Effect of Nitrogen Fertilization Levels on Bio-ethanol Production of Sweet Sorghum Varieties

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ABSTRACT

Two field experiments investigated the impact of nitrogen fertilizer on bioethanol production from various sweet sorghum varieties in Egypt. The study, conducted across two seasons, analyzed the effects of fertilizer rates (60, 90, and 120 kg N/fed.) on stalk length, sucrose content, stripped stalk yield, juice yield, and ethanol yield. Significant variations were observed in most studied traits across both seasons, except juice extraction percentage, which only differed significantly in the second season. Sweet sorghum plants receiving the highest nitrogen application (120 kg N/fed.) demonstrated the most desirable outcomes for most traits. Conversely, the lowest fertilizer application (60 kg N/fed.) resulted in the least favorable outcomes across both seasons. Additionally, significant differences were noted between the sweet sorghum varieties themselves. SS 301-1 and MN 1500 varieties consistently achieved the highest values for most studied traits, except for juice extraction percentage in the second season, where Rex and Brands varieties excelled. In conclusion, the study suggests that applying 120 kg N/fed of nitrogen fertilizer to SS 301-1 sweet sorghum variety can potentially enhance sucrose content and bioethanol production within the specific soil conditions of the Egyptian experiment.

Keywords: Sweet sorghum varieties; nitrogen fertilization; bio-ethanol.

INTRODUCTION

Sweet sorghum (Sorghum bicolor, L. Moench) is a prominent cereal crops, particularly in the worlds semi-arid tropic. It is grown in over 105 countries across Africa, Asia, Oceania and Americas on 40 million hectares, sweet sorghum also, important carp due to its multiple uses, as it is used in human food and animal feed in the form of concentrated grains or green fodder, as well as entering in to many industries such as starch, cellulose, alcohol, brooms, baskets and many handicrafts and others. Sorghum is the most drought tolerant summer field crops, but it is one of the crops that stress the soil as a result of depleting many nutrients, especially nitrogen. Nitrogen is necessary element to increase productivity and quality traits of sweet sorghum, which is reflected on bio ethanol production, especially that sweet sorghum from C4 crop, which characterized by high photosynthetic efficiency, with edition to, study response of sweet sorghum varieties to nitrogen fertilizer rates. Several from the studies searched response of sweet sorghum varieties to nitrogen fertilizer rates in the world. Olugbemi and Ababyomi (2016),in Nigeria, found that nitrogen fertilizer application with 120 kg N/ha. rate enhanced ethanol Production of SW variety of sweet sorghum under experiment soil conditions. Also, Besheit and Mekdad (2016),inEgypt, indicated that Brands variety plants fertilization with 120 kg N/fed. rate gave the maximum values for Productivity and quality traits compared with the other treatments of sweet sorghum. And ,in India,indicated that CSH 22 SS variety Plants fertilization with 150 kg N/ha. rate Produced highest green stalk and ethanol yield comperd with the other varieties of sweet sorghum in India Mekdad and El. Sherif (2016),in Egypt, found that Brands variety Plants fertilization with 120kg N/fed. with 75 kg K_2O/fed. gave the best values for yield ,yield components and ethanol production of sweet sorghum under arid regions conditions. Also, Ekefre et al. (2017) indicated that M81E superior to sweet sorghum varieties Dale and These in ethanol Production in southeast united states.,in Egypt, indicated that Honey sweet sorghum variety gave the maximum values for brix, sucrose %, total sugars and bio-ethanol, that when fertilized with 100 kg N/fed. rate compared with the others varieties SS301-1,MN1500,Rex,Brands,MN4080,Umbreella under experiment soil conditions. Also, in Egypt, indicated that SS-301 sweet sorghum variety gave the highest ethanol production compared with the others varieties Ramada, Gk-coba and Mn- 4508. Olugbemi et al. (2018) found that SW Dansadau 2007 gave the maximum values for yield ,its components and ethanol production at use 80 kg N/ha. rate under experiment soil conditions in Nigeria. Tomar and Sai (2018) indicated that CSV 24 SSweet sorghum variety plants fertilized

with120 kg N/ha. rate gave maximum amount of juice, consequently ethanol Production under the study conditions in India. Also, Galal et al. (2019) indicated that Honey sweet sorghum variety fertilized with 100 kg N/fed. gave the highest values for brix % juice, sugar yield and ethanol yield compared with willey, Brandes and Roma varieties under experiment soil conditions in Egypt. Also, Ghallab and Helmy (2023) found that MN 1500 and MN8311sweet sorghum varieties recorded the maximum values for brix%, Juice yield and ethanol yield compared with all studied varieties in EL-Giza and Alexandria in Egypt. Consequently, these the study aimed to investigate effect of nitrogen fertilizer rates on bio-ethanol Production of some sweet sorghum varieties.

