Egypt. J. Agron. **Vol. 41,** No.2, pp. 105 - 117 (2019)

Biofuel, Sugar Content, Grain Yields and Qualities of Two *Sorghum bicolor* in Responses to Levels and Timing of Nitrogen Applications

A. A.A. Mekdad#, S.M. Emam
Department of Agronomy, Faculty of Agriculture, Fayoum University, Fayoum, Egypt.

TWO FIELD experiments were conducted during the 2017 and 2018, the objective of this work was to evaluate two sweet sorghum varieties under the effect of three nitrogen levels and two different timing of nitrogen application on plant characteristics, quality and yield traits of sweet sorghum. The experimental design was a split-split plot in RCBD with three replications. The main plots were assigned to sweet sorghum varieties *viz.*, Brandes (V_1) and Honey (V_2). The subplots were occupied with three levels of nitrogen 80 (N_1), 100 (N_2) and 120 (N_3). Two nitrogen applications times *viz.*, at two equal doses (T_1) and at three equal doses (T_2) were arranged in the sub-subplots treatments.

Recapitulating our results indicated that nitrogen fertilizer levels and timing of nitrogen application had a highly significant ($P \leq 0.01$). Moreover, varieties differed significantly ($P \leq 0.05$) positive effect on yield and yield components traits in both seasons. The grain yield (1.12 and 1.28ton/fed, fed= 4200 m^2= 0.405 hectare) in each seasons, were obtained by Brandes variety (V_1) with 120N kg fed^{-1} (N_3) and T_2 (third equal doses of nitrogen application).

The obtained results of regression analysis of theoretical ethanol yield clarified that, there were three traits, i.e. the sucrose %, the stalk yield and the juice weight in the first year, while in the second year, six traits, i.e. the sugar yield, the sucrose%, the stalk yield, the brix %, the juice extraction% and juice weight were significantly ($P \leq 0.001$) contributed to variation in the theoretical ethanol yield per feddan.

Keywords: *Sorghum bicolor*, Varieties, Nitrogen levels, Times split nitrogen and ethanol yield**.**
Note: The feddan is a recognized and approved unit in our region and is equal to 4200m^2= 0.405hectare)

Introduction

The sweet sorghum (*Sorghum bicolor* (L.) Moench), is estimated a potential bioenergy crop and promising multipurpose crop, classified as sweet, grain and forage types, which grow in arid and semiarid regions, and is a leading contender for biofuel production (Nuessly et al., 2013 and Viator et al., 2015). It has many good traits, such as a resistance of drought, water deficiency and salinity. In addition, is represented as higher biomass and sugar content. In arid and semiarid environments, including Egypt, low soil fertility and limited rainfall have reduced crop productivity.

The productivity and its quality of the sweet sorghum are greatly influenced by many factors. Varieties chosen were one of the widely substantial decisions. There is a great difference among sorghum the varieties in stem dimension, yield and its components (Mekdad & El-Sherif, 2016 and Rady & Mekdad, 2016). So, it has shining chance and efforts are required for creating and identifying the varieties, having higher sugar content and higher ethanol production potential. Silva et al. (2018) tested two sweet sorghum varieties (BRS 506 and SF 15), reported that first one had the higher leaves number, total chlorophyll (Chlor. total) and they found that the same variety is the best for cultivation in Brazil with useful agronomic traits.

As known, the nitrogen is an essential element, for plants growth and it is still one of the major factors limiting crop yield. Utilization of the nitrogen enhanced sugar percentage, stalks and

#Corresponding author email: aam07@fayoum.egu.eg
DOI: 10.21608/agro.2019.10075.1152

sugar yield in the sweet sorghum plants (Mekdad & El-Sherif, 2016). Increasing the nitrogen element enhances significantly yield and quality of *Beta vulgaris* plants (Mekdad, 2015), as well as in sweet sorghum (Mekdad & El-Sherif, 2016). Almodares & Hoseini (2016) and Mekdad & El-Sherif (2016) reported that, the effect of nitrogen levels on stem dimension of (*Sorghum bicolor* (L.) Moench) was significant, as well as produce the higher values of stem fresh weight, sugar and ethanol yield.

The nitrogen timing at suitable crop growth period, is very important, to enhance the nitrogen use efficiency and increase of the productivity of sweet sorghum. Not all nitrogen applied, is absorbed by the crop since leaching, and is one of the fundamental challenges for nitrogen loss. The nitrogen applied of 92kg/ha at time of 10–15, 35–40 and 55–60 days after planting, gave the optimum grain yield Abebe & Feyisa (2017). Levels and time of nitrogen application are considered among the central abiotic factors, limiting the productivity of the crop. Castilo et al. (1992) studied the effect of nitrogen timing, on the yield of rice. They proved that the superiority of the early nitrogen application, as compared with a late one on the straw yield. Grain and stover yield as well as 1000-seed weight (Melaku et al., 2017).

Therefore, the goal of this study was to evaluate, the response of two varieties of sweet sorghum, to an optimum level and time of the nitrogen application, to increase optimum profitable yield under arid conditions.

