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# EFFECT OF IRRIGATION INTERVALS AND NITROGEN FERTILIZER ON GROWTH AND YIELD OF TWO SWEET SORGHUM VARIETIES

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## ABSTRACT

Two field experiments were carried out at EL-Atf village, EL- Edwa, EL- Minia Governorate, Egypt during 2009 and 2010 seasons to study the effect of three irrigation intervals (irrigation every 10, 15 and 20 days) and four nitrogen fertilizer rates (without nitrogen added (control), 50, 70, and 90 kg N /feddan) on growth and yield of two sweet sorghum varieties (Honey and Rex).The experiments were laid out in split- split plot design with three replication.

The obtained results showed that average values of leaf area index, stalk height, stalk fresh weight, sucrose percentage, stalk yield / fed and sugar yield ton /fed. were significantly affected by irrigation intervals in both seasons. Prolonging irrigation period from 10 to 20 days significantly reduced all above mentioned studied traits in both seasons.

Results showed clearly that nitrogen fertilizer rates had a significant effect on all studied traits in both seasons. Increasing nitrogen fertilizer rates from 0 to 90 kg N/fed. significantly increased all studied characters, except sucrose % which decreased in both seasons.

Results illustrated that sweet sorghum varieties significantly differed in all studied characters in both seasons, except sucrose which were insignificantly differed in both seasons. Sweet sorghum variety Honey surpassed variety Rex in all studied traits in both seasons.

The interaction effect between irrigation intervals and nitrogen fertilizer rates was significant on all studied characters in both seasons. At all irrigation periods, increasing nitrogen fertilizer rate from 0 to 90 kg N/fed gradually increased all studied traits, except sucrose % which decreased in both seasons. The obtained results indicated that the interaction effect among irrigation intervals and sweet sorghum varieties was significant on all estimated traits in both seasons. On the other hand, sucrose % insignificantly affected in both seasons. At all irrigation intervals, sweet sorghum variety Honey exceeded variety Rex in all recorded traits in both seasons. The present results showed clearly that the interaction between nitrogen fertilizer rates and sweet sorghum varieties had a significant effect on all studied characters except on sucrose % which was insignificant in both seasons. The higher values of all measured characters were recorded when fertilized variety Honey with nitrogen fertilizer at the rate of 90 kg N/fed than variety Rex at the same of nitrogen rate in both seasons. The recoded results showed that the interaction effect between irrigation intervals, nitrogen fertilizer rates and sweet sorghum varieties was significant on all studied traits, except sucrose % which was insignificant in both seasons. At the irrigation every 20 days, fertilized variety Honey with 90 kg N/fed gave the highest leaf area index, stalk height, stalk fresh weight, stalk yield/fed and sugar yield/fed. in both seasons.

Highly significant and positive correlation coefficients were detected between sugar yield and each of leaf area index, stalk height and stalk yield/fed.

Generally, it could be recommended that under shortage of irrigation water, fertilized sweet sorghum variety Honey with nitrogen fertilizer at the rate of 90 kg N/fed. increased stalk and sugar yield ton/fed. under El-Minia Governorate conditions.

## INTRODUCTION

Sorghum (*sorghum bicolor L., Moench*) is multipurpose cereal, contain grain, forage and sweet types. Sweet sorghum or sorgo (*Sorghum bicolor, L*.) mainly is planted for sugar and ethanol production (Gnansounoua *et al*. 2005) Sugar cane is the main source of sugar production in the world. In Egypt this crop is facing many problems such as long growing season and higher water and fertilizers requirements. Sweet sorghum is highly biomass production, low water and fertilizers requirements as well as short growing season comparing with sugar cane. Currently, the same equipments are used to process both sugar cane and sweet sorghum stalks. About 25% from sugarcane stalks used in molasses production. Therefore sweet sorghum stalks can be replaced sugarcane stalks of molasses production and used in sugar production .Nowadays, the first important step in Egyptian strategy is increasing sugar production and decreasing the quantities of water use in sugarcane culture by substitution part of sugarcane area by sweet sorghum under hot and dry climate condition. Saving irrigation water is necessary to face the shortage of irrigation water. Such saving for irrigation water is likely to be achieved by increasing irrigation intervals and using drought tolerant varieties.

Taha, *et al.* (1999) reported that irrigation intervals at 10 days gave the highest values of growth characters, yield and yield components, juice percentage and syrup yield. Plants irrigated every 30 days intervals gave the maximum brix, reducing sugar % and sucrose %. Irrigation intervals at 20 days gave the highest purity %. Mastrorilli *et al. (*2002) found that sweet sorghum biomass production was reduced (36% less) when water stress occurred during the stem elongation stage. Later growth stages were less sensitive to soil water stress. Yanaso and Detpiratmongkol (2009) reported that water deficit reduced plant height, stem dry weight and stem fresh weight yield / ha. Ting and Peixi (2011) found that the maximum stem and above ground biomass yield occurred in moderate drought stress condition with stem fresh weight of 77.3 t/ha. Stem juice brix increased from 21.9% with normal water to 22.4% with severe drought.

The previously researches showed that increasing water stress decreased growth and yield of sweet sorghum, therefore, attempts have been made to overcome these deleterious effects upon plant growth and yield. One of which is applying adequate nitrogen fertilizer rate for sweet sorghum. El-Hawary (1995) showed that plant height, stalk fresh weight, stalk and sugar yield (ton/fed.) significantly increased with increasing nitrogen fertilizer rate up to 60Kg N/fed. Taha, *et al*. (1999) showed that plant height, stalk yield, sucrose %, purity % and syrup yield increased with increasing N rate. Al- Modrres *et al*. (2006) mentioned that application of nitrogen fertilizer significantly increased stem dry weight, total dry weight, growth and yield of sweet sorghum. Nemeth and IzsaKi (2007) found that the improvement of N

supply the sugar content of the stem juice decreased but increased molliable stalk and sugar yield/ha. Thakur *et al.* (2009) revealed that applying 120kgN/ha. gave maximum growth, dry matter production, yield attributes and yield of sweet sorghum.

