

## Response of Different Sugar Beet Cultivars to Nitrogen Fertilizer Rates under the Arid Land Conditions

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**Abstract.** This study was conducted during 2016-2018 at the Agriculture Research Station of King Abdulaziz University at Hada Al-Sham, Saudi Arabia. The study aimed to evaluate three sugar beet cultivars (Farida, Dita and Heros) under three nitrogen fertilizer rates (100, 200 and 300 kg N/ha). As nitrogen fertilizer rate increased root yield, yield components, sucrose (%) and yield significantly increased in both seasons. Fresh root yield under 300 kg N/ha was the highest in both seasons. Farida cv. was the highest in root yield (60.62 t/ha and 97.00 t/ha) and sucrose yield (4.15 and 6.95 t/ha) in both seasons, respectively.

**Keywords.** Cultivar, Nitrogen fertilizer, Root yield, Sucrose, Sugar beet.

### 1. Introduction

Sugar beet (*Beta vulgaris* L.) is one from the main economic field crops in the world. Sugar beet is the second source for sugar production after sugar cane. It is the world's most cultivated crop after sugar cane for the production of sucrose for human consumption. Sugar beet is a crop characterized with high tolerance degree for the salinity in soil and irrigation water (Cooke and Scott, 1993). The highest sugar yield was obtained by irrigation with 75% from the total crop water requirement with EC = 8 mmhos/cm<sup>2</sup> (Hills *et al.*, 1983). Sucrose content increased as salinity increased (Katerji *et al.*, 1997). Sugar beet root yield and sucrose content significantly different among the sugar beet genotypes (Refay, 2010). Nitrogen fertilizer significantly increased sucrose yield and percentage in sugar beet root (Russell *et al.*, 1971). The highest yield was harvested on the

plot fertilized with the highest N rate. In years with extended drought, sugar beet achieved the maximum yield in the treatment of the higher rates of nitrogen fertilizer. Nitrogen is the nutrient limiting the most sugar beet productivity (Herget, 2010). The late N application increased chlorophyll concentration in the leaves but had no significant effect on radiation use efficiency in late summer and autumn (Malnou *et al.*, 2007). Too little N retards leaf growth (Milford *et al.*, 1985) gives pale green foliage due to low chlorophyll concentration and accelerates leaf senescence (Draycott and Christenson, 2003). Too much N induces over-production of dark green leaves and a shift in dry matter distribution at the expense of storage root and sugar yields (Milford *et al.*, 1988): The extra leaves seem to provide little benefit in terms of additional intercepted radiation (Scott *et al.*, 1994). Sugar beet requires adequate N to

expand the canopy rapidly and this N often comes from recently applied fertilizer. However, once the canopy has been produced, the crop may increase in dry weight three fold and in N uptake by at least  $100 \text{ kg ha}^{-1}$  (Last *et al.*, 1983, Armstrong *et al.*, 1986 and Malnou *et al.*, 2006). Does the crop require a N fertilizer source for this or can N be absorbed in sufficient quantity and sufficiently rapidly from soil sources to maximize yield. Once a large canopy has been produced, can the soil supply enough N (a) to maintain canopy size so that light interception is optimized and (b) so that the foliage remains an efficient converter of light energy into dry matter and sugar (Scott and Jaggard, 1993).

Sugar beet genotypes significantly different in storage capacity especially carbohydrates (Schrepel and Hoffmann, 2013). According to Kenter *et al.*, (2006), van Swaaij and Huijbregts (2010), in sugar beets geno-typic differences in storage losses exist which are enhanced with increasing storage duration (Kenter and Hoffmann, 2009).

Campbell and Klotz (2007) also found a significant genotype effect on storage losses, but it was rather low compared to the effect of the environment (growing site  $\times$  year) and the inter-action (genotype  $\times$  environment). The sugar beet genotype significantly affected sugar yield and storage besides root yield (Hoffmann *et al.* , 2005).

The study aims to evaluate three different sugar beet cultivars under three nitrogen fertilizer rates concerning root yield , root traits ,sucrose content and sucrose yield /ha under the arid land conditions.