Materials and Methods

The present investigation was carried out at the farm of the Faculty of Agriculture, Demo (29°17` N; 30°53` E), Fayoum University, Egypt, during the 2017 and 2018. The experimental soil was sandy loam with organic matter of 0.71%, the electrical conductivity of 3.54dS/m and pH of 7.21. The objective of this work was to evaluate, two sweet sorghum varieties viz., Brandes and Honey under the effect of three nitrogen levels and two different timing of nitrogen application, on plant characteristics, quality and yield traits of the sweet sorghum. The experiment was set up according to three-factorial (Split-plot plot) block design, in three replications, with the basic plot size of 10.5m^2 , each experimental basic unit included 5 ridges, 60cm apart and 3.5m long, (1/400fed., fed= 4200 m^2= 0.405 hectare). The main plots were assigned to varieties viz., Brandes (V_1) and Honey (V_2). The subplots were occupied with three levels of the nitrogen (ammonium nitrate, NH_4NO_3 (33.5% N) at the level of 80 (N_1), 100 (N_2) and 120 (N_3). Two nitrogen application times viz., at two equal doses (T_1)= 1/2N at 15 and 1/2N at 30 days after planting and at three equal doses (T_2)= 1/3 N at 15, 1/3N at 30 and 1/3N 45 days after planting were arranged in the sub-subplots treatments. Potassium sulphate (48% K_2O) applied to the soil in granular form at 50kg K_2SO_4\fed) and applied in two equal doses i.e., after thinning and before the second irrigation (surface irrigation as recommended). Calcium super phosphate (15.5% P_2O_5) at a rate of 200kg/fed was applied during land. Seedlings were thinned at two plants/hill, after 21 days from sowing. Other cultural practices such as hoeing, irrigation, etc., were maintained aimed at levels to assure optimum production. The preceding winter crop was sugar beet (*Beta vulgaris*, L) in both seasons. After sterilization using 1% (v/v) sodium hypochlorite, experiments were sown on May 7th and 5th in the first and second season and harvest was at dough to the ripe stage (on August 29th and 26th) in the 2017 and 2018 seasons, respectively.

At harvest time, a random sample of twenty plants from each sub-subplot was taken to determine the following traits. Growth traits: Stem length, stem diameter, stem weight, leaf weight and seed index. Juice quality traits: Stems was taken from each sub-subplot stripped, cleaned and squeezed by electric roller pilot mill. Brix%: estimated by using a digital refractometer, sucrose% determined by using direct polarization method as described by A.O.A.C (1995), purity %: Calculated by dividing sucrose% / T.S.S% x100, juice extraction%: Determined by dividing juice weight/stem weight x 100. Yield and its components: Net stripped stem, leaves, grain, sugar and juice yield, the theoretical ethanol yield (l fed^{-1}) was calculated according to a method described by Lipinski (1978), the ethanol yield= sugar content (brix%) × 6.5 (converting index) × 0.85 (producing index) × fresh biomass (t fed^{-1}). Where: Converting index is constant (6.5) to explain the efficiency of converting the sugar and biomass of stem yield of the sweet sorghum to ethanol. Producing index is constant (0.85) to explain the efficiency of manufacturing sugar and biomass of stem yield of sweet sorghum to ethanol.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-split plot design as published by Gomez & Gomez (1984), using GenStat 12th edition. Least Significant Difference (LSD) method was used to test the differences between treatment means at 5 and 1% level of probability.

Results and Discussion

Effect of sweet sorghum varieties

The results in Tables 1-3 indicated that the two varieties significantly differed at 5% in regards to the stalk diameter and weight, the ear length and weight, the sucrose%, the juice weight and extraction, as well as the yield in terms of stalk, the leaves, the grain, the sugar, the juice and theoretical ethanol in both season of the experimental. In the 2017 season, varieties significantly differed in the leaves weight and seed index, while brix in the 2018. Conversely, the two varieties had no significantly differed regarding in the stalk height and purity in the 2017 and 2018 seasons. The Brandes (V_1) variety, presented the highest mean values of former traits, as compared with the anther variety Honey (V_2). The differences in these traits between varieties might be due to the differences in their genetic the make-up.

Such data, are in the same trend with Mohamed et al. (2006), EL-Sheikh et al. (2011), Mekdad & El-Sherif (2016) and Ekefre et al. (2017). The superiority of Brandes variety in the theoretical ethanol yield (L/fed) and the sugar yield (ton/fed) in the two seasons might be due to its high records of sucrose mean, brix, the juice extraction and stalks yield.

It was observed that, variety of Brandes (V1) has significantly increases in the stalk diameter (cm) by 10.24 and 10.04%, the stalk weight (kg/plant) by 26.60 and 24.58%, ear length (cm) by 13.45 and 13.48%, ear weight (g) by 4.53 and 29.17%, the sucrose % by 8.96 and 8.62%, the juice weight (kg) by 31.87 and 29.39%, the juice extraction % by 4.31 and 4.15%, the stalk yield (ton/fed) by 8.31 and 14.43%, the leaves yield (ton/fed) by 30.52 and 26.47%, grain yield (ton/fed) by 27.15 and 39.78%, juice yield (ton/fed) by 12.93 and 19.11%, sugar yield (ton/fed) by17.32 and 24.81% and theoretical ethanol (L/fed) by 17.49 and 23.86% across two seasons, respectively, compared with variety of Honey (V_2). Our results reported that, thicker and heavier values of variety Brandes (V_1) stalks could have higher stalks juice and sugar yield and consequently gave the higher values of theoretical ethanol yield. Meantime, the change among verities of sweet sorghum ability in ethanol yield detected herein was confirmed previously by Almodares & Goli (2013) and Mekdad & El-Sherif (2016).

Effect of nitrogen fertilization

Results in Tables 1-3 indicated that, nitrogen fertilizer levels exerted significant effects at the level of 1% on all traits under studied such as, the stalk and the ear dimension, the weight of stalk, the leaves and ear, the seed index, the percentage of brix, sucrose and purity, the juice weight and extraction, as well as, yield in terms of the stalk, the leaves, the grain, the juice, the sugar and the theoretical ethanol in both seasons.