Taha, *et al*. (1994) reported that sweet sorghum variety "Honey" has a superiority over variety "Sort" regarding to growth, yield and yield components characters and juice quality. Gomaa (1995) found that sweet sorghum varieties significantly differed in plant height and yield of stalk and sugar per feddan. El-Hawary (2000), showed that there were a significant differences between sweet sorghum varieties for plant height, stalk fresh weight, stalk and sugar yields/feddan and sucrose %. Also El-Lattief (2011) reported that sweet sorghum cultivar "Honey" had the lightest stalk height, sucrose %, purity % and stalk and sugar yields/fed, as well as had the lowest reducing sugar content compared to variety Tracy. Also reported that plant height, stalk fresh weight and sucrose % were positively and strongly correlated with stalk yield.

This investigation was carried out to study the effect of irrigation intervals and nitrogen fertilizer rates on growth and yield of two sweet sorghum cultivars at middle Egypt.

## MATERIALS AND METHODS

Two field experiments were carried out at EL- Atf village, EL- Edwa, EL- Minia Governorate, Egypt during 2009 and 2010 seasons to study the effect of irrigation intervals and nitrogen fertilizer rate on growth, yield and its components of two sweet sorghum varieties. The irrigation intervals and nitrogen fertilization treatments as will as two sweet sorghum varieties studied were as follows:

**I- Irrigation intervals**

Three irrigation intervals namely irrigation every 10, 15 and 20 days were studied. The irrigation treatments were applied after 30 days from sowing date. Furrow irrigation was used and engulf water was added at each irrigation treatments to bring the soil profile to field capacity.

**II- Nitrogen fertilizer rates**

Four nitrogen fertilizer rates i.e. without nitrogen added (control), 50, 70, and 90 kg N /feddan in form of ammonium nitrite (33%N).Nitrogen rate was applied at two equal half, the first half was applied at 20 days from sowing and the second one was applied at 60 days from sowing.

**III- Sweet sorghum varieties**

The two sweet sorghum varieties studied were Honey and Rex.

The experiments were laid out in split- split plot design with three replications. The irrigation treatments were distributed in main plots, nitrogen fertilizer rates were allocated in the sub plots and sweet sorghum verities were assigned in sub sub plots. The area of each sub sub plots was 10.5 $m^2$ (7ridges × 0.5m width × 3.0 m long).

Soil samples were collected prior to sowing through the experimental site to determine. the mechanical and chemical analysis of the soil at

experimental site according to standard methods of Page (1982) and Arnoid (1986)are presented in table (1).

**Table (1): Mechanical and chemical analysis of soil the experimental at site in 2009 and 2010 seasons.**

| Soil analysis | Season | |
|---|---|---|
| | 2009 | 2010 |
| **Mechanical analysis** | | |
| **Clay%** | 41.20 | 46.50 |
| **Silt %** | 36.90 | 29.90 |
| **Sand %** | 21.90 | 23.60 |
| **Soil Texture** | Clay | Clay |
| **Chemical analysis** | | |
| **Available P (ppm)** | 20.00 | 70.00 |
| **Available k (ppm)** | 60.00 | 20.00 |
| **Available N (ppm)** | 45.00 | 32.00 |
| **PH** | 7.80 | 7.50 |
| **EC (ds/m)** | 4.10 | 4.40 |
| **Available micronutrients ppm (EDTA)** | | |
| $Na^{+}$ | 0.34 | 0.31 |
| $Mg^{+2}$ | 6.30 | 4.20 |
| $So4^{-2}$ | 10.10 | 7.20 |
| $CaCo_3^{++}$ | 24.50 | 24.55 |
| $So_4^{++}$ | 10.10 | 7.20 |
| $Cl^{-}$ | 3.20 | 3.00 |

The soil was prepared as usually and phosphorus fertilization were applied prior seed bed preparation at the rate of 100kg calcium super phosphate per fed. (15.5% $P_2O_5$). Seeds of the studied verities were hand sown at 20cm hill apart on 6th June and 22nd May in 2009 and 2010 seasons, respectively. All the other agronomic practices were followed as usually done for the sweet sorghum crop.

At ripe stage five individual guarded plants were chosen at random from the middle ridges of each plot and the following data were recorded.

1- Leaf area index
2-Stalk height (cm), it was measured without panicle length.
3- Stalk fresh weight (g).
4-Sucrose percentage, it was measured by Saccharimeter.
5- Stalk yield / fed. (ton).
6- Sugar yield /fed. (ton), it was estimated by multiplying stalk yield by sucrose percentage.

The plants in the three middle ridges of each sub sub plot were harvested to determine the following traits:

The data were statistically analyzed as described by Steel and Torrie (1980). Correlation coefficient between sugar yield /fed. (ton) and each of leaf area index, stalk height (cm), stalk fresh weight (g), sucrose percentage and stalk yield / fed. (ton) were computed as applied by Steel and Torrie (1980). Path analysis methodology proposed by Dewey and Lu (1959) was used to

partition the simple correlation coefficients of the previous step into direct and indirect effect.

## RESULTS AND DISCUSSION

Average leaf area index, stalk height, stalk fresh weight, sucrose %, stalk and sugar yields/fed of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates and their interactions in 2009 and 2010 seasons are shown in Tables (2-9).