## 2. Materials and Methods

This research was conducted during 2016/2017 and 2017/2018 seasons in the Agricultural Research Station, King Abdulaziz University at Hada Al-Sham region, Saudi

Arabia. Three sugar beet (*Beta vulgaris L.*) Cultivars were tested under nitrogen fertilizer rates in a split plot design with 4 replications. The main plot treatments were 3 nitrogen fertilizer rates ( 100, 200 and 300 kg N/ha). The sub plot treatments were 3 sugar beet cultivars: Farida polygerm cv. from Egypt, Dita monogerm cv. from Belgium and Heros polygerm cv. from Syria. The sub plot consisted of 10 rows with 3 m length, 4 m width and 40 cm between each 2 rows with 30 cm between hills. Surface drip irrigation system was used and the dripper lines was installed with 40 cm between two adjacent dripper lines while the distance between drippers is 30 cm. The type of the dripper line is RAIN BIRD LD- 06- 12-1000 Landscape drip 0.6 G/h @12". Inlet pressure on each tape was about 1.5 bars. The system uses 125-micron disk filter. The common cultural practices other than the nitrogen fertilization were done according to El-Nakhlawy and Ghandorah , 2009. Root length, root weight and root yield/ha were measured at harvesting and sucrose content (%) was determined using the Polarimetry method (A.O.A.C., 2006), also sucrose yield /ha was recorded from the data of sucrose (%) and dry root yield /ha.

## 3. Statistical Analysis

The obtained data of the experiment in the two seasons was statistically analyzed through analysis of variance procedures (ANOVA) then revised least significance difference (RLSD) test was used to compare between the treatment means after applying the statistical analysis assumptions according to El-Nakhlawy (2010) using SAS (2006).

## 4. Results and Discussions

### 4.1 Effect of Nitrogen Fertilizer Rates

The statistical comparison between the means of the studied traits of sugar beet under the rates of nitrogen fertilizer (Tables 1 and 2) showed that the rate of 300 kg N/ha produced

the highest means in all traits. The results showed that as nitrogen rate increased sugar beet root length, diameter and weight significantly increased during the 2016/2017 and 2017/2018 seasons. Under 300 kg N/ha root length increased by 105 % and 126% compared to the 200 kg N/ha and 100 kg N/ha in the first season, respectively, and with 102% and 108% in the second season. Root diameter increased by 108% and 115% in the first season and by 103% and 111% in the second season compared with 200 kg N/ha and 100 kg N/ha respectively. The positive response to increasing nitrogen rate was pronounced in root weight where it increased by 126% and 146% in the first season and by 114% and 52% in the second season compared with the 200 and 100 Kg N/ha. The Fresh root yield/ha under 300 kg N/ha was higher than under 200 and 100 kg N/ha by 114% and 127% as average of the 2 seasons. As for sucrose yield/ha, the obtained results showed that under 300 kg n/ha sucrose yields were 4.28 t and 6.39 t/ha while under 100 kg N/ha were 2.7 t and 3.93 t/ha in the first and second seasons, respectively (Table 2).

The linear response of sugar beet to nitrogen fertilizer rates might be due to the positive effect of increasing nitrogen rate on increasing leaf area and chlorophyll content of sugar plants, accordingly, it enhanced in increasing photosynthetic rate, accordingly increasing sugar beet root yield components, yield, sucrose content and sucrose yield/ha (Armstrong *et al.*, 1986 and Malnou *et al.*, 2006). The similar results were found by different authors where they reported that too little N retards leaf growth (Milford *et al.*, 1985), gives pale green foliage due to low chlorophyll concentration and accelerates leaf senescence (Draycott and Christenson, 2003).

#### 4.2 Effect of Sugar Beet Cultivars

The statistical comparisons of means of each root length, diameter and weight of the

three sugar beet cultivars during the 2 studied seasons (Table 3) showed that Farida cv had the tallest root in both seasons (228.6 and 215 mm) with significant differences from Dita and Heros cv but no significant differences were found between Dita and Heros cvs in the 2 seasons.. Root lengths of the three cultivars were (228.7 mm, 204.8 mm, and 208.69 mm) for Farida, Heros and Dita cvs, respectively (Table 3). Root diameter was higher in Farida cv, and differed significantly from the other 2 cvs. In addition, significant differences were showed between Dita and Heros cvs in both seasons. Farida cv root diameter were 92,83 mm and 118.5 mm in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively followed by Dita cv (88.15 mm and 115.6 mm, respectively) then Heros with means of 70.72 mm and 113.42 mm in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively (Table 3). The statistical comparisons between the three sugar beet cultivars concerning root fresh weight (Table 3) showed significant differences between Farida cv and the other 2 cvs. Root fresh weight means were 804.37g, 612.23g and 602.8 23 g for Farida, Heros and Dita cvs, respectively in the first season. Farida cv produced the highest root yield /ha (60.62t/ha) followed by Dita cv. (57.26 t/ha) then Heroes cultivar 45.62 t/ha) in the first season. In addition, the same trend was found in the second season, while root yield/ha means were 97.00 t, 90.72 t and 64.55 t/ha, respectively (Table 4). As for, sucrose content (%) in sugar beet root, Dita cv. Was the highest (18.80% and 19.25% in the 2 seasons, respectively) followed by Farida (17.91% and 18.335, respectively) while Heros was the lowest sucrose (%) with values of 11.80 % and 13.26%, respectively (Table 4). Sucrose yield/ha were similar in the trend as sucrose contents where Farida cv was the highest (4.15 t, 6.95 t) followed by Dita cv (3.43 t and 6.67 t) and the lowest was Heros cv (2.12 t and 3.35 t/ha) in the first and second seasons, respectively (Table 4).