The highest values of the stalk height (4.22 and 4.21cm), the stalk diameter (2.95 and 2.90cm), the stalk weight (1146.53 and 1171.30g/plant), the leaves weight (225.17 and 213.26g/plant), the ear length (34.76 and 33.78cm), the ear diameter (9.93 and 10.05cm), the ear weight (138.48 and 132.11g/plant), the seed index (31.79 and 41.34g), as well as the brix (16.55 and 16.69%), the sucrose (9.54 and 9.59%), the purity (57.59 and 57.47%), the juice weight (448.50 and 459.90g), the juice extraction (39.02 and 39.20%) furthermore, the stalk yield (24.41 and 25.62ton/fed), the leaves yield (4.85 and 4.70ton/fed), the grain yield (1.50 and 1.48ton/fed), the sugar yield (1.58 and 1.68ton/fed), the juice yield (9.53 and 10.05ton/fed) and finally the theoretical ethanol yield (1287.21 and 1359.92L/fed) in the first and second season, respectively, were produced from fertilizing sweet sorghum plants with 120kg N/fed (N_3). On the contrary, the lowest values of pervious traits were obtained from 60kg N/fed (N_1) in the two growing seasons. Almodares et al. (2008), Usofzadeh et al. (2013), Mekdad & El-Sherif (2016) and Harshlata & Sai (2018) reported that increasing the nitrogen fertilization increased stalk height and the stalk diameter, as well as the stalk, the sugar, the juice and the theoretical ethanol yield. Furthermore, concerning the positive effect of nitrogen application on sugar beet Mekdad (2015) and Mekdad & Rady (2016) reported that increasing nitrogen fertilizer levels increased significantly the productivity of sugar beet. The increase in pervious traits due to nitrogen application can be explained through the fact that nitrogen element has an essential role in building up metabolites, activating enzymes and enhanced stalk dimension as well as stalk fresh weight, so consequently higher stalk, juice, sugar and theoretical ethanol yields per unit area.

TABLE 1. Effect of varieties, nitrogen levels and timing of nitrogen application on sweet sorghum yield attributes in the 2017 and 2018 seasons.

Treatment		Stalk height (m)		Stalk diameter (cm)		Leaves weight (g)		Stalk weight (g)		Ear length (cm)		Ear diameter (cm)		Ear weight (g)		Seed index (g)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Varieties (V)	Brandes (V_1)	3.99	3.94	2.80	2.74	209.17	197.08	1028.23	1037.38	32.38	31.74	8.98	9.00	124.91	119.80	31.37	40.26
	Honey (V_2)	3.69	3.62	2.54	2.49	179.86	171.39	812.22	832.72	28.54	27.97	8.01	7.95	96.70	95.23	25.21	33.72
LSD 0.05		NS.	NS.	0.11*	0.12*	14.37*	NS.	106.13*	175.48*	2.37*	0.95*	NS.	NS.	5.64*	14.70*	4.91*	NS.
Nitrogen levels (N)	80 (N_1)	3.52	3.43	2.44	2.38	166.86	156.54	713.71	717.40	26.72	26.28	7.25	7.02	81.56	81.56	24.82	32.55
	100 (N_2)	3.77	3.70	2.61	2.55	191.52	182.89	900.43	916.45	29.90	29.51	8.30	8.36	112.37	108.87	28.12	37.08
	120 (N_3)	4.22	4.21	2.95	2.90	225.17	213.26	1146.53	1171.30	34.76	33.78	9.93	10.05	138.48	132.11	31.79	41.34
LSD 0.05		0.18 **	0.28**	0.05**	0.07**	7.83**	13.35**	41.58**	29.50**	1.44**	1.66**	0.35**	0.51**	7.09**	8.48**	1.33**	0.90**
Timing application (T)	Twice equal doses (T_1)	3.74	3.65	2.57	2.51	186.37	173.31	863.17	867.93	29.23	28.87	8.13	8.04	102.33	100.61	27.33	35.85
	Third equal doses (T_2)	3.94	3.91	2.77	2.71	202.67	195.16	977.28	1002.17	31.69	30.84	8.86	8.92	119.28	114.42	29.25	38.14
LSD 0.05		0.04**	0.13**	0.06**	0.04**	4.78**	5.50**	23.97**	14.58**	0.83**	0.80**	0.14**	0.29**	3.83**	4.17**	0.48*	0.52**
V*N		NS.	NS.	*	NS.	*	NS.	NS.	**	NS.	NS.	**	*	NS.	NS.	NS.	NS.
V*T		NS.	NS.	NS.	*	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	*	*
N*T		NS.	NS.	*	**	NS.	NS.	NS.	**	*	NS.	NS.	NS.	NS.	NS.	NS.	*
V*N*T		*	NS.	*	NS.	NS.	NS.	*	**	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.

*P< 0.05; **P< 0.01 and NS.: Non-significant.

TABLE 2. Effect of varieties, nitrogen levels and timing of nitrogen application on sweet sorghum yield in the 2017 and 2018 seasons.