Results presented in Tables 2-7 indicate that prolonging irrigation times were significantly decreased leaf area index, stalk height, stalk fresh weight, and stalk yield/fed and sugar yield/fed., but sucrose % increased in both seasons. Increasing irrigation period from 10 to 20 days reduces leaf area index by 17.91 and 17.29 %, stalk height by 9.47 and 9.54 %, stalk fresh weight by 13.14 and 7.65 %, stalk yield/fed. by 18.05 and 15.69 % as well as sugar yield/fed by 15.78 and 13.14 % in 2009 and 2010 seasons, respectively. While, irrigation sweet sorghum every 15 days caused 10.54 and 8.99 % reduction in stalk yield/fed as well as 9.81 and 8.02 % reduction in sugar yield/fed compared to irrigation every 10 days in 2009 and2010seasons, respectively. On the other hand, the widest irrigation period (every 20 days) increased sucrose % by 0.45 and 0.53 as compared with those of plants irrigated every 10 days in 2009 and 2010 seasons, respectively. The reduction in growth and yield of sweet sorghum caused by prolonging irrigation interval may be attributed to general retardation of enzymatic processes particularly those concerned with photosynthesis and water decrease influenced the cell volume and divisions which led to decreasing height and fresh weight of stalk which led to reducing yield.

These results are in agreement with those of Yanaso and Detpiratmongkol (2009) and Ting and Peixi (2011)

Results recorded in Tables 2-7 show clearly that nitrogen fertilizer rates had a significant effect on all studied traits in both seasons. Increasing nitrogen fertilizer rate from zero to 90 kg N/feddan gradually increased leaf area index by 31.68 and 27.73 %, stalk height by 25.70 and 20.89 %, stalk fresh weight by 46.51 and 45.62 %, stalk yield/fed. by 40.38 and 46.25 % as well as sugar yield/fed. by 32.52 and 40.91 % in 2009 and 2010 seasons, respectively. On the contrary, sucrose % significantly decreased with increasing nitrogen fertilizer rate in both seasons. The highest sucrose % 17.06 and 17.07 was recorded with plants didn't fertilized by nitrogen (control), while the lowest sucrose percentage 16.06 and 16.14 was found when fertilized plants with nitrogen fertilizer at the rate of 90 kg N/fed compared to all other studied treatments in 2009 and 2010 seasons, respectively. The increase in growth and yield of stalk and sugar/fed caused by increasing nitrogen fertilizer rate might be attributed to the increase leaf area index, thus increased photosynthesis and net assimilation rate which led to enhanced stalk length and stalk fresh weight, therefore raising stalk and sugar yield .These results are in harmony with those of El-Hawary (1995), Taha, *et al.* (1999) and Thakur *et al.* (2009).

**Table 2: Average leaf area index of two sweet sorghum varieties as affected by Irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation Intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | Varieties | | Mean | Varieties | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 7.77 | 8.23 | 8.06 | 8.23 | 8.09 | 8.15 |
| | 50 | 8.78 | 8.76 | 8.77 | 8.87 | 8.72 | 8.80 |
| | 70 | 9.24 | 9.50 | 9.37 | 9.22 | 9.62 | 9.42 |
| | 90 | 10.04 | 10.45 | 10.25 | 9.74 | 10.12 | 9.93 |
| Mean | | 8.96 | 9.24 | 9.10 | 9.10 | 9.14 | 9.08 |
| Every 15 days | 0 | 7.64 | 8.32 | 7.98 | 7.41 | 7.72 | 7.56 |
| | 50 | 8.58 | 8.98 | 8.78 | 8.17 | 8.14 | 8.12 |
| | 70 | 9.17 | 9.59 | 9.38 | 8.44 | 8.34 | 8.34 |
| | 90 | 9.90 | 9.87 | 9.88 | 9.15 | 10.07 | 9.61 |
| Mean | | 8.82 | 9.19 | 9.01 | 8.29 | 8.57 | 8.43 |
| Every 20 days | 0 | 6.77 | 5.93 | 6.35 | 6.36 | 6.79 | 6.57 |
| | 50 | 6.82 | 7.66 | 7.24 | 6.70 | 6.93 | 6.81 |
| | 70 | 7.80 | 7.16 | 7.48 | 7.52 | 7.94 | 7.73 |
| | 90 | 8.44 | 9.20 | 8.82 | 8.36 | 9.50 | 8.94 |
| Mean | | 7.46 | 7.49 | 7.47 | 7.24 | 7.79 | 7.51 |
| Over all for nitrogen rates | 0 | 7.39 | 7.95 | 7.45 | 7.33 | 7.53 | 7.43 |
| | 50 | 8.06 | 8.47 | 8.26 | 7.91 | 7.93 | 7.92 |
| | 70 | 8.74 | 8.72 | 8.73 | 7.40 | 8.64 | 8.51 |
| | 90 | 9.46 | 10.12 | 9.81 | 9.08 | 9.90 | 9.49 |
| Mean | | 8.41 | 8.72 | 8.57 | 8.18 | 8.50 | 8.34 |

| **L.S.D. at (5%) for:** | | |
|---|---|---|
| **Irrigation (I)** | **0.17** | **0.16** |
| **Nitrogen (N)** | **0.15** | **0.121** |
| **Variety (V)** | **0.096** | **0.09** |
| **(I× N)** | **0.12** | **0.21** |
| **(I× V)** | **0.17** | **0.15** |
| **(N× V)** | **0.19** | **0.06** |
| **(I× N×V)** | **0.34** | **0.30** |