The obtained results showed that Farida cv. produced the highest sugar beet root yield and sucrose yield /ha, and these results might be due to the genetic makeup of Farida cv. and it had polygenes contributed in increasing yield components of root length ,root diameter, root weight which reflected in increasing root yield /ha (Hoffmann *et al.*, 2005). Increasing in yield components positively affected the sucrose biosynthesis within the root cells and produced the highest sucrose yield (Kenter *et al.*, 2006 and Van Swaij and Huijbregts, 2010).

#### 4.3 Effect of the Interaction between Nitrogen Fertilizer Rates and Sugar Beet Cultivars

As for sugar beet root length, diameter and weight under the effect of the interaction between nitrogen fertilizer rates and cultivars, the presented data (Table 5) showed no significant differences were showed in the last three sugar beet traits in the two studied seasons.

The highest means of root length, diameter and weight were produced from Farida cv. Under 300 kg N/ha in the two seasons. In addition, the highest values from fresh root yield/ha, sucrose content (%) and sucrose yield/ha were produced from Farida cv. Fertilized with 300 kg N/ha. Fresh root yield /ha ranged from 79.11t/ha to 40.69 t/ha in the first season and from 109.87 t/ha to 72.16 t/ha in the second season. Sucrose yield /ha ranged from 5.51 t/ha to 1.69 t/ha in the first season and from 6.76 t to 4.73 t/ha in the second season (Table 6).

The results of the interaction of the insignificance effects of the interaction on the six studied traits of sugar beet might be due to the same response of each genotype to the three nitrogen fertilizer rates for the physiological and metabolic traits, which reflected into the non-significance effects for the interaction (Campbell and Klotz, 2007).

**Table 1. Means of root length (mm), root diameter (mm) and root fresh weight of sugar beet under the effect of nitrogen fertilizer rates during 2016/2017 and 2017/2018 seasons.**

| Nitrogen fertilizer rate (kg N/ha) | Means            |          |                    |          |                       |          |
|------------------------------------|------------------|----------|--------------------|----------|-----------------------|----------|
|                                    | Root length (mm) |          | Root diameter (mm) |          | Root fresh weight (g) |          |
|                                    | 2016/17          | 2017/18  | 2016/17            | 2017/18  | 2016/17               | 2017/18  |
| 100                                | 194.22 c*        | 196.16 c | 77.57 c            | 110.22 c | 536.23 c              | 643.89 c |
| 200                                | 206.90 b         | 208.55 b | 83.82 b            | 119.41 b | 621.06 b              | 857.6 b  |
| 300                                | 217.72 a         | 212.76 a | 89.01 a            | 122.60a  | 783.44 a              | 979.03 a |

\*Means of each trait under the main factor treatments followed by the same letter are not significantly different according to RLSD at  $\leq 0.05$ .

**Table 2. Means of fresh root yield (t/ha), sucrose content (%) and sucrose yield/ha (t) of sugar beet under the effect of nitrogen fertilizer rates during 2016/2017 and 2017/2018 seasons.**

| Nitrogen fertilizer rate (kg N/ha) | Means                   |          |                     |         |                      |         |
|------------------------------------|-------------------------|----------|---------------------|---------|----------------------|---------|
|                                    | Fresh root yield/ha (t) |          | Sucrose content (%) |         | Sucrose yield/ha (t) |         |
|                                    | 2016/17                 | 2017/18  | 2016/17             | 2017/18 | 2016/17              | 2017/18 |
| 100                                | 58.53 c*                | 80.05 c  | 15.31 c             | 15.81 c | 2.7 c                | 3.93 c  |
| 200                                | 65.02 b                 | 90.80 b. | 16.29 b             | 17.01 b | 3.45 b               | 5.06 b  |
| 300                                | 74.09 a                 | 101.42 a | 17.02 a             | 17.96 a | 4.28 a               | 6.39 a  |

\*Means of each trait under the main factor treatments followed by the same letter are not significantly different according to RLSD at  $\leq 0.05$ .