Treatment		Stalk yield (ton/fed)		Leaves yield (ton/fed)		Grain yield (ton/fed)		Sugar yield (ton/fed)		Juice yield (ton/fed)		Ethanol yield (L/fed)	
		2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Varieties (V)	Brandes (V_1)	23.86	25.29	4.49	4.36	1.36	1.30	1.49	1.61	9.26	9.85	1205.71	1290.33
	Honey (V_2)	22.03	22.10	3.44	3.44	0.79	0.93	1.27	1.29	8.20	8.27	1026.23	1041.74
LSD 0.05		0.74*	3.19*	0.64*	0.53*	0.45*	0.36*	0.08*	0.20*	0.31*	1.08*	121.61*	156.03*
Nitrogen levels (N)	80 (N_1)	21.30	21.50	3.16	3.15	0.75	0.83	1.18	1.22	7.87	7.99	937.35	960.15
	100 (N_2)	23.14	23.98	3.88	3.85	0.98	1.03	1.38	1.46	8.78	9.15	1123.36	1178.05
	120 (N_3)	24.41	25.62	4.85	4.70	1.50	1.48	1.58	1.68	9.53	10.05	1287.21	1359.92
LSD 0.05		0.92**	0.97**	0.32**	0.25**	0.17**	0.14**	0.05**	0.05**	0.34**	0.35**	43.37**	46.34**
Timing application (T)	Twice equal doses (T1)	22.51	23.24	3.71	3.68	0.98	1.04	1.33	1.40	8.50	8.84	1071.68	1120.51
	Third equal doses (T 2)	23.39	24.16	4.22	4.12	1.17	1.19	1.43	1.50	8.96	9.28	1160.27	1211.57
$LSD_{0.05}$		0.21**	0.26**	0.11**	0.10**	0.05**	0.04**	0.02**	0.02**	0.08**	0.11**	27.27**	14.51**
V*N		NS.	NS.	NS.	NS.	*	*	NS.	NS.	NS.	NS.	NS.	NS.
V*T		NS.	NS.	NS.	NS.	*	**	NS.	NS.	*	NS.	NS.	NS.
N*T		NS.	NS.	*	*	*	**	NS.	NS.	NS.	NS.	NS.	NS.
V*N*T		NS.	NS.	NS.	NS.	*	*	NS.	NS.	NS.	NS.	NS.	NS.

*P< 0.05; **P< 0.01 and NS.: Non-significant.

TABLE 3. Effect of varieties, nitrogen levels and timing of nitrogen application on sweet sorghum quality in the 2017 and 2018 seasons.

Treatment		Brix %		Sucrose %		Purity %		Juice extraction %		Juice weight (g)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Varieties (V	Brandes (V_1)	16.07	16.31	9.12	9.20	56.71	56.35	38.76	38.91	400.27	405.20
	Honey (V_2)	15.40	15.53	8.37	8.47	54.24	54.45	37.16	37.36	303.53	313.16
$LSD_{0.05}$		NS.	0.36*	0.80*	0.58*	NS	NS	0.97*	0.47*	32.84*	66.54*
Nitrogen levels (N)	80 (N_1)	14.98	15.16	7.93	8.05	52.91	53.04	36.94	37.13	264.55	267.28
	100 (N_2)	15.67	15.91	8.77	8.87	55.93	55.70	37.93	38.03	342.64	350.37
	120 (N_3)	16.55	16.69	9.54	9.59	57.59	57.47	39.02	39.20	448.50	459.90
$LSD_{0.05}$		0.15**	0.22**	0.18**	0.18**	1.48**	1.69**	0.29**	0.33**	15.92**	11.25**
Timing application (T)	Twice equal doses (T_1)	15.62	15.78	8.56	8.66	54.72	54.79	37.70	37.95	327.60	331.57
	Third equal doses (T_2)	15.85	16.06	8.93	9.01	56.24	56.02	38.23	38.32	376.20	386.80
$LSD_{0.05}$		0.17**	0.05**	0.15**	0.08**	1.04**	0.051**	0.26**	0.17**	9.68**	6.49**
V*N		NS.	NS.	*	NS.	NS.	NS.	NS.	NS.	NS.	**
V*T		NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.
N*T		NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.
V*N*T		NS.	NS.	NS.	NS.	NS.	NS.	NS.	NS.	*	**

*P< 0.05; **P< 0.01 and NS.: Non-significant.

Effect of nitrogen timing application

Application of nitrogen timing significant differed at 1% across both seasons (Tables 1-3). The taller stalk (3.94 and 3.91m), the thicker stalk (2.77 and 2.71cm), the heaver stalk (977.28 and 1002.17g/plant), the heaver leaves (202.67 and 195.16g/plant), the taller ear (31.69 and 30.84cm), the thicker ear (8.86 and 8.92cm), the heaver ear (119.28 and 114.42g), the higher seed index (29.25 and 38.14g), the higher brix (15.85 and 16.06%), the higher sucrose (8.93 and 9.01%), the higher purity (56.24 and 56.02%), the heaver juice (376.20 and 386.80g/plant), the higher juice extraction (38.23 and 38.32%), as well as, the higher stalk yield (23.39 and 24.16ton/fed), the higher leaves yield (4.22 and 4.12ton/fed), the higher grain yield (1.17 and 1.19ton/fed), the higher juice yield (8.96 and 9.28ton/fed), the higher sugar yield (1.43 and 1.50ton/fed) and finally the higher theoretical ethanol yield (1160.27 and 1211.57L/fed) in the 2017 and 2018 seasons, respectively, were obtained at third equal doses of the nitrogen application (T_2)= 1/3N at 15, 1/3N at 30 and 1/3N 45 days after planting. However, on the other hand, the lower pervious traits were obtained at the twice equal nitrogen doses (T_1)= 1/2N at 15 and 1/2N at 30 days after planting.

According to Mohammad et al. (2011) in wheat crop, Tilahun et al. (2013) in rice crop and Yohanna (2014) in the sweet sorghum crop reported that, nitrogen timing application had significantly effect on the yield and yield components. To sum up, split nitrogen application, gave the heaviest grain yield. Split application of the nitrogen fertilizer timing at twice doses, increase in grain yield of sorghum over a single dose. Generally, in this work, split application nitrogen timing at third equal doses (T_2)= 1/3N at 15, 1/3N at 30 and 1/3N 45 days after planting, resulted in good performance than split nitrogen timing was applied at twice equal doses 1/2N at 15 and 1/2N at 30 days after planting and mitigate the loss of nutrients by leaching.