Results tabulated in Tables 2-7 illustrate that sweet sorghum varieties significantly differed in all studied characters in both seasons, except sucrose was insignificantly differed in both seasons. Sweet sorghum variety Honey surpassed variety Rex in leaf area index by 3.86 and 3.91 %, stalk height by 3.51 and 3.21 %, stalk fresh weight by 5.15 and 5.19 % stalk yield/fed. by 4.53 and 5.66 % as well as sugar yield/fed. by 3.31 and 4.16 % in 2009 and 2010 seasons, respectively. On the other hand, variety Rex gave the highest sucrose % than variety Honey but, this difference was insignificant in both seasons. The superiority of variety Honey in stalk and sugar yields may be attributed to this variety which have the highest leaf area index, stalk height, stalk fresh weight which caused increase in stalk and sugar yield. These results are in harmony with those of El-Hawary (2000) and El-Lattief (2011).

**Table 3: Average stalk length (cm) of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | variety | | Mean | variety | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 323.30 | 363.34 | 343.17 | 326.00 | 347.00 | 336.50 |
| | 50 | 365.67 | 376.34 | 371.00 | 360.34 | 367.00 | 363.67 |
| | 70 | 787.67 | 394.00 | 390.84 | 375.34 | 380.67 | 377.00 |
| | 90 | 403.34 | 412.67 | 408.00 | 394.00 | 406.34 | 400.17 |
| Mean | | 396.92 | 386.59 | 378.23 | 36342 | 375.23 | 369.34 |
| Every 15 days | 0 | 316.00 | 330.00 | 323.00 | 337.00 | 344.34 | 340.67 |
| | 50 | 347.67 | 357.00 | 352.34 | 359.37 | 363.67 | 361.67 |
| | 70 | 373.00 | 380.34 | 376.67 | 369.34 | 375.34 | 372.34 |
| | 90 | 397.67 | 406.00 | 401.84 | 382.00 | 390.34 | 386.12 |
| Mean | | 358.59 | 368.34 | 363.46 | 362.00 | 368.42 | 365.21 |
| Every 20 days | 0 | 278.00 | 284.67 | 281.34 | 272.67 | 293.00 | 282.84 |
| | 50 | 337.34 | 353.00 | 345.17 | 315.00 | 331.67 | 323.34 |
| | 70 | 358.00 | 356.00 | 362.60 | 350.00 | 362.00 | 356.00 |
| | 90 | 379.34 | 388.00 | 381.12 | 367.67 | 380.67 | 374.12 |
| Mean | | 336.92 | 347.92 | 342.42 | 326.34 | 341.84 | 334.10 |
| Over all for nitrogen rates | 0 | 305.67 | 326.00 | 315.84 | 311.90 | 328.12 | 320.00 |
| | 50 | 350.89 | 362.12 | 356.17 | 345.00 | 354.12 | 349.56 |
| | 70 | 372.89 | 380.12 | 376.51 | 364.23 | 373.67 | 368.45 |
| | 90 | 391.78 | 402.23 | 397.00 | 381.23 | 392.42 | 386.84- |
| Mean | | 335.14 | 367.62 | 361.38 | 350.59 | 361.84 | 356.23 |

| **L.S.D. at (5%) for:** | | |
|---|---|---|
| **Irrigation (I)** | **1.59** | **1.21** |
| **Nitrogen (N)** | **1.73** | **0.15** |
| **Variety (V)** | **1.69** | **0.91** |
| **(I× N)** | **3.00** | **2.60** |
| **(I× V)** | **2.94** | **1.57** |
| **(N×V)** | **3.39** | **1.81** |
| **(I× N×V)** | **5.88** | **3.14** |

The interaction effect between irrigation intervals and nitrogen fertilizer rates was significant on all studied characters in both seasons. At all irrigation periods, increasing nitrogen fertilizer rate from zero to 90 kg N/fed. gradually increased all studied traits, except sucrose % which decreased in both seasons. Fertilized sweet sorghum plants with 90 kg N/fed. at the longest irrigation intervals (every 20 days) caused 38.90, 35.47, 34.52, 37.23 and 29.82 % as well as 36.07, 32.27, 33.71, 41.23 and 32.94 % increase in leaf area index, stalk height, stalk fresh weight, stalk yield/fed. and sugar yield/fed. as compared with those of plants grown without receiving nitrogen fertilizer (control) under the same irrigation period in 2009 as well as 2010 seasons, respectively. These results suggested that increasing nitrogen fertilizer rate advocated and alleviated the injurious effect of water deficit and increased growth and yield of sweet sorghum. The obtained results indicated that the interaction effect among irrigation intervals and sweet sorghum varieties was significant on all estimated traits in both seasons. On the other

hand, sucrose % was insignificantly affected in both seasons. At all irrigation intervals, sweet sorghum variety Honey exceeded in all recorded traits compared to variety Rex in both seasons. However, at irrigation every 30 days, sweet sorghum variety Honey gave the highest leaf area index 7.49 and 7.79, stalk height 347.92 and 341.84 cm, stalk fresh weight 699.00 and 700.84, stalk yield/fed. 24.44 and 23.66 tons and sugar yield/fed. 4.04 and 3.98 tons compared to variety Rex in 2009 and 2010 seasons, respectively. These results indicted that variety Honey was more drought tolerant than variety Rex.

