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# Effect of Rate Urea and Ammonium Sulphate Nitrogen on Sugarbeet Yield and Quality

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## ABSTRACT

*Two experiments were conducted in the seasons 2014/15 and 2015/16 in the Sugar Research Center-Guneid farm, Sudan. The objective was to investigate the effect of two nitrogen fertilizer carriers, namely ammonium sulphate and urea; with four nitrogen rates, viz: 0, 43 kg N ha$^{-1}$, 86 kg N ha$^{-1}$ and 129 kg N ha$^{-1}$ on sugarbeet yield and quality. Land of the farm was cracking heavy clay soils (Vertisols) with low N and organic matter. Nitrogen Sugarbeet cultivar (Lenard) was sown in ridges 80 cm apart, 15 cm between holes. Treatments were laid in a factorial arrangement randomized complete block design with four replicates. Results revealed that there were no significant or consistent differences between the two source of N in tuber and sugar yields for the two seasons. Therefore, it is more economical to apply urea with its higher N content (46% N). Tuber yield and yield components increased significantly with the increase of N rate. Maximum tuber and sugar yields was obtained by 86 kg N/ ha rate in the first season. In the second season rate of 129 kg N/ha obtained maximum tuber and sugar yields. Therefore, it is recommended to apply 109.5 kg N/ha (100 kg urea/*feddan), an intermediate dose between the two significant rates of this study N rates 86 and 129 kg /ha showed similar tuber and sugar yield. Sugarbeet quality was high and in the second season 2015/16 was even better probably due to the lower winter temperatures prevailed in the second season. Therefore, it is necessary to adjust the sowing date of sugarbeet crop in Sudan to make use of the warm weather for vegetative growth and the cooler weather for sugar accumulation to end up in maximum tuber and sugar yield.*

**Key words:** Urea, AS, sugarbeet, tuber yield, sugar yield.

*Note: Feddan= 4200 m$^2$, a familiar land unit for the Sudanese farmer.

## INTRODUCTION

Sugar beet (*Beta vulgaris* L. var. *Saccharifera*, L.) is a plant with high content of sucrose stored in the roots and so it is the second important crop in the production of sugar. Beet sugar reached 39.2 million metric tons of raw sugar that represents about 21% of the global sugar production (Czarnikow 2016).

Sugar beet is a crop of the Mediterranean and temperate regions (Mectalfe and Elkins, 1980). According to Ahmed (personal communication), the Europeans bred and conditioned sugar beet North to suit their climates. In the same manner, it can be conditioned to suit the other climates. In

this sense, the recent breeding of the so-called tropical cultivars, as reported by Nelson, 2005 and Asade, 2007, enabled the production of sugar beet in some countries like Pakistan and Sudan as potential. Some of these cultivars gave satisfactory tuber yields when tried in the Sudan, e.g, Pamela and Sonja (Karori and Elrayh, 1998), and Valentina (Elhag *et. al.*, 2016).

Currently, production sugar in the Sudan is done from sugarcane. However, there is a gap of 750,000 metric tonnes of sugar between the local consumption and the local production (Hamid and Mohamed, 2006). To fill this gap attempts are encouraged to invest in sugar beet industry. In this regard, efforts to introduce sugar beet to Sudan have continued since the late 1990's. Research and demonstration fields have shown encouraging indicators for the success of the crop. Since sugarcane cannot be grown successfully in these regions, huge efforts were exerted to grow sugar beet. Moreover, extraction of sugar from sugar beet was one of the major agricultural and industrial developments in the nineteen century in Northern Europe which promoted the sustainable production of sugar beet.

Sugar beet, that it can suit well in the crop rotation of agricultural schemes such as Gezira, marginal land such as salt-affect and poor soils. Moreover, sugar beet is a short season crop with an age of 4 - 6 months (Asadi, 2007). They added that, sugar beet requires one third of irrigation water and half of fertilizers need by sugarcane.