Interaction effects

Effect of the bilateral interaction between the two sweet sorghum varieties and tree nitrogen levels

Recapitulating our results showed in Table 4 reported that, the mean values of the ear diameter (10.06 and 10.70cm) and the grain yield (1.95 and 1.78ton/fed) in both season, as well as the stalks diameter (3.12cm), the leaves weight (246.71g) and the sucrose (9.82%) in the first season, furthermore the stalk weight (1254.77g) and the juice weight (499.09kg) in the second season were significantly affected by the interaction. The highest means values of former traits, were recorded by Brandes variety (V_1) with the highest nitrogen level application (N_3) 120kg N/fed. Reddy et al. (2008) and Mekdad & El-Sherif (2016) reported that, the interaction between nitrogen levels fertilizer and varieties were significant for stalk weight (kg/plant), sucrose %, juice extract (gm^{-2}) and sugar yield (ton ha^1).

Effect of the bilateral interaction between the two sweet sorghum varieties and two timing of nitrogen application

To sum up, data illustrated in Table 5 reveal that, the values means of the seed index (32.56 and 41.66g) and the grain yield (1.48 and 1.40ton/fed) in both seasons, the juice yield (9.44ton/fed) in the 2017 season, as well as stalk diameter (2.86cm) in the 2018 season were significantly affected by the interaction. The highest mean values of former traits, were recorded by Brandes variety (V_1) of sweet sorghum with the times of nitrogen application at third doses (T_2)= 1/3N at 15, 1/3N at 30 and 1/3N 45 days after planting.

Effect of the bilateral interaction between three nitrogen levels fertilization and two timing of nitrogen application

Nitrogen levels by timing of nitrogen application, showed significant effects on the stalk diameter (3.11 and 3.07cm), the leaves yield ton/fed (5.20 and 4.99ton) and the grain yield (1.65 and 1.63ton/fed) in each season, as well as the ear length (36.84cm) in the first season, furthermore the stalk weight (1256.20g) and the seed index (42.96g) in the second season of sweet sorghum varieties (Table 6), were obtained by the higher of nitrogen levels (N_3) 120N kg fed^{-1} and T_2 (split nitrogen times application at third equal doses= 1/3N at 15, 1/3N at 30 and 1/3N 45 days after planting) (Table 6). These results are in agreement with those showed by Melaku et al. (2017) in sweet sorghum yield and Abebe & Feyisa (2017) in *Zea mays* L. yield.

Effect of the trilateral interaction among the two sweet sorghum varieties, three levels of nitrogen fertilizer and two timing of nitrogen application

Interaction of varieties and nitrogen levels with the timing of nitrogen also showed significantly effects on the stalk weight (1304.17 and 1289.00g) (Table 7), the juice weight (521.09 and 514.55g) and grain yield (2.18 and 1.99ton/fed) in each seasons, as well as the stalk height (4.63cm) and the stalk diameter (3.36cm) in 2017 season (Table 7), were obtained by Brandes variety (V_1) with 120N kg fed^{-1} (N_3) and T_2 (at third equal nitrogen doses 1/3N at 15, 1/3N at 30 and 1/3 N 45 days after planting) (Table 7).

Yield analysis study

Correlation coefficient

The results of correlation coefficients, in Table 8 between theoretical ethanol yield L fed^{-1} and each of stalk weight plant^{-1} g, yield of stalk, sugar and juice (ton fed^{-1}), brix, sucrose and juice extraction % as well as juice weight (kg) were computed, in order to throw light, on the relationship of effectual traits interest. Positive and highly significant ($P \leq 0.01$) correlations were obtained between ethanol yield L fed^{-1} and each of juice yield (r= 0.976** and 0.983**), sugar yield (r= 0.978** and 0.991**) and sucrose % (r= 0.979** and 0.948**). Also, positive and highly significant correlation coefficient were seen between sugar yield t fed^{-1} and stalk yield ton fed^{-1} in (r= 0.949** and 0.974**) as well as between brix % (r= 0.958** and 0.943**) in 1st and 2nd seasons, respectively, this result is consistent with the previous researchers of (Rady & Mekdad, 2016).

According to Stepwise results, in data in Table 9 clarified that, there are three traits, i.e. sucrose, stalk yield and juice weight in the 2017 season and six ones, i.e. sugar yield, sucrose (%), stalk yield, brix %, juice extraction % and juice weight in the 2018 season, were significantly ($P \leq 0.001$) contributed to variation in theoretical ethanol yield per feddan.

Conclusions

This study tested the effects of nitrogen levels and timing of the N application on performances of two sweet sorghum varieties Brandes and Honey. To sum up, 2- Years of study showed that, the highest yield of grain, sugar, juice and theoretical ethanol were obtained by Brandes variety and higher level of nitrogen fertilization at 120kg N/fed with split nitrogen times application at third equal doses (1/3N at 15, 1/3N at 30 and 1/3N 45 days after planting). Timing of nitrogen applications, can play a basic role, in strategically of nutrient management, which is productivity and environmentally responsible. Timing nitrogen applied, can help farmers improving efficiency of nutrient, increase crop yields and decrease the losses of nutrients by leaching.

TABLE 4. Effect of the interaction between varieties and nitrogen fertilizer levels on yield, yield attributes and quality of sweet sorghum in the 2017 and seasons.

Varieties (V)	Nitrogen levels (N)	Stalk diameter (cm) 2017	Stalk weight (g) 2018	Leaves weight (g) 2017	Ear diameter (cm)		Grain yield (ton/fed)		Juice weight (kg) 2018	Sucrose % 2017
					2017	2018	2017	2018		
Brandes (V_1)	80 (N_1)	2.56	808.58	176.12	7.80	7.08	0.96	0.96	307.22	8.44
Brandes (V_1)	100 (N_2)	2.72	1048.81	204.68	9.06	9.22	1.19	1.16	409.30	9.11
Brandes (V_1)	120 (N_3)	3.12	1254.77	246.71	10.06	10.70	1.95	1.78	499.09	9.82
Honey (V_2)	80 (N_1)	2.33	626.22	157.60	6.69	6.96	0.54	0.71	227.33	7.43
Honey (V_2)	100 (N_2)	2.51	784.10	178.36	7.53	7.50	0.77	0.89	291.44	8.43
Honey (V_2)	120 (N_3)	2.78	1087.84	203.63	9.80	9.41	1.06	1.19	420.72	9.25
LSD $_{0.05}$		0.06*	41.72**	11.08*	0.49**	0.73*	0.24*	0.20*	15.90**	0.25*

*P< 0.05; **P< 0.01.