**Table 4: Average stalk fresh weight (g)/ plant of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | variety | | Mean | variety | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 595.00 | 602.00 | 568.50 | 588.34 | 596.67 | 592.00 |
| | 50 | 781.67 | 795.34 | 788.50 | 633.34 | 706.34 | 669.84 |
| | 70 | 820.00 | 861.67 | 840.84 | 794.34 | 818.67 | 806.50 |
| | 90 | 909.67 | 970.00 | 939.84 | 896.00 | 943.37 | 919.84 |
| Mean | | 776.59 | 807.26 | 791.92 | 727.76 | 76634 | 747.05 |
| Every 15 days | 0 | 583.34 | 621.34 | 602.34 | 574.67 | 634.00 | 604.34 |
| | 50 | 646.67 | 705.67 | 676.17 | 649.34 | 701.34 | 675.34 |
| | 70 | 763.00 | 840.00 | 801.50 | 755.67 | 817.67 | 786.67 |
| | 90 | 860.00 | 920.00 | 890.00 | 867.67 | 918.67 | 893.17 |
| Mean | | 713.26 | 771.78 | 742.50 | 711.84 | 767.92 | 739.88 |
| Every 20 days | 0 | 585.34 | 591.67 | 588.50 | 589.67 | 599.00 | 594.34 |
| | 50 | 630.00 | 671.00 | 650.50 | 632.34 | 673.00 | 652.67 |
| | 70 | 709.67 | 73167 | 720.67 | 709.34 | 726.34 | 717.84 |
| | 90 | 781.67 | 801.67 | 791.67 | 784.34 | 805.00 | 794.67 |
| Mean | | 676.67 | 699.00 | 687.84 | 678.92 | 700.84 | 689.88 |
| Over all for nitrogen rates | 0 | 587.90 | 605.00 | 596.45 | 583.90 | 609.90 | 596.90 |
| | 50 | 686.12 | 724.00 | 705.06 | 638.34 | 693.56 | 66595 |
| | 70 | 764.23 | 811.12 | 787.67 | 753.12 | 784.56 | 770.34 |
| | 90 | 850.46 | 897.23 | 873.84 | 849.34 | 883.12 | 869.23 |
| Mean | | 722.17 | 759.34 | 740.76 | 706.17 | 742.79 | 725.60 |

| **L.S.D. at (5%) for:** | | |
|---|---|---|
| **Irrigation (I)** | **6.12** | **7.84** |
| **Nitrogen (N)** | **5.72** | **4.44** |
| **Variety (V)** | **5.34** | **4.65** |
| **(I× N)** | **9.91** | **7.69** |
| **(I× V)** | **9.28** | **8.05** |
| **(N× V)** | **10.71** | **9.29** |
| **(I× N×V)** | **18.55** | **16.09** |

The presented results show clearly that the interaction between nitrogen fertilizer rates and sweet sorghum varieties had a significant effect on all studied characters except on sucrose % it was insignificant in both seasons. The highest values of all measured characters were recorded when fertilized variety Honey with nitrogen fertilizer at the rate of 90 kg N/fed. than

variety Rex in both seasons. Fertilized variety Honey with nitrogen fertilizer at a rate of 90 kg N/fed. gave the highest stalk yield/fed. 30.79 and 30.70 tons as well as sugar yield/fed. 4.90 and 4.92 tons, on the contrary, the lowest values were 21.15 and 19.96 tons as well as 3.61 and 3.44 tons were recorded with variety Rex without fertilization in the same respect in 2009 and 2010 seasons, respectively.

**Table 5: Average sucrose % of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | variety | | Mean | variety | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 16.89 | 16.94 | 16.92 | 16.97 | 16.63 | 16.80 |
| | 50 | 16.37 | 16.07 | 16.22 | 16.75 | 16.60 | 16.68 |
| | 70 | 15.98 | 15.84 | 15.91 | 16.35 | 16.10 | 16.23 |
| | 90 | 15.97 | 15.72 | 15.85 | 16.00 | 15.80 | 15.90 |
| Mean | | 16.30 | 16.18 | 16.23 | 16.52 | 16.28 | 16.40 |
| Every 15 days | 0 | 16.95 | 17.00 | 16.98 | 17.05 | 16.90 | 16.98 |
| | 50 | 16.39 | 16.18 | 16.29 | 16.85 | 16.80 | 16.83 |
| | 70 | 16.30 | 16.00 | 16.51 | 16.55 | 16.25 | 16.40 |
| | 90 | 16.10 | 16.90 | 16.00 | 16.20 | 16.02 | 16.11 |
| Mean | | 16.44 | 16.27 | 16.34 | 16.66 | 16.49 | 16.58 |
| Every 20 days | 0 | 17.30 | 17.23 | 17.27 | 17.60 | 17.25 | 17.43 |
| | 50 | 16.80 | 16.50 | 16.65 | 17.30 | 17.20 | 17.25 |
| | 70 | 16.65 | 16.25 | 16.45 | 16.80 | 16.50 | 16.65 |
| | 90 | 16.50 | 16.15 | 16.33 | 16.50 | 16.30 | 16.40 |
| Mean | | 16.81 | 16.53 | 16.68 | 16..90 | 16.81 | 16.93 |
| Over all for nitrogen rates | 0 | 17.05 | 17.06 | 17.06 | 17.21 | 16.93 | 17.07 |
| | 50 | 16.52 | 16.25 | 16.39 | 16.97 | 16.87 | 16.92 |
| | 70 | 16.31 | 16.03 | 16.17 | 16.57 | 16.28 | 16.43 |
| | 90 | 16.19 | 15.92 | 16.06 | 16.23 | 16.04 | 16.14 |
| Mean | | 16.52 | 16.32 | 16.42 | 16.75 | 16.53 | 16.64 |

| **L.S.D. at (5%) for:** | | |
|---|---|---|
| **Irrigation (I)** | **0.24** | **0.18** |
| **Nitrogen (N)** | **0.15** | **0.24** |
| **Variety (V)** | **NS** | **NS** |
| **(I× N)** | **0.26** | **0.42** |
| **(I× V)** | **NS** | **NS** |
| **(N× V)** | **NS** | **NS** |
| **(I× N×V)** | **NS** | **NS** |