The aim of this work was to evaluate the performance of six sweet sorghum varieties and their response to soil application of nitrogen fertilization under Egyptian conditions.

MATERIALS AND METHODS

Tow field experiments were conducted at Agricultural Research Center Station Giza, during the summer seasons of 2018 and 2019 to study the effect of nitrogen fertilizer rates on juice yield quality and ethanol production of some sweet sorghum varieties. Physical and chemical properties of the experimental soil are shown in Table (1).Soil analysis for two seasons were carried out according to Jackson (1973) . Sowing dates were 5nd and 1st May in 2018 and 2019 seasons, all sweet sorghum varieties were sown at same the dates, respectively. Seedlings were thinned into one plant/hill after 20 days from sowing. Plot size was 24.5 m^2 (7rows, 50 cm apart and 7m long) and 20 cm apart between hills. Phosphorus fertilizer at the rate of 15.5 kg P_2O_5 / fed . in the form of calcium super phosphate (15.5 % P_2O_5) was added during soil preparation . Potassium fertilizer was soil added at the rate of 24 kg / fed .K_2O as potassium sulphate (48 % k_2O) in one dos with 1st dos of nitrogen .

Treatments:

Nitrogen fertilizer rates :

N fertilizer treatments were applied as Urea (46.5 % N) at two equal doses just before the 1st and the 2nd irrigation time (21 and 35 days from sowing). Nitrogen fertilization treatments were as follow:

60 Kg N/ fed.

90 Kg N/ fed.

120 Kg N/ fed.

Sweet sorghum varieties.

A split plot design with three replicates was used where, sweet sorghum varieties was arranged in main plots and nitrogen fertilizer rates were randomly assigned to sub-plots. The normal agronomic practices were done as recommended. At 105 days from sowing, a sample of ten random guarded plants from the five center rows was taken to determine the following growth and quality traits.

Umbrella

Brands

Rex

MN 4080

MN 1500

SS 301-1

The following varieties were obtained from Sugar Crop Research Institute, Agricultural Research Center Station, Giza, Egypt.

Studied traits

Stalk length in cm: Measured from the soil surface to node at base of top moister.

Juice quality traits:

At harvest twenty stripped stalks were taken randomly from each plot and were immediately crushed through 3 roller lab Mill, the raw juice was filtered and weighed. Juice extraction percentage (JEP), Juice yield (JY t/fed) and Sugar yield (SY t/fed) were calculated according to the equation:

*JEP% = (Juice weight x 100) /stripped stalks weight.

Sucrose %. Determined by using direct polarization method as described by De-whalley (1964).

Stripped stalk yield(ton/fed).

juice extraction %

Juice yield (JY t/fed.) = (Stripped yield x JEP%) / 100.

Ethanol yield (L/fed.) = (JY x FS x 3.78 x 0.8 x 10) / 5.68

Where: 3.78, 0.8, 10 and 5.68 are constants.

The collected data were statistically analyzed according to the method described by Snedecor and Cochran (1981). Treatment means were compared using LSD at 5% level of difference as outlined by Steel et al. (1997).

RESULTS AND DISCUSSION

Effect of nitrogen fertilizer rates on stalk length, sucrose%, stripped stalk yield, juice extraction %, Juice yield and ethane yield of some sweet sorghum genotypes in 2018 and 2019 seasons are presented in Tables from 2-7

Results indicated that the differences between nitrogen fertilizer rates for stalk length, sucrose%, stripped stalk yield, Juice yield, and ethanol yield were significant in the two seasons.whil, jucie extraction trait was significant in second season only. Sweet Sorghum Plants fertilization with 120 kg N/fed., gave the maximum values for most studied traits, while the lowest values were obtained from 60kg N/fed., Treatment in the two seasons. These results might be attributed to that nitrogen is an essential nitrogen element for plants growth and one of the major factors limiting crop yield, Also, nitrogen role in many from Physiological process in plants such as chlorophyll and carotenoids synthesis, consequently, increase Photosynthesis rate which led to increase leaf area index, net assimilation rate, subsequently increase vegetative growth of sweet sorghum plants, which led to nitrogen enhanced to sucrose %, Juice yield and ethanol Production. These results are in agreement with olugbemi and Ababyomi (2016), Sawargaonkar and Wani (2016), Mekdad and EL-sherif (2016), Ekefre et al. (2017), Sakia Abazied (2018)Tomar and Sai (2018) and Galal et al. (2019).