TABLE 5. Effect of the interaction between varieties and timing of nitrogen fertilizer application on yield, yield attributes and quality of sweet sorghum in the 2017 and 2018 seasons.

Varieties (V)	Timing of nitrogen application (T)	Stalk diameter (cm) 2018	1000 weight (g)		Grain yield (ton/fed)		Juice yield (ton/fed) 2017
			2017	2018	2017	2018	
Brandes (V_1)	Twice equal doses (T_1)	2.61	30.17	38.86	1.25	1.19	9.08
Brandes (V_1)	Third equal doses (T_2)	2.86	32.56	41.66	1.48	1.40	9.44
Honey (V_2)	Twice equal doses (T_1)	2.41	24.49	32.83	0.72	0.88	7.92
Honey (V_2)	Third equal doses (T_2)	2.56	25.94	34.61	0.86	0.98	8.48
LSD 0.05		0.06*	0.68*	0.73*	0.07*	0.05**	0.11*

*P< 0.05; **P< 0.01.

TABLE 6. Effect of the interaction between nitrogen fertilizer and timing application of nitrogen fertilizer on yield, yield attributes and quality of sweet sorghum in the 2017 and 2018 seasons.

Nitrogen levels (N)	Timing of nitrogen application (T)	Stalk diameter (cm)		Stalk weight (g) 2018	Seed index (g) 2018	Ear length (cm) 2017	Leaves yield (ton/fed)		Grain yield (ton/fed)	
		2017	2018				2017	2018	2017	2018
80 (N_1)	Twice equal doses (T_1)	2.36	2.30	689.36	31.61	25.88	3.01	3.04	0.68	0.79
80 (N_1)	Third equal doses (T_2)	2.53	2.47	745.44	33.49	27.55	3.32	3.26	0.82	0.88
100 (N_2)	Twice equal doses (T_1)	2.56	2.51	828.03	36.20	29.11	3.62	3.59	0.91	0.99
100 (N_2)	Third equal doses (T_2)	2.66	2.60	1004.87	37.96	30.69	4.15	4.12	1.04	1.07
120 (N_3)	Twice equal doses (T_1)	2.79	2.73	1086.40	39.73	32.69	4.50	4.41	1.36	1.33
120 (N_3)	Third equal doses (T_2)	3.11	3.07	1256.20	42.96	36.84	5.20	4.99	1.65	1.63
$LSD_{0.05}$		0.10*	0.08**	25.25**	0.90*	1.44*	0.19*	0.18*	0.09*	0.06**

*P< 0.05; **P< 0.01.

TABLE7. Effect of the interaction among varieties, nitrogen and timing application of nitrogen fertilizer application on yield, yield attributes and quality of sweet sorghum in the 2017 and 2018 seasons.

Varieties (V)	Nitrogen levels (N)	Timing of nitrogen application (T)	Stalk height (m) 2017	Stalk diameter (cm) 207	Stalk weight (g)		Grain yield (ton/fed)		Juice weight (kg)	
					2017	2018	2017	2018	2017	2018
Brandes (V_1)	80 (N_1)	Twice equal doses (T_1)	3.56	2.47	771.66	775.35	0.90	0.91	288.95	293.39
Brandes (V_1)	80 (N_1)	Third equal doses (T_2)	3.68	2.65	859.40	841.80	1.01	1.00	325.57	321.06
Brandes (V_1)	100 (N_2)	Twice equal doses (T_1)	3.70	2.67	922.57	921.64	1.11	1.10	357.38	357.94
Brandes (V_1)	100 (N_2)	Third equal doses (T_2)	4.01	2.76	1100.62	1175.98	1.26	1.22	428.88	460.66
Brandes (V_1)	120 (N_3)	Twice equal doses (T_1)	4.38	2.87	1211.00	1220.53	1.72	1.56	479.75	483.63
Brandes (V_1)	120 (N_3)	Third equal doses (T_2)	4.63	3.36	1304.17	1289.00	2.18	1.99	521.09	514.55
Honey (V_2)	80 (N_1)	Twice equal doses (T_1)	3.33	2.24	570.69	603.36	0.46	0.68	206.23	218.45
Honey (V_2)	80 (N_1)	Third equal doses (T_2)	3.55	2.42	653.09	649.07	0.62	0.75	237.47	236.22
Honey (V_2)	100 (N_2)	Twice equal doses (T_1)	3.63	2.46	744.76	734.42	0.72	0.87	247.22	271.50
Honey (V_2)	100 (N_2)	Third equal doses (T_2)	3.75	2.57	833.77	833.77	0.83	0.92	310.07	311.38
Honey (V_2)	120 (N_3)	Twice equal doses (T_1)	3.83	2.71	958.32	952.27	0.99	1.10	359.05	364.50
Honey (V_2)	120 (N_3)	Third equal doses (T_2)	4.04	2.85	1112.65	1223.41	1.12	1.28	434.12	476.94
LSD $_{0.05}$			**0.11***	**0.14***	**58.71***	**35.70****	**0.12***	**0.09***	**23.72***	**15.89****

*P< 0.05; **P< 0.01.