The recoded results showed that the interaction effect between irrigation intervals, nitrogen fertilizer rates and sweet sorghum varieties was significant on all studied traits, except sucrose % which was insignificant in both seasons. At the irrigation every 20 days, fertilized variety Honey with 90 kg N/fed. gave the highest leaf area index 9.20 and 9.21, stalk height 388.00 and 380.67 cm, stalk fresh weight 801.67 and 805.00 g, stalk yield/fed. 27.63 and 27.72 tons as well as sugar yield/fed. 4.46 and 4.52 tons compared to all other these interaction treatments in 2009 and 2010 seasons, respectively.

**Table 6: Average stalk yield (ton) /fed of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | variety | | Mean | variety | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 23.87 | 24.79 | 24.33 | 22.08 | 23.90 | 23.00 |
| | 50 | 27.76 | 27.76 | 27.76 | 24.09 | 25.68 | 24.89 |
| | 70 | 29.46 | 31.86 | 30.66 | 28.17 | 30.03 | 29.140 |
| | 90 | 32.76 | 33.13 | 32.95 | 32.09 | 32.80 | 32.41 |
| Mean | | 28.46 | 29.39 | 28.92 | 26.59 | 28.10 | 27.35 |
| Every 15 days | 0 | 20.32 | 21.08 | 20.70 | 18.85 | 20.28 | 19.57 |
| | 50 | 21.48 | 23.79 | 22.64 | 20.94 | 22.96 | 21.95 |
| | 70 | 28.90 | 29.18 | 29.09 | 26.79 | 27.54 | 27.17 |
| | 90 | 30.62 | 31.60 | 31.20 | 30.20 | 31.56 | 30.79 |
| Mean | | 25.33 | 26.41 | 25.87 | 24.12 | 25.59 | 24.89 |
| Every 20 days | 0 | 19.27 | 20.38 | 19.82 | 18.96 | 19.69 | 19.33 |
| | 50 | 20.50 | 23.92 | 22.21 | 20.06 | 22.22 | 21.13 |
| | 70 | 25.31 | 25.84 | 25.57 | 23.90 | 24.99 | 24.44 |
| | 90 | 26.77 | 27.63 | 27.20 | 26.87 | 27.72 | 27.30 |
| Mean | | 22.96 | 24.44 | 23.70 | 22.44 | 23.66 | 23.06 |
| Over all for nitrogen rates | 0 | 21.15 | 22.08 | 21.67 | 19.96 | 21.29 | 20.65 |
| | 50 | 23.25 | 25.16 | 24.20 | 21.69 | 23.62 | 22.66 |
| | 70 | 27.89 | 28.86 | 28.42 | 26.29 | 27.52 | 26.90 |
| | 90 | 30.05 | 30.79 | 30.42 | 29.70 | 30.70 | 30.20 |
| Mean | | 25.59 | 26.75 | 26.17 | 24.40 | 25.78 | 25.10 |
| **L.S.D. at (5%) for:** | | | | | | | |
| **Irrigation (I)** | | **0.29** | | | **0.25** | | |
| **Nitrogen (N)** | | **0.23** | | | **0.26** | | |
| **Variety (V)** | | **0.12** | | | **0.15** | | |
| **(I× N)** | | **0.40** | | | **0.44** | | |
| **(I× V)** | | **0.19** | | | **0.13** | | |
| **(N× V)** | | **0.23** | | | **0.31** | | |
| **(I× N×V)** | | **0.40** | | | **0.53** | | |

Correlation coefficients between all pairs of studied traits are shown in Table (8). The results revealed that there was a highly significant positive correlation between sugar yield and each of stalk yield (0.998**), stalk length (0.901**) and leaf area index (0.891**) However, insignificant associations were observed between sugar yield and stalk fresh weight.

Negative and highly significant correlation was found between sucrose % and each of stalk length (-0.932**), stalk yield (-0.921**) and sugar yield (-0.898**). The correlation between stalk length and stalk yield was found to be positive and highly significant (0.901**).

The present results are similar to those reported by El-Deeb (1998) and Kachapur and Salimath (2009).

Information obtained from simple correlation coefficient can be enlarged by partitioning it into direct and indirect effects for a given set of casual interrelationships. The matrix of direct and joint effects for the studied characters is shown in Table (9).

**Table 7: Average sugar yield /fed (ton) of two sweet sorghum varieties as affected by irrigation intervals and nitrogen fertilizer rates in 2009 and 2010 seasons.**