The main produce of sugar beet is sugar. However, other uses are not less important. Sugar beet pulp and molasses are by-products widely used as animal feed. Sugar beet tops and beets removed by thinning are also useful livestock feed**.** Molasses, a by-product of sugar beet, are used widely in alcohol, pharmaceuticals and bakery yeast industries.

Nitrogen (N), is the single most important nutrient for optimum sugar beet production (Mohamed khan, 2014). He added that nitrogen status of the plant affects early growth or time of full canopy closure and the quality of the sugar beet at harvest. Chapman and Carter, (1976) stated that sugar beet requires a well balanced supply of mineral nutrients, especially nitrogen. The development of severe N deficiencies too early in the growing season, while enhancing quality, will reduce sugar beet root yield. Proper nitrogen fertilizer use increases both root and sugar yields. However, excessive nitrogen increases impurities and decreases sugar content (Mohamed khan, 2014). Sharif and Egbbal (1994), reported that increasing nitrogen rates up to 180 kg/ha increased root fresh weight and root yield but decreased sucrose content. However, Eddowes (1976), in Europe, recommended the application of 100 to 150 kg N/ha.

Urea with its relatively higher nitrogen content (46%) , easy handling, safe storage and transportation is the main N-source used for sugarcane and other crops in the Sudan (Mukhtar, 2008). Ammonium sulphate (21% N and 24% S) was recently released by the national crop. Husbandry Committee as a N- source in the Sudan (Mohammed, 2001). However, it contains lower nitrogen % compared to urea, it is considered more suitable for alkaline soils (Havlin *et. al.*,1999). However, Nemeat- Alla (2001), found that ammonium sulphate as a nitrogen source surpassed other nitrogen fertilizer sources or urea and produced the highest values of root length, diameter, root top fresh weight and root yield.

Fertilization is a limiting factor for sugar beet production. Therefore, it is vital to choose the right source, right rate, right time and place of macro and micro nutrients to produce the maximum yield and quality for sugar beet crop (Abd El-Gawad *et. al.*, 2004).

The main objective of this study:

1. To evaluate the response of sugar beet to two nitrogen sources.

2. To obtain the suitable dose of urea and Ammonium sulphate for high yields.

## MATERIALS AND METHOD

This study was conducted at the sugarcane research center at Guneid farm located approximately (Latitude $14^0$ $52^-$ N and Longitude $33^0$ $19^-$ E) 117 kilometers south of Khartoum on the eastern bank of the Blue River Nile, within the central clay plain of the Sudan. Soils of the farm belong to the order Vertisols, clayey with more than 45 % clay, and alkaline with pH around 8.2. Moreover, the soils are low in organic matter (O.M), total nitrogen (N < 0.05%) and available phosphorus (P < 10 ppm), (Idris, 1990). For two seasons 2014-2015 and 2015-2016. The sugar beet crop was sown in both seasons in November.

**Treatments:** The experiment consisted of two factors:

A: Source of Nitrogen fertilizers: 1- Urea 46% N 2- Ammonium Sulphate (AS) 21% Nitrogen and 24% Sulphur

B: Nitrogen fertilizer consisted of 4 rates as follows:

1. control (0.0 N).
2. 43 kg N/ha.
3. 86 kg N/ha
4. 129 kg N/ha.

These treatments were arranged in a factorial Randomized Complete Block Design (RCBD), with four blocks and 8 treatments. Plot size is 42 $m^2$.

The land was deep ploughed then harrowed to a fine tilth and leveled. Ridges were made 80 cm apart. Sugar beet cultivar Lenard was sown putting 2-3 seeds per hole at 15 cm apart within the row on the top of ridge. Then thinned latter to plant per hole. Application of fertilizer was done in split doses: Half at sowing, the other half after 8 weeks from sowing. Hand weeding was done ever needed.

