recoded the greatest values of NUE for roots yield (in the first season) and loss sugar yield (in the two seasons). The highest NUE value for roots yield in the second season obtained with application ammonium sulphate at the rate of 100 Kg N/ fed. In this regards, Terry, (2008) and Jon et al., (2009) suggested that higher NUE reduced applied fertilizer and less nitrogen application cost.

Table 6. Effect of two sources and three rates of nitrogen fertilizer on sugarbeet impurity parameters during 2018/ 19 and 2019/ 20 seasons

| Treatments       | N Rates | 2018/ 19 |            |            | 2019/ 20 |            |            |
|------------------|---------|----------|------------|------------|----------|------------|------------|
|                  |         | K%       | N%         | α-N        | AC       | K%         | N%         | α-N        | AC       |
| Urea 46%         | 80      | 5.41     | 2.89       | 3.45       | 2.40     | 5.08       | 3.18       | 3.42       | 2.42     |
|                  | 100     | 5.39     | 2.86       | 2.92       | 2.84     | 4.72       | 2.55       | 3.01       | 2.43     |
|                  | 120     | 4.84     | 2.71       | 2.89       | 2.63     | 4.31       | 2.50       | 2.95       | 2.36     |
| Ammonium sulphate| 80      | 5.72     | 2.78       | 2.94       | 2.91     | 5.14       | 2.68       | 3.39       | 2.31     |
| 20.6%            | 100     | 4.80     | 2.45       | 2.66       | 2.73     | 4.64       | 2.55       | 2.53       | 2.85     |
|                  | 120     | 3.48     | 2.16       | 2.40       | 2.36     | 4.01       | 2.30       | 2.53       | 2.51     |
| LSD0.05          |         | 0.08     | 0.21       | 0.11       | 0.18     | 0.18       | 0.17       | 0.25       | 0.14     |
| N/Fed            | 80      | 5.57     | 2.84       | 3.20       | 2.65     | 5.11       | 2.93       | 3.41       | 2.37     |
|                  | 100     | 5.10     | 2.66       | 2.79       | 2.78     | 4.68       | 2.55       | 2.77       | 2.64     |
|                  | 120     | 4.16     | 2.44       | 2.65       | 2.50     | 4.16       | 2.40       | 2.74       | 2.43     |
| LSD0.05          |         | 0.06     | 0.15       | 0.08       | 0.13     | 0.13       | 0.12       | 0.18       | 0.10     |
| Sources          | Urea 46%| 5.21     | 2.82       | 3.09       | 2.62     | 4.70       | 2.74       | 3.13       | 2.40     |
|                  | Ammonium sulphate 20.6% | 4.67 | 2.46 | 2.67 | 2.67 | 4.60 | 2.51 | 2.82 | 2.56 |
| LSD0.05          |         | 0.28     | ns         | 0.10       | Ns       | ns         | 0.22       | 0.23       | ns       |
Table 7. Effect of two sources and three rates of nitrogen fertilizer on nitrogen use efficiency (NUE) for sugarbeet yields (Kg/ Kg N) during 2018/ 19 and 2019/ 20 seasons

| Treatments         | N Rates | 2018/ 19 |            |            |            | 2019/ 20 |            |            |
|---------------------|---------|----------|------------|------------|------------|----------|------------|------------|
|                     |         | Roots    | Gross      | White      | Loss       | Roots    | Gross      | White      | Loss       |
|                     |         | yield    | Sugar      | sugar      | sugar      | yield    | Sugar      | sugar      | sugar      |
| Urea 46%            | 80      | 247.50   | 43.05      | 34.50      | 8.55       | 214.50   | 38.16      | 32.28      | 5.88       |
|                     | 100     | 251.50   | 44.62      | 36.08      | 8.54       | 211.90   | 38.65      | 33.54      | 5.11       |
|                     | 120     | 229.25   | 42.31      | 35.10      | 7.21       | 216.42   | 40.64      | 35.76      | 4.87       |
| Ammonium sulphate   | 80      | 293.13   | 51.59      | 41.37      | 10.21      | 247.88   | 42.99      | 36.55      | 6.44       |
| 20.6%               | 100     | 283.10   | 53.03      | 44.44      | 8.59       | 268.70   | 49.14      | 42.74      | 6.40       |
|                     | 120     | 262.50   | 53.16      | 46.69      | 6.46       | 255.00   | 50.49      | 45.17      | 5.32       |
| LSD₀.₀₅             |         | 3.15     | 4.66       | 1.00       | ns         | 6.48     | 2.05       | 2.04       | 0.37       |
| N/Fed               | 80      | 270.31   | 47.32      | 37.94      | 9.38       | 231.19   | 40.58      | 34.41      | 6.16       |
|                     | 100     | 267.30   | 48.82      | 40.26      | 8.56       | 240.30   | 43.90      | 38.14      | 5.76       |
|                     | 120     | 245.88   | 47.73      | 40.90      | 6.84       | 235.71   | 45.56      | 40.47      | 5.09       |
| LSD₀.₀₅             |         | 2.22     | 0.29       | 0.71       | 1.80       | 4.58     | 1.45       | 1.44       | 0.26       |
| Sources             |         | Urea 46% |            |            |            | Ammonium |            |            |            |
|                     |         |          | sulphate   | 20.6%      |            | sulphate | 20.6%      |            |            |
| LSD₀.₀₅             |         | 2.05     | 3.35       | 1.37       | 0.14       | 14.39    | 3.29       | 2.37       | ns         |