| Irrigation intervals | N. rates kg/fed. | 2009 season | | | 2010 season | | |
|---|---|---|---|---|---|---|---|
| | | variety | | Mean | variety | | Mean |
| | | Rex | Honey | | Rex | Honey | |
| Every 10 days | 0 | 4.03 | 4.20 | 4.12 | 3.75 | 3.98 | 3.86 |
| | 50 | 4.54 | 4.46 | 4.50 | 4.04 | 4.26 | 4.15 |
| | 70 | 4.71 | 5.00 | 4.88 | 4.61 | 4.88 | 4.72 |
| | 90 | 5.23 | 5.12 | 5.22 | 5.12 | 3.76 | 5.15 |
| Mean | | 4.64 | 4.76 | 4.69 | 4.39 | 4.57 | 4.49 |
| Every 15 days | 0 | 3.44 | 3.58 | 3.51 | 3.21 | 3.43 | 3.32 |
| | 50 | 3.52 | 3.85 | 3.69 | 3.53 | 3.86 | 3.69 |
| | 70 | 4.71 | 4.67 | 4.69 | 4.35 | 4.48 | 4.45 |
| | 90 | 4.93 | 5.02 | 4.98 | 4.89 | 5.05 | 4.97 |
| Mean | | 4.16 | 4.30 | 4.23 | 4.03 | 4.22 | 4.13 |
| Every 20 days | 0 | 3.33 | 3.51 | 3.42 | 3.34 | 3.40 | 3.37 |
| | 50 | 3.44 | 3.95 | 3.70 | 3.47 | 3.82 | 3.64 |
| | 70 | 4.21 | 4.20 | 4.21 | 4.01 | 4.12 | 4.07 |
| | 90 | 4.42 | 4.46 | 4.44 | 4.43 | 4.52 | 4.48 |
| Mean | | 3.86 | 4.04 | 3.95 | 3.79 | 3.98 | 3.90 |
| Over all for nitrogen rates | 0 | 3.61 | 3.77 | 3.69 | 3.44 | 3.60 | 3.52 |
| | 50 | 3.84 | 4.09 | 3.97 | 3.68 | 3.98 | 3.83 |
| | 70 | 4.55 | 4.64 | 4.60 | 4.36 | 2.85 | 4.42 |
| | 90 | 4.87 | 4.90 | 4.89 | 4.82 | 4.92 | 4.96 |
| Mean | | 4.23 | 4.37 | 4.3 | 4.09 | 4.26 | 4.18 |
| **L.S.D. at (5%) for:** | | | | | | | |
| **Irrigation (I)** | | | **0.06** | | **0.06** | | |
| **Nitrogen (N)** | | | **0.04** | | **0.05** | | |
| **Variety (V)** | | | **0.03** | | **0.04** | | |
| **(I× N)** | | | **0.08** | | **0.10** | | |
| **(I× V)** | | | **0.06** | | **0.07** | | |
| **(N× V)** | | | **0.07** | | **0.06** | | |
| **(I× N×V)** | | | **0.13** | | **0.10** | | |

**Table 8: Matrix of simple correlation coefficients among sugar yield and its components in sweet sorghum over 2009 and 2010 seasons.**

| Traits | L A | S L | S F W | S % | S Y | Y |
|---|---|---|---|---|---|---|
| Leaf area index (LA) | 1 | 0.911** | -0.080 | 0.895** | 0.905** | 0.891** |
| Stalk length (SL) | | 1 | -0.043 | -0.932** | 0.914** | 0.901** |
| Stalk fresh weight (SFW) | | | 1 | 0.146 | -0.120 | -0.112 |
| Sucrose percentage (S %) | | | | 1 | -0.921** | -0.898** |
| Stalk yield (SY) | | | | | 1 | 0.998** |
| Sugar yield (Y) | | | | | | 1 |

**** significant at 0.01 probability levels**

The maximum direct effects were obtained for stalk yield (1.152) and sucrose % (0.139). It is reported that the indirect effects of stalk yield and sucrose % were less important compared to their direct effects. The high positive direct effects of the stalk yield and sucrose % in addition to their highly significant coefficients of correlation is evidence that the direct

selection through the two traits would be effective for improving sugar yield of sweet sorghum.

The coefficient of determination and relative importance using path analysis for sugar yield and its related factors are shown in Table (9).

The results revealed that the greatest parts of sugar yield variability were explained by the direct effect of number of stalk yield (71.54) and sucrose % (1.04). The great contribution of these traits on sugar yield supported their importance as selection criteria in sweet sorghum breeding program.

**Table 9: Path coefficients (direct and joint effects) of sugar yield and its related characters in sweet sorghum.**

| Characters | L A | S L | S F W | S % | S Y | $r_{xy}$ |
|---|---|---|---|---|---|---|
| **L A** | **-0.034** | 0.027 | -0.02 | -0.124 | 1.04 | 0.891** |
| **S L** | -0.031 | **0.03** | -0.021 | -0.13 | 1.05 | 0.901** |
| **S F W** | -0.029 | 0.027 | **-0.023** | -0.126 | 1.10 | -0.112 |
| **S %** | 0.03 | -0.028 | 0.021 | **0.139** | -1.06 | -0.898** |
| **S Y** | -0.031 | 0.027 | -0.022 | -0.128 | **1.152** | 0.998** |

**Residual effect = 0.03**

**Note: L A = Leaf area index, SL= stalk length, S F W = Stalk fresh weight, S %= Sucrose percentage, SY= Stalk yield and Y = Sugar yield**

**- The direct effects occupied the diagonal cells (bold and underline).**

**Table 10: The coefficient of determination (CD) and relative importance (RI %) of sugar yield components in sweet sorghum.**

| Characters | | Sugar yield | |
|---|---|---|---|
| | | CD | RI % |
| **Direct effects** | | | |
| Leaf area index (L A) | | 0.001 | 0.062 |
| Stalk length (SL) | | 0.001 | 0.047 |
| Stalk fresh weight (S F W) | | 0.0005 | 0.03 |
| Sucrose percentage (S %) | | 0.019 | 1.04 |
| Stalk yield (SY) | | 1.326 | 71.54 |
| **Indirect effects** | | | |
| **L A via** | **SL** | -0.002 | 0.099 |
| | **SFW** | 0.001 | 0.073 |
| | **S%** | 0.008 | 0.456 |
| | **SY** | -0.071 | 3.82 |
| **SL via** | **SFW** | -0.001 | 0.066 |
| | **S%** | -0.008 | 0.413 |
| | **SY** | 0.062 | 3.356 |
| **SFW via** | **S%** | 0.006 | 0.312 |
| | **SY** | -0.05 | 2.72 |
| **S%** | **SY** | -0.295 | 15.91 |
| **Total (direct + indirect)** | | 0.999 | 99.95 |
| **Residuals** | | 0.001 | 0.05 |
| **Total** | | 1.000 | 100 |