The tubers were harvested 22 weeks after sowing when the lower leaves started to develop the yellow (brown color). Tubers in the two inner ridges were pulled, cleaned and weighed for determination of the tuber yield.

**Data collection:**

1. Number of leaves.
2. Number of tubers (roots) .
3. Thickness of roots.
4. Weight of leaves (leaves yield harvest).
5. Tuber yield.

Yield parameters were taken at harvest.

**Quality determination**

25 tuber samples from each plot were randomly taken and sliced and analyzed for quality parameters. These were brix% (total soluable solids), pol% (sucrose content) and ERS%( estimated

recoverable sugar) beet. The first analysis was done at harvest. Two more analysis was done, one after one week from harvest noted as brix1, pol1, ERS1 and pulp1. One more analysis was done two week after harvest noted as brix2, pol2, ERS2 and pulp2. Method of quality determination was done according to ICUMSA (1994).

Analysis of variance (ANOVA) was carried out for all the taken characters. LSD (least significant difference) was used for mean separation. Statistics softwares were used for this purpose.

## RESULT AND DISCUSSION

### 1. The effect of N sources on sugar beet yield and quality components of sugar beet:

The results of this study showed that there were no significant differences between the two source of N in the measured agronomic and quality parameters of sugar beet, as shown in Tables (1, 2 and the combine analysis in Table 3) in the two seasons of the study. In this sense, Kafaga, *et al.* (2007), stated that there was no significant differences between the nitrogen forms, urea and AS, on root and sugar yields, while they reported highly significant effect in using urea on sugar beet fresh weight, declaring the superiority of urea. However, Nemeat-Alla (2001), found that ammonium sulphate as a nitrogen source surpassed other nitrogen fertilizer sources or urea and produced the highest values of root length, diameter, root top fresh weight and root yield.

The combine analysis of sugar beet yield components (Table 3), revealed that the first season significantly exceeded the second one in tuber population, leaf and tuber yield. This was probably because of the warmer weather of the first season that enhanced the vegetative growth and consequently ended in better tuber yield. On the contrary, the second season, have significantly exceeded the first season in quality of sugar beet expressed as brix %, pol%, and ERS% beet, this also probably because of the cooler weather prevailed during the second season such as minimum temperature and RH% which enhanced the quality of the sugar beet crop at the expense of tuber and yield components.. However, in sugar yield, as a product of beet quality (ERS%) and tuber yield, the two seasons showed equal measurements. In this sense, it can be said that these points should be considered in the cultivation of sugar beet in Sudan. Judicious management of sowing dates that will get most use of weather. Early sowing of sugar beet in September or even in August, as suggested by Mukhtar (2016), will be very satisfactory to make use hot climate for vegetative growth during September, October and early December, for maximum tuber yield. In the same direction, the cool weather of winter months will enhance quality of sugar beet. Hence it will end in maximum sugar yield.

### 2.The effect of N rates on tuber yield and quality components of sugar beet:

The data in Tables (1 and 2) showed that there was no significant differences in beet tuber height as response to N rate in the two seasons. However, the data in Tables (1) and (2) showed that leaf and tuber yields increased significantly with the increase of N rates from control up to 86 kg N/ha. The combine analysis in Table (3), revealed that there was highly significant differences in leaf and tuber yields for N rates. In this regard, Sharif and Egbbal (1994), reported that increasing nitrogen rates up to 180 kg/ha increased root fresh weight and root yield. Eddowes (1976), in Europe, recommended the application of 100 to 150 kg N/ha. This was in a way similar to the findings of this study.

### The effect of N sources and rates on sugar beet quality one and two weeks after harvest:

Similar to the quality results of this study at harvest, lab analysis of quality traits one and two weeks after harvest showed no significant differences between urea and AS for the two seasons in brix %, pol %, ERS% and pulb% (Table 4 a and b). In the first season, brix %, pol %, ERS% have increased

with delayed analysis. On the other hand, pulp % decreased than when at harvest recording 1.6%. This probably suggests that the sugar beet in the first season still needs more time to mature and to have better quality.