TABLE 8. A matrix of simple correlation coefficient between ethanol yield (L fed^{-1}) and other important traits estimated in the 2017 and 2018 season.

Character	Stalk weight plant^{-1} (g)		Stalk yield (ton fed^{-1})		Brix %		Sucrose %		Juice extraction %		sugar yield (ton fed^{-1})		Juice weight (kg)		Juice yield (ton fed^{-1})		Ethanol yield (L fed^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Stalk weight plant^{-1} (g)	1	1	.866**	.836**	.933**	.937**	.945**	.945**	.890**	.911**	.958**	.920**	.998**	.999**	.932**	.883**	.948**	.929**
Stalk yield (t fed^{-1})			1	1	.857**	.863**	881**	.839**	.733**	.828**	.949**	.974**	.856**	.841**	.973**	.990**	.957**	.966**
Brix %					1	1	.916**	.947**	.819**	.881**	.958**	.943**	.930**	.937**	.900**	.895**	.923**	.939**
Sucrose %							1	1	.851**	.909**	.943**	.917**	.942**	.945**	.926**	.882**	.979**	.948**
Juice extraction %									1	1	.878**	.912**	.913**	.925**	.870**	.896**	.833**	.904**
sugar yield (t fed^{-1})											1	1	.958**	.926**	.987**	.992**	.978**	.991**
Juice weight (kg)													1	1	.932**	.890**	.942**	.932**
Juice yield (t fed^{-1})															1	1	.976**	.983**
Ethanol yield (l fed^{-1})																	1	1

** Correlation coefficient is significant at P≤ 0.01

TABLE 9. Correlation coefficient (r), coefficient of determination (R^2) and standard error of the estimates (SEE) for predicting ethanol yield (L fed^{-1}) in the 2017 and 2018 seasons.

Season	R	R^2	SEE	Sig.	Fitted equation
2017	1.00	0.999	5.742	***	Ethanol yield= -928.59 + 118.15 sucrose + 41.55 stalk yield + 0.16 juice weight
2018	1.000	1.000	1.86	***	Ethanol yield=975.64 + 721.20 sugar yield + 126.14 sucrose + 5.27 stalk yield -68.78 brix -68.78 juice extraction +0.04 juice weight

References

A.O.A.C. (1995) "*Official Methods of Analysis*" Published by the A.O.A.C. Box 540, Washington.

Abebe, Z. and Feyisa, H. (2017) Effects of nitrogen rates and time of application on yield of maize: Rainfall variability influenced time of N application. *Int. J. of Agron*. **1**(1), 1-10.

Almodares, A. and Goli, M. (2013) Preliminary study on the effect of plant population density and sweet sorghum cultivars on bioethanol production, *Biofuels*, **4(**2), 163-167.

Almodares, A. and Hoseini, S. H. (2016) Effect of sowing dates and nitrogen levels for ethanol production from sweet sorghum stalks and grains. *Afr. J. Agric. Res.* **11**(4), 266-275.

Almodares, A., Taheri1, R., Chung, I.M. and Fathi, M. (2008) The effect of nitrogen and potassium fertilizers on growth parameters and carbohydrate contents of sweet sorghum cultivars. *J. Environ. Biol.* **29**(6), 849-852.

Castilo, E.G., Buresh R.J. and Ingram, K.T. (1992) Lowland Rice yield as affected by timing of water deficit and nitrogen fertilization. *Agron. J.* **84,** 152-159.

Ekefre, D.E., Mahapatra, A.K., Latimore Jr, M., Bellmer, D.D., Jena, U., Whitehead, G.J. and Williams, A.L. (2017) Evaluation of three cultivars of sweet sorghum as feedstocks for ethanol production in the Southeast United States. *Heliyon.* **3,** 1-18.

EL-Sheikh, S.R.E., EL-Labbody, A.H.S.A. and Osman, A.M.H. (2011) Response of three sweet sorghum varieties to potassium mineral -and bio – fertilization. *Egypt. J. Agric. Res*. **89**(3), 1019-1027.

Gomez, K.A. and Gomez, A.A. (1984) "*Statistical Procedures For Agricultural Research*". Book John Willey and Sons Inc., New York.

Harshlata, G.S. and Sai, S. (2018) Effect of planting density and levels of nitrogen on ethanol production of sweet sorghum (*Sorghum bicolor* [L.] Moench) varieties. *The Pharma Innovation J.* **7**(2), 04-07.

Lipinski, E.S. (1978) Sugar crops as a source of fuels, vol. II. *Processing and Conversion,* Research Dept. of

Energy. Final Report. Battelle Columbus Labs, OH.

Mekdad, A.A.A. (2015) Sugar beet productivity as affected by nitrogen Fertilizer and foliar spraying with boron. *Int. J. Curr. Microbiol. Appl. Sci*. **4**(4), 181-196.

Mekdad, A.A.A. and El-Sherif, A.M.A. (2016) The effect of nitrogen and potassium fertilizers on yield and quality of sweet sorghum varieties under arid regions conditions. *Int. J. Curr. Microbiol. Appl. Sci*. **5**(11), 811-823.

Mekdad, A.A.A. and Rady, M.M. (2016) Response of *Beta vulgaris* L. to nitrogen and micronutrients in dry environment. *Plant Soil Environ*. **62**(1), 23-29.

Melaku, N.D., Bayu, W., Ziadat, F., Strohmeier, S., Zucca, C., Tefera, M.L., Ayalew, B. and Klik, A. (2017) Effect of nitrogen fertilizer rate and timing on sorghum productivity in Ethiopian highland Vertisols. *Archives of Agron and Soil Sci*. **1**(1), 1-12.

Mohamed, K.E., Ferweez, H. and Allam, S.M. **(**2006) Effect of K fertilization on yield and quality of sweet sorghum juice and syrup. *Bull. Fac. Agric. Cairo Univ.* **57,** 401-416.