**Table 3. Means of root length (mm), root diameter (mm) and root fresh weight of sugar beet cultivars during 2016/2017 and 2017/2018 seasons.**

| Cultivars | Means            |         |                    |          |                       |          |
|-----------|------------------|---------|--------------------|----------|-----------------------|----------|
|           | Root length (mm) |         | Root diameter (mm) |          | Root fresh weight (g) |          |
|           | 2016/17          | 2017/18 | 2016/17            | 2017/18  | 2016/17               | 2017/18  |
| DITA      | 208.69 b*        | 209.3 b | 88.15 b            | 115.6 b  | 602.8 b               | 833.52 c |
| HEROS     | 204.8 b          | 210 b   | 70.72 c            | 113.42 c | 612.23 b              | 868.49 b |
| FARIDA    | 228.7 a          | 215 a   | 92.83 a            | 118.5 a  | 804.37a               | 899.87 a |

\*Means of each trait under the main factor treatments followed by the same letter are not significantly different according to RLSD at  $\leq 0.05$ .

**Table 4. Means of fresh root yield (t/ha), sucrose content (%) and sucrose yield/ha (t) of sugar beet cultivars during 2016/2017 and 2017/2018 seasons.**

| Cultivars | Means                   |         |                     |         |                      |         |
|-----------|-------------------------|---------|---------------------|---------|----------------------|---------|
|           | Fresh root yield/ha (t) |         | Sucrose content (%) |         | Sucrose yield/ha (t) |         |
|           | 2016/17                 | 2017/18 | 2016/17             | 2017/18 | 2016/17              | 2017/18 |
| DITA      | 57.26 b*                | 90.72 b | 18.80 a             | 19.25 a | 3.43 b               | 6.67 b  |
| HEROS     | 45.62 c                 | 64.55 c | 11.80 b             | 13.26 c | 2.12 c               | 3.35 c  |
| FARIDA    | 60.62 a                 | 97.00 a | 17.91 a             | 18.33 b | 4.15 a               | 6.95 a  |

\*Means of each trait under the main factor treatments followed by the same letter are not significantly different according to RLSD at  $\leq 0.05$ .

**Table 5. Means of root length (mm), root diameter (mm) and root fresh weight (g) under the effect of the interaction between nitrogen fertilizer rates and sugar beet cultivars during 2016/2017 and 2017/2018 seasons.**

| Nitrogen fertilizer rate (kg N/ha) | Cultivars | Means            |         |                    |         |                       |         |
|------------------------------------|-----------|------------------|---------|--------------------|---------|-----------------------|---------|
|                                    |           | Root length (mm) |         | Root diameter (mm) |         | Root fresh weight (g) |         |
|                                    |           | 2016/17          | 2017/18 | 2016/17            | 2017/18 | 2017/18               | 2016/17 |
| 100                                | DITA      | 185.95           | 194.06  | 68.8               | 101.4   | 487.48                | 597.02  |
|                                    | HEROS     | 195.25           | 190.68  | 70.45              | 114.4   | 458.5                 | 589.89  |
|                                    | FARIDA    | 201.48           | 203.75  | 93.47              | 114.88  | 662.73                | 744.78  |
| 200                                | DITA      | 207.93           | 208.21  | 76.22              | 114.1   | 545.92                | 896.31  |
|                                    | HEROS     | 206.36           | 200.76  | 76.80              | 124.18  | 546.17                | 780.92  |
|                                    | FARIDA    | 212.42           | 216.7   | 98.45              | 119.96  | 771.11                | 895.59  |
| 300                                | DITA      | 218.18           | 214.7   | 75.33              | 129.3   | 775.01                | 1007.2  |
|                                    | HEROS     | 212.87           | 204.75  | 84.87              | 117.7   | 596.04                | 870.66  |
|                                    | FARIDA    | 222.13           | 218.83  | 106.85             | 120.82  | 979.28                | 1059.2  |
| RLSD (0.05)                        |           | NS               | NS      | NS                 | NS      | NS                    | NS      |

NS: not significant at  $p \leq 0.05$ .