Oppositely, in the second season (2015/16), brix %, pol %, ERS% have decreased with delayed analysis. On the other hand, pulp % increased than when at harvest recording 4.8%. This probably suggests that the sugar beet has reached maturity at harvest. In delayed analysis, sugar beet quality has begun to deteriorate denoted by decreasing of the former mentioned traits and increasing of pulp % (fiber). Hence, it can be said that, sugar beet needs shorter age when matures in better weather.

With respect to of N rates, brix, pol and ERS percentages one and two weeks after harvest followed the same trend at harvest. As shown in Figure 1, the difference in quality of sugar beet in the two seasons of the study was more distinct than the effects of N rates or sources.

In conclusion, as shown in appendix 1, one kg of urea is nearly half of one kg of AS in price. Since there was no significant differences in tuber and sugar yield between urea and AS in this study, it is better to apply urea with its higher N content (46% N). N rates 86 and 129 kg /ha showed similar tuber and sugar yield. Therefore, for the ease of application to the Sudanese farmer who use to deal with feddan (4200 $m^2$) instead of a hectare, it is better to recommend 100 kg urea per feddan which equals to 109.5 kg N/ha, a dose between the two significant rates of this study. Moreover, the high difference between the two seasons in tuber and quality traits, necessitates the judicious management of sowing dates that maximizes both yield and quality characters which eventually will end up in more sugar yield.

**Recommendations**

Based on the results of this study for nitrogen fertilization of sugar beet in Guneid area, Sudan, it is recommended to apply of 109.5 kg N /ha as urea that equals to 100 kg urea per feddan (one feddan =4200 $m^2$).

Table 1. The effect of Urea, Ammonium Sulphate (AS) and nitrogen rates on the yield and quality components of sugar beet, season 2014/15

| Parameters | Nitrogen source | | LSD | Nitrogen rates (kg)/ha | | | | LSD | C.V. (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Urea | AS | | 0.0 | 43 | 86 | 129 | | |
| Tuber height (cm) | 33.0 | 33.8 | 2.3 | 33.6 | 31.7 | 33.9 | 34.4 | 3.2 | 9.3 |
| Plant population/ha | 67317 | 64792 | 5449 | 68930 | 63360 | 65390 | 66540 | 7705 | 11.2 |
| Tuber yield (ton/ha) | 42.0 | 40.6 | 4.9 | 25.5 | 39.2 | 51.6 | 48.9 | 6.9 | 16.1 |
| Leaf yield (ton/ha) | 7.6 | 7.5 | 1.2 | 6.3 | 6.8 | 8.1 | 8.9 | 1.7 | 22.0 |
| Brix % beet | 18.7 | 18.2 | 2.3 | 16.4 | 18.4 | 20.1 | 19.0 | 3.2 | 16.6 |
| Pol % beet | 16.0 | 15.8 | 1.8 | 14.1 | 16.2 | 17.0 | 16.4 | 3.2 | 15.0 |
| ERS % beet | 13.6 | 13.8 | 1.9 | 12.5 | 13.7 | 14.5 | 14.0 | 3.2 | 17.7 |
| Pulp % beet | 2.0 | 2.2 | 0.6 | 1.6 | 2.6 | 1.9 | 2.2 | 0.9 | 40.5 |
| Sugar yield (ton/ha) | 5.7 | 5.5 | 0.6 | 3.1 | 5.3 | 7.3 | 6.8 | 0.9 | 15.2 |