It could be recommended to apply ammonium sulphate fertilizer at a rate of 120 Kg N/fed Bangar El-Sukar region, because it increases the yield components, quality percentages and photosynthetic pigments as well as NUE for gross sugar and white sugar yields, and reduces loss sugar yield, loss sugar percent, and all impurities concentrations.

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أثر استخدام التسميد النيتروجيني من مصادر ومعدلات مختلفة على نمو ومكونات المحصول والجودة وكفاءة التسميد النيتروجيني لبنجر السكر

بحث

حسام محمد الشرنوبي

نفتت تجربتان حقليتان بمنطقة بنجر السكر بمدينة برج العرب بمحافظة الإسكندرية، خلال موسمين 2018/2019 و2019/2020 وذلك لدراسة تأثير التسميد بمصادر مختلفين من النيتروجين (سلفات الأمونيوم 20.6% والوريا 46%) وثلاث معدلات تسميد (80 و100 و120 كجم نيتروجين/فدان) على بعض صفات النمو والمحصول وخصائص الجودة وكذلك كفاءة استخدام السماد النيتروجيني (كم/كم ن) لمحصل بنجر السكر وتم استخدام تصميم القطع المشفق مره واحدة في أربع مكررات.

- أظهرت النتائج وجود اختلافات معنوية سجلت بين مصادر التسميد النيتروجيني المختلفة تأثيراً معنويًا لكل الصفات المدروسة في الموسمين فيما عدا محصول السكر المقفود ومؤشر الجودة في الموسم الأول.

- التسميد بمعدل 120 كجم نيتروجين للفدان سجل أعلى قيم لكل من حجم الجذور ومعظم مكونات المحصول وصفات الجودة ومحصول السكر الكلي ومحصول السكر الأبيض. كما سجل هذا المعدل التسميد أقل قيم للشواذ (K, Na, α-amino N, AC) والشواذ بالنسبة للسكر المقفود، ومحصول السكر ومحصول السكر المقفود في كلا المواسمين.

- التفاعل بين مصادر ومعدلات التسميد النيتروجيني أثرت معنوية على (طول الجذر والوزن الغض) في نباتات بنجر السكر في الموسم الأول فقط، ومعنوية معنوية معنوية معنوية معنوية معنوية معنوية معنوية نباتات بنجر السكر في كل الأسلاك النباتية في الموسم الثاني فقط.

- كما أظهر التفاعل بين مصادر ومعدلات التسميد النيتروجيني في كلا المواسمين تأثيراً معنويًا على الصفات الأثية: محصول الجذور ومحصول العرش ومحصول السكر الأبيض للفدان وكل مكونات الشواذ.

- نباتات بنجر السكر التي تسميدها بكبريتات الأمونيوم نباتات بنجر السكر التي تسميدها بالوريا أظهرت فروقاً معنوية في الصفات الأثية: الوزن الغض للجذور والأوراق، وطول الجذر ومعنوية معنوية مساحة الورقة (A1A)، وتراكم المادة الجافة للنبات كمؤشر لتصاصات النمو. كما أظهرت تأثيراً معنويًا على محصول الجذور ومحصول السكر الكلي ومحصول السكر الأبيض ومحصول السكر الأبيض معنويًا معنويًا معنويًا معنويًا معنويًا معنويًا معنويًا معنويًا معنويًا جميع الصفات في جميع الأسلاك النباتية في الموسم الأول فقط.
السكر المفقود، وأيضاً الإنتاج الكامل لمحصول السكر، و
محصول الجذور وكل مكونات الشوائب.
- لذا فإنه ينبغي استخدام كبريتات الأمونيوم بمعدل
120 كجم/فدان في منبحة بنجر السكر ببرج العرب
بمحافظة الإسكندرية.

وفي العموم أظهر التسميد بكبريتات الأمونيوم بمعدل
120 كجم/فدان أعلى قيم لحجم الجذور والكلوروفيل b و
معظم صفات المحصول وصفات الجودة و NUE للسكر الكلي
ومحصول السكر الأبيض، كما أعطى أقل قيم نسبة
لمحصول الجذور ومحصول السكر الكلي ومحصول السكر الأبيض.
لذا فإنه ينصح باستخدام كبريتات الأمونيوم بمعدل