**Table 6. Means of fresh root yield (t/ha), sucrose content (%) and sucrose yield/ha (t) of sugar beet under the effect of the interaction between nitrogen fertilizer rates and sugar beet cultivars during 2016/2017 and 2017/2018 seasons.**

| Nitrogen fertilizer rate (kg N/ha) | Cultivars | Means                   |         |                     |         |                      |         |
|------------------------------------|-----------|-------------------------|---------|---------------------|---------|----------------------|---------|
|                                    |           | Fresh root yield (t/ha) |         | Sucrose content (%) |         | Sucrose yield/ha (t) |         |
|                                    |           | 2016/17                 | 2017/18 | 2016/17             | 2016/17 | 2017/18              | 2016/17 |
| 100                                | DITA      | 59.69                   | 82.33   | 17.82               | 17.83   | 3.29                 | 4.73    |
|                                    | HEROS     | 40.82                   | 72.16   | 10.95               | 12.3    | 1.69                 | 2.31    |
|                                    | FARIDA    | 62.09                   | 85.68   | 17.16               | 17.29   | 3.37                 | 4.74    |
| 200                                | DITA      | 68.96                   | 87.22   | 19.08               | 19.54   | 4.30                 | 5.29    |
|                                    | HEROS     | 42.22                   | 89.78   | 11.86               | 13.2    | 2.13                 | 3.06    |
|                                    | FARIDA    | 69.42                   | 95.51   | 17.94               | 18.47   | 3.93                 | 6.84    |
| 300                                | DITA      | 79.11                   | 102.61  | 19.65               | 20.4    | 4.72                 | 8.26    |
|                                    | HEROS     | 51.82                   | 91.8    | 12.77               | 14.26   | 2.61                 | 4.17    |
|                                    | FARIDA    | 78.36                   | 109.87  | 18.65               | 19.24   | 5.51                 | 6.76    |
| RLSD (0.05)                        |           | NS                      | NS      | NS                  | NS      | NS                   | NS      |

NS: not significant at  $p \leq 0.05$ .

## 5. Conclusion

The obtained results of the present study showed that the 300 kg N/ha produced the highest root traits, root yield/ha and sucrose content (%) and sucrose yield/ha. Farida polygerm cv. was the highest cv in sugar beet root yield and yield components followed by Dita monogerm cv. and the lowest was Heros polygerm cv. also, Farida cv. was the highest in sucrose yield/ha followed by Dita cv but dita cv was the highest in sucrose content followed by Farida while the lowest cultivar in sucrose content and sucrose yield/ha was Heros cultivar.

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## استجابة أصناف مختلفة من بنجر السكر لمعدلات من السماد النيتروجيني

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المستخلص. أجريت هذه الدراسة بمحطة الأبحاث الزراعية التابعة لجامعة الملك عبد العزيز بمنطقة هذا الشام خلال موسمي ٢٠١٦/٢٠١٧م، و ٢٠١٧/٢٠١٨م بهدف تقييم ثلاثة أصناف من بنجر السكر (فريدة، وديتا، وهيروس) تحت تأثير ثلاثة مستويات من السماد النيتروجيني (١٠٠، ٢٠٠، ٣٠٠ كجم نيتروجين /هكتار). وأوضحت نتائج الدراسة أنه بزيادة معدل السماد النيتروجيني حدثت زيادة معنوية في كل من محصول الجذور /هكتار ومكونات هذا المحصول من طول الجذر وقطره ووزن الجذر، وأيضاً في نسبة السكر بالجزور ومحصول السكر /هكتار، وأعطت معاملة التسميد ٣٠٠ كجم نيتروجين /هكتار أعلى محصول جزور وسكر في الموسمين، وكان الصنف فريدة هو الأعلى في محصول الجذور الطازج/هكتار إذ أنتج ٦٠,٦٢ طن /هكتار، ٩٧,٠ طن /هكتار في الموسمين على التوالي، يليه صنف ديتا، بينما كان الصنف هيروس الأقل في الإنتاجية للهكتار من الجزور والسكر. وقد أنتج الصنف فريدة أعلى محصول سكر في الموسمين (٤,١٥ طن، ٦,٩٥ طن/هكتار علي التوالي).

الكلمات المفتاحية: أصناف، بنجر السكر، سكر، سماد نيتروجيني، محصول الجزور.