Table 2. The effect of Urea, Ammonium Sulphate (AS) and nitrogen rates on the yield and quality components of sugar beet, season 2015/16

| Parameters | Nitrogen source | | LSD | Nitrogen rates (kg)/ha | | | | LSD | C.V. (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Urea | AS | | 0.0 | 43 | 86 | 129 | | |
| Tuber height (cm) | 32.7 | 33.5 | 2.9 | 30.8 | 33.0 | 33.8 | 34.8 | 4.1 | 12.0 |
| Plant population/ha | 38451 | 38073 | 4749 | 39820 | 40000 | 35470 | 37760 | 6716 | 16.9 |
| Tuber yield (ton/ha) | 32.3 | 31.3 | 4.8 | 18.28 | 27.2 | 37.5 | 44.3 | 6.8 | 20.6 |
| Leaf yield (ton/ha) | 3.5 | 3.6 | 0.7 | 2.8 | 3.1 | 4.0 | 4.3 | 1.0 | 26.7 |
| Brix % beet | 23.4 | 23.8 | 1.2 | 23.6 | 24.5 | 23.1 | 23.2 | 1.6 | 6.7 |
| Pol % beet | 21.1 | 21.2 | 1.1 | 21.1 | 22.1 | 20.6 | 20.8 | 1.6 | 7.2 |
| ERS % beet | 18.6 | 18.7 | 1.1 | 18.6 | 19.6 | 18.1 | 18.2 | 1.6 | 8.2 |
| Pulp % beet | 2.6 | 2.3 | 0.78 | 2.0 | 2.2 | 3.1 | 2.7 | 1.1 | 41.0 |
| Sugar yield (ton/ha) | 6.0 | 5.9 | 1.0 | 3.4 | 5.4 | 6.8 | 8.1 | 1.4 | 23.4 |

Figure 1. Effect of N rates on brix, pol and pulp of sugar beet, at harvest, one week after harvest and two weeks after harvest, on seasons 2014/15 (1) and 2015/16 (2)