**Note:Bold and underline cells indicate the highest values of direct and indirect effects.**

According to the relative importance of joint effect components, it appeared that the highest values were recorded for the indirect effect of sucrose % on sugar yield through its association with stalk yield (15.91)

followed by the joint effect of leaf area index *via* stalk yield (3.82) followed by stalk length *via* stalk yield (3.36) and stalk fresh weight through stalk yield (2.72). Trivial values of relative importance were obtained by the other direct and indirect effects. Totally, the studied traits accounted for 99.95 % of sugar yield variation. The current results are in parallel line with those obtained by Sidramappa *et al* (2011)and Moench *et al*. (2011).

Generally, it could be recommended that under prolonging irrigation interval up to 20 days water, fertilized sweet sorghum variety Honey with nitrogen fertilizer at the rate of 90 kg N/fed. increased stalk and sugar yields /fed. under El-Minia Governorate conditions.

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**قسم المحاصيل-كليه الزراعه جامعه الازهر- القاهره-مصر**

اجريت تجربتان حقليتان بقريه العطف مركز العدوه بمحافظه المنيا خلال موسمي الزراعة ٢٠٠٩ و ٢٠١٠ لدراسه تأثير فترات الري (الري كل ١٠و١٥و٢٠ يوم) ومعدلات السماد الازوتي (بدون اضافه و٥٠و٧٠و٩٠ كجم ف /فدان) علي نمو ومحصول صنفين من الذرة السكرية (Honey وRex) وصممت التجربه في تصميم القطع المنشقه مرتين
وتتلخص اهم النتائج فيما يلي
اظهرت النتائج اختلافات معنوية علي دليل مساحه الاوراق وطول الساق ووزن الساق غض والنسبه المئويه للسكروز ومحصول السيقان /فدان ومحصول السكر /فدان في كلا من الموسمين حيث ادت زياده فترات الري من ١٠الي٢٠ الي نقص معنوي في كل الصفات المدروسه فيما عدا النسبه المئويه للسكروز في كلا من الموسمين
اوضحت النتائج ان للسماد الازوتي تأثيرا معنويا علي كل الصفات المدروسه ما عدا النسبه المئويه للسكروزفى كلا من الموسمين و ادت زياده معدل السماد الازوتي من صفر الي ٩٠ كجم ن /فدان الي زياده قيم كل الصفات المدروسه فيما عدا النسبه المئويه للسكروز في كلا من موسمي الدراسه
اظهرت النتائج اختلافات معنوية بين الاصناف في جميع الصفات المدروسه في كلا الموسمين حيث تفوق الصنف Honeyعلي الصنف Rex معنويا في كل صفات الدراسه ماعدا النسبه المئويه للسكروز كانت غيرمعنوية في كلا الموسمين.
كان للتفاعل بين فترات الري ومعدلات السماد الازوتي تأثيرا معنويا علي جميع الصفات المدروسه في كلا الموسمين .ادت زياده معدل السماد الازوتي الي ٩٠ كجم ن /فدان الي زياده قيم كل الصفات المدروسه تحت كل فترات الري المختلفه فيما عدا النسبه المئويه للسكروز في كل الموسمين .
اشارت النتائج ان تاثيرالتفاعل بين فترات الري والاصناف كان معنويا علي كل الصفات المدروسه فيما عدا النسبه المئويه للسكروز كان غير معنويا في كلا الموسمين .
تحت كل فترات الري تفوق الصنف Honeyعلي الصنف Rex في كل الصفات المدروسه وسجل اعلي محصول للسيقان والسكر/فدان تحت ظروف الري كل ٢٠يوم في كلا الموسمين .
اظهرت النتائج ان تاثير التفاعل بين التسميد الازوتي والاصناف كان معنويا علي كل الصفات المدروسه ما عدا النسبه المئويه للسكروز كان غير معنويا في كلا الموسمين فقد سجل الصنف Honey اعلي كميه من محصول السيقان والسكر / فدان عند تسميده بمعدل ٩٠ كجم ن/فدان في كلا موسمي الدراسه .
سجلت النتائج ان تاثير التفاعل بين فترات الري والتسميد الا زوتي والاصناف كان معنويا علي كل الصفات المدروسه فيما عدا النسبه المئويه للسكروز كان غير معنويا في كل الصفات المدروسه .فقد اعطي الصنف Honey اعلي القيم لكل الصفات المدروسه وخاصه محصول السيقان والسكر /فدان عند تسميده بمعدل ٩٠ كجم ن /فدان مع اطاله فترات الري حتي ٢٠ يوم ما عدا النسبه المئويه للسكروز في كلا الموسمين.
اظهرت النتائج ان هناك ارتباطات موجبة وعالية المعنوية بين محصول السكر وكلامن دليل مساحة الاوراق وطول الساق ومحصول السيقان طن/فدان.
عموما توصي الدراسه ان تحت ظروف اطلة فترة الري الي ٢٠ يوم ادي اضافة ٩٠ كجم ن/فدان للصنف Honey الي زياده كميه محصول الفدان من السيقان والسكر تحت ظروف محافظه المنيا.

**قام بتحكيم البحث**

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