Mohammad, T., Jamal Khan, M.D., Khan, A.D., Arif, M.D., Jan, D.D., Saeed, M.D. and Zahir, M.D. (2011) Improving wheat productivity through source and timing of nitrogen fertilization. *J. Bot*. **43**(2), 909-911.

Nuessly, G.S., Wang, Y., Sandhu, H., Larsen, N. and Cherry, R.H. (2013) Entomologic and agronomic evaluations of 18 sweet sorghum cultivars for biofuel in Florida. *Fla. Entomol*. **96**(2), 512-528.

Rady, M.M. and Mekdad, A.A.A. (2016) Productivity response to plant density in five Sorghum bicolor varieties in dry environments. *Egypt. J. Agron*. **38** (3), 531-546.

Reddy, P.S., Reddy, B.V.S., Kumar, A.A. and Rao, P.S. (2008) Standardization of nitrogen fertilizer rate for sugar yield optimization in sweet sorghum. *J. SAT Agri. Res*. **6**, 1-4.

Silva, T.M., Oliveira, A.B., Moura, J.G., Lessa, B.F.T. and Oliveira, L.S.C. (2018) Agronomic evaluation of sweet sorghum in semiarid region: Cultivar and spacing effects. *J. Agric. Sci*. **10**(10), 103-113.

Tilahun, T., Alemayehu, A., Minale, L. and Zelalem, T. (2013) Effects of nitrogen split application on productivity, nitrogen use efficiency and economic benefits of maize production in Ethiopia. *Int. J. Agric Policy Res*. **1**(4), 109-115.

Usofzadeh, M., Daneshvar, M., Almodares, A. and Eisvand, H.R. (2013) Effects of nitrogen fertilizer and plant growth regulator on stalk yield and bioethanol in sweet sorghum. Iranian *J. Plant Physiol.* **3**(3), 711-716.

Viator, H.P., Lu, S. and Aragon, D. (2015) Influence of panicles and leafy material on sweet sorghum juice quality. *J. Am. Soc. Sugar Cane Technol*. **35,** 21-30.

Yohanna, M.K. (2014) Effect of time of nitrogen application on the performance of maize (*Zea mays* L.) varieties at Mubi, Northern Guinea Savanna of Nigeria. *Am. J. Res. Comm*. **2**(2), 71-81.

(Received 27/ 2/2019;
accepted 9/6 /2019)

إستجابه بعض أصناف الذرة الرفيعة لمستويات ومواعيد إضافة التسميد النيتروجينى لإنتاج الوقود الحيوي والسكر والحبوب

على عبدالله على مقداد، صلاح الدين محمد إمام
قسم المحاصيل - كلية الزراعة - جامعة الفيوم- الفيوم- مصر.

أجريت تجربتين حقليتين فى مزرعة كلية الزراعة بالفيوم بمنطة دمو- جامعة الفيوم- مصر خلال عامى الدراسة 2018 و 2017 لدراسة تأثير سلوك صنفين من محصول الذرة الرفيعة السكرية (براندز و هانى) و ثلاثة مستويات من التسميد النيتروجينى (80، 100 و120 كجم/ فدان) وميعادين من إضافة التسميد النيتروجينى (على دفعتين متساويتين بحيث يتم إضافة 1/2 كمية النيتروجين الأولى عند 15 يوم من الزراعة و 1/2 كمية النيتروجين الثانية عند 30 يوم من الزراعة، المعاملة الأخرى على ثلاثة دفعات متساوية بحيث 1/3 كمية النيتروجين الأولى عند 15 يوم من الزراعة، 1/3 كمية النيتروجين الثانية عند 30 يوم من الزراعة و 1/3 كمية النيتروجين الثالثة عند 45 يوم من الزراعة) على المحصول على المحصول ومكوناته. تم إستخدام القطع المنشقة مرتين فى تصميم القطاعات كاملة العشوائية ذى ثلاثة مكررات فى الموسمين. وقد إحتلت معاملتى الأصناف القطع الرئيسية ووزعت الثلاثة معدلات من التسميد النيتروجينى فى القطع الشقية الأولى فى حين تم توزيع ميعادين إضافة التسميد النيتروجين فى القطع الشقية الثانية. أظهرت النتائج المتحصل عليها أن معاملة كلا من التسميد النيتروجينى و مواعيد إضافة التسميد النيتروجين كانت عالية المعنوية ($P\leq 0.01$) بينما أختلفت الأصناف معنويا ($P\leq 0.05$) وكانت المعاملات ذات تأثير إيجابي على صفات المحصول ومكوناته ووكذلك صفات الجودة في كلا الموسمين.

أظهرت النتائج المتحصل عليها أن أعلى وزن للسيقان (1112.62 و1223.41 جرام) ووزن العصير المستخلص (434.12 و 476.94جرام) وكذلك محصول الحبوب (1.12 و 1.28 طن/فدان) في كلا الموسمين ناتجة من زراعة الصنف (براندز) مع إستخدام معاملة المعدل العالى من التسميد النيتروجينى (120 كجم/فدان) والمعاملة الثانية من مواعيد إضافة التسميد النيتروجينى (على ثلاثة دفعات متساوية 1/3 كمية النيتروجين الأولى عند 15 يوم من الزراعة، 1/3 كمية النيتروجين الثانية عند 30 يوم من الزراعة و 1/3 كمية النيتروجين الثالثة عند 45 يوم من الزراعة). وأظهر نتائج تحليل الإرتباط أن هناك إرتباط عالى المعنوية بين المحصول النظرى من الإيثانول مع كل من محصول السيقان والنسبة المئوية للسكر والمواد الصلبة الكلية وكذلك وزن العصير المستخلص.