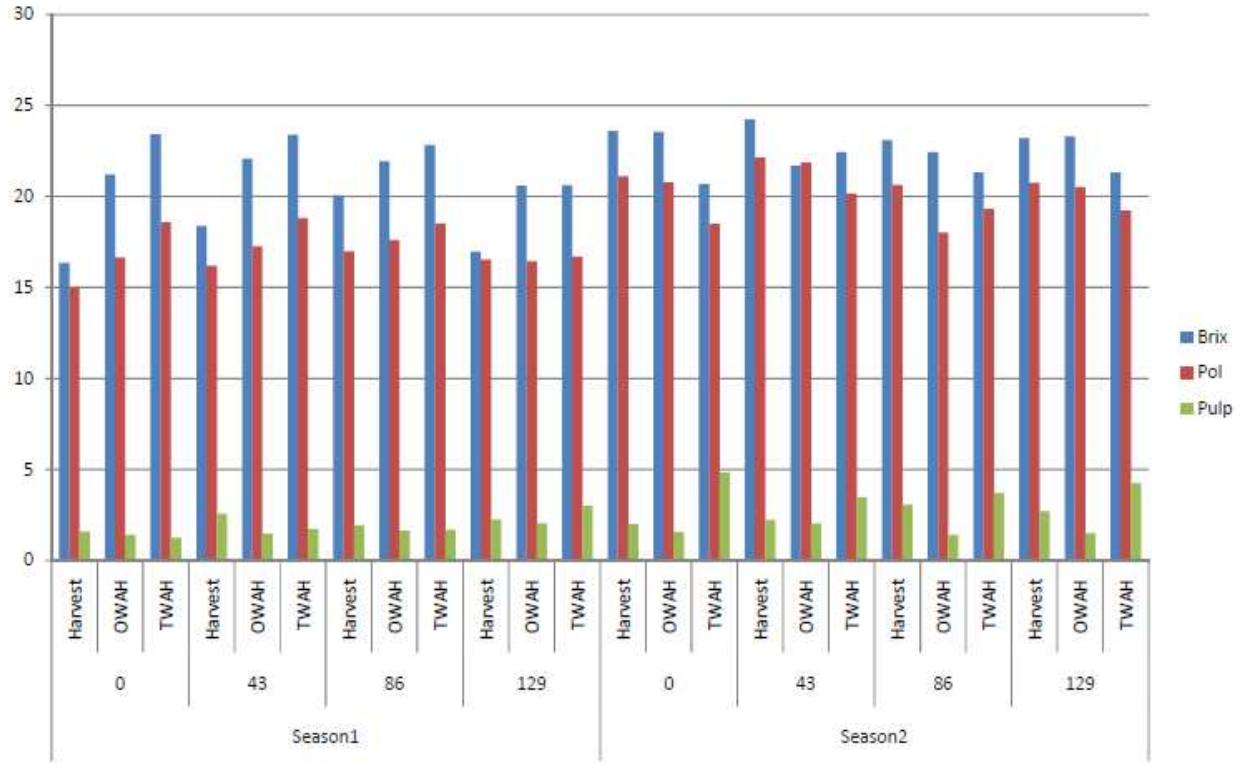

Table 3. The combine effects of seasons, N source and N rates on yield and quality components; beet and sugar yield of sugar beet in seasons 2014/15 and 2015/16. Guneid, Sudan.

| Parameters | Seasons | | N sources | | LSD | N rates (kg/ha) | | | | LSD | C.V. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014/15 | 2015/16 | Urea | AS | | 0.0 | 43 | 86 | 129 | | |
| Tuber height (cm) | 33.4 | 33.5 | 33.0 | 33.8 | 1.6 | 33.6 | 31.7 | 33.9 | 34.4 | 2.2 | 9.3 |
| Plant population/ha | 66055 | 38262 | 52864 | 51433 | 3507 | 54374 | 51680 | 50430 | 52148 | 4960 | 13.3 |
| Tuber yield (ton/ha) | 43.0 | 31.9 | 38.7 | 36.1 | 2.0 | 29.1 | 32.0 | 44.4 | 44.0 | 2.0 | 30.2 |
| Leaf yield (ton/ha) | 8.8 | 3.5 | 6.2 | 6.0 | 1.6 | 6.6 | 4.8 | 5.9 | 7.2 | 2.4 | 52.1 |
| Brix % beet | 18.5 | 23.6 | 21.0 | 21. | 1.2 | 20.0 | 21.4 | 21.6 | 21.1 | 1.7 | 11.6 |
| Pol % beet | 15.9 | 21.6 | 18.6 | 18.5 | 1.2 | 17.6 | 19.2 | 18.8 | 18.6 | 1.7 | 13.1 |
| ERS % beet | 13.4 | 18.7 | 16.1 | 16.0 | 1.2 | 15.1 | 16.7 | 16.3 | 16.1 | 1.7 | 15.2 |
| Pulp % beet | 2.1 | 2.5 | 2.3 | 2.3 | 0.5 | 1.8 | 2.4 | 2.5 | 2.5 | 0.7 | 40.7 |
| Sugar yield (ton/ha) | 6.0 | 5.9 | 6.1 | 5.7 | 0.7 | 3.8 | 5.2 | 7.3 | 7.5 | 1.0 | 23.8 |

Table 4 (a). Effect of N source (urea and AS) on quality parameters of sugar beet, at harvest, one and two weeks after harvest, season 2014/15

| | At harvest | | LSD | One week after harvest | | LSD | Two weeks after harvest | | LSD |
|---|---|---|---|---|---|---|---|---|---|
| | Urea | AS | | Urea | AS | | Urea | AS | |
| Brix % beet | 18.7 | 18.2 | 2.3 | 21.7 | 21.2 | 2.1 | 22.0 | 23.2 | 2.1 |
| Pol % beet | 16.1 | 16.3 | 1.8 | 17.0 | 17.0 | 1.8 | 17.6 | 18.7 | 2.0 |
| ERS % beet | 13.6 | 13.8 | 1.9 | 14.5 | 14.5 | 1.8 | 15.1 | 16.2 | 2.0 |
| Pulp % beet | 2.0 | 2.2 | 0.6 | 1.70 | 1.6 | 0.47 | 2.1 | 1.8 | 0.81 |

Table 4 (b). Effect of N source (urea and AS) on quality parameters of sugar beet, at harvest, one and two weeks after harvest, season 2015/16

| | At harvest | | LSD | One week after harvest | | LSD | Two weeks after harvest | | LSD |
|---|---|---|---|---|---|---|---|---|---|
| | Urea | AS | | Urea | AS | | Urea | AS | |
| Brix % beet | 18.7 | 18.2 | 1.2 | 22.2 | 23.3 | 3.2 | 21.7 | 21.2 | 1.9 |
| Pol % beet | 16.1 | 16.3 | 1.1 | 19.8 | 20.8 | 2.8 | 19.5 | 19.1 | 1.6 |
| ERS % beet | 13.6 | 13.8 | 1.1 | 18.5 | 18.2 | 1.7 | 17.0 | 16.6 | 1.6 |
| Pulp % beet | 2.0 | 2.2 | 0.78 | 1.6 | 1.6 | 0.43 | 4.8 | 4.3 | 1.3 |

Appendix1. The price of N fertilizer sources urea and ammonium sulphate

| Nitrogen source | N concentration | The local price of one sac | N kgs amount in one sac (N50 kg) | Price of one kg N pure | Tuber yield ton/ha |
|---|---|---|---|---|---|
| Urea | 46% | 290 (S.P) | 23 kg N | 12.6 (S.P) | 37.68 |
| AS | 21% | 250 (S.P) | 10.5 kg N | 23.8 (S.P) | 35.98 |

Appendix 2. Monthly maximum, minimum, mean temperatures and RH (relative humidity) for season 2014/15 at Wad Medani Meteorological Station

| Month | Maximum Temperature (°C) | Minimum Temperature (°C) | Mean Temperature (°C) |
|---|---|---|---|
| December | 35.6 | 17.2 | 26.4 |
| January | 33.1 | 13.7 | 23.4 |
| February | 38.3 | 17.7 | 28.0 |
| March | 39.1 | 21.7 | 30.7 |
| Mean | 36.7 | 17.6 | 27.1 |

Appendix 3. Monthly maximum, minimum, mean temperatures and RH (relative humidity) for season 2015/16 at Wad Medani Meteorological Station

| Month | Maximum Temperature (°C) | Minimum Temperature (°C) | Mean Temperature (°C) |
|---|---|---|---|
| December | 32.0 | 13.2 | 22.6 |
| January | 31.8 | 12.8 | 22.3 |
| February | 36.3 | 16.3 | 26.3 |
| March | 41.8 | 22.3 | 32.1 |
| Mean | 35.5 | 16.2 | 25.8 |

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| Parameters | Nitrogen source | | LSD | Nitrogen rates (kg)/ha | | | | LSD | C.V. (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Urea | AS | | 0.0 | 43 | 86 | 129 | | |
| Tuber yield (ton/ha) | 42.0 | 40.6 | 4.9 | 25.5 | 39.2 | 51.6 | 48.9 | 6.9 | 16.1 |
| Brix % beet | 18.7 | 18.2 | 2.3 | 16.4 | 18.4 | 20.1 | 19.0 | 3.2 | 16.6 |
| Pol % beet | 16.0 | 15.8 | 1.8 | 14.1 | 16.2 | 17.0 | 16.4 | 3.2 | 15.0 |
| ERS % beet | 13.6 | 13.8 | 1.9 | 12.5 | 13.7 | 14.5 | 14.0 | 3.2 | 17.7 |
| Pulp % beet | 2.0 | 2.2 | 0.6 | 1.6 | 2.6 | 1.9 | 2.2 | 0.9 | 40.5 |
| Sugar yield (ton/ha) | 5.7 | 5.5 | 0.6 | 3.1 | 5.3 | 7.3 | 6.8 | 0.9 | 15.2 |