Results also, Presented in Tables from 2- 7 indicated that the difference between sweet sorghum varieties were significant in both seasons. The highest values for most studied traits were obtained from SS301-1and MN/1500 varieties in both seasons, whie in second season only was obtained from Rex and Brandes varieties in Juice extraction % trait These the results may be due to genetically differences between varieties, especially, in its interaction with environmental conditions. These results are in agreement with Besheit and Mekdad (2016), Sawargaonkar and Wani (2016),Mahdy et al. (2018) and Ghallab and Helmy (2023), they indicated that the interactions between genetic traits and environmental conditions significantly affected for SS 301-1, MN 1500 and Brands on all studied traits compared with the others varieties, consequently, gave these genotypes the maximum values for all studied traits, especially ethanol production.

The interaction between nitrogen fertilizer rates and sweet sorghum genotypes was significant for most studied traits in the two seasons. Nitrogen fertilizer application with 120 kg N/fed., rate with SS301-1sweet sorghum varity gave the maximum values for most studied traits, while the minimum values for most studied were obtained from the interaction between 60 kg N/ fed., rate and Rex sweet sorghum genotype in both seasons-except juice extraction% trait interaction was in second season only.

It could be concluded that nitrogen fertilizer application with 120 kg N/fed. rate with SS 301-1 sweet sorghum variety Led to increased sucrose% and ethanol Production.

CONCLUSION

Under the conditions of this work, it is recommended to planting the SS 301-1 variety of sweet sorghum and fertilized with 120 kg N/fed to get higher sucrose%, yield/fed and ethanol production.

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Table 1: Mechanical and chemical properties of the experimental site in the 2018 and 2019 seasons.

Seasons	2018	2019
Mechanical analysis partial soil distribution		
Sand %	12.16	12.78
Silt %	48.85	49.18
Clay %	38.99	38.04
Soil texture	Silt clay loam	
Chemical analysis		
pH	8.10	8.13
Ecmols/m^3	2.55	2.63
$CaCO_3$	1.81	1.86
Available N (mg/kg)	20	28
Available P (mg/kg)	7.75	7.60
Available K (mg/kg)	183	179

Table 2: Effect of nitrogen fertilizer rates on stalk length (cm) of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	stalk length (cm)							
	2018 season				2019 season			
Genotypes	Nitrogen levels (kg)/fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	202.70	210.30	214.00	209.00	201.7	230.3	283.7	238.6
MN4080	205.30	212.70	219.30	212.40	219.3	273.3	286.3	259.7
Umbreella	235.90	267.30	280.60	261.30	243.3	286.7	290.7	273.6
Brandes	251.60	312.60	324.90	296.40	348.7	319.7	338	335.4
MN1500	285.00	342.00	357.70	328.20	259.7	320.3	340.3	306.8
SS301-1	347.30	338.30	367.70	351.10	304.7	322.3	341.7	322.9
Mean	254.60	280.50	294.00		262.9	292.1	313.4	
LSD 0.05								
A				5.86				22.27
B				21.89				39.46
AB				Ns				Ns

Table 3: Effect of nitrogen fertilizer rates on Sucrose %of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	Sucrose %							
	2018 season				2019 season			
Genotypes	Nitrogen rates (kg)/fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	5.883	6.607	6.803	6.431	6.86	7.143	7.76	7.254
MN4080	6.783	7.463	7.943	7.397	6.913	7.957	8.463	7.778
Umbreella	8.077	8.52	9.827	8.808	8.67	9.537	10.02	9.409
Brandes	8.94	9.07	9.947	9.319	9.17	9.99	10.51	9.89
MN1500	9.563	9.73	10.373	9.889	9.38	10.14	10.78	10.1
SS301-1	9.62	10.15	10.43	10.067	9.47	10.91	11.593	10.65
Mean	8.144	8.59	9.221		8.411	9.279	9.854	
LSD 0.05								
A				0.32				0.04
B				0.39				0.04
AB				Ns				0.07

Table 4: Effect of nitrogen fertilizer rates on Stripped stalk yield (t/fed.) of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	Stripped stalk yield (t/fed.)							
	2018 season				2019 season			
Genotypes	Nitrogen rates (kg) /fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	11.5	17.1	20.6	16.4	13.5	19.3	23	18.6
MN4080	13.4	18.4	23.7	18.5	14.2	19.7	24.5	19.5
Umbreella	13.3	19.6	23.9	18.9	14.4	21.7	25.7	20.6
Brandes	13.5	20.3	27	20.3	14.7	21.8	29.1	21.9
MN1500	16.1	21.9	27.9	21.9	14.9	21.8	29.9	22.2
SS301-1	16.7	24.1	28.8	23.2	15.8	26.8	31.8	24.8
Mean	14.1	20.2	25.3		14.6	21.8	27.3	
LSD 0.05								
A				0.29				0.59
B				0.07				0.10
AB				0.11				0.17

Table 5: Effect of nitrogen fertilizer rates on Juice extraction %of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	Juice extraction %							
	2018 season				2019 season			
Genotypes	Nitrogen rates (kg) /fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	66.032	45.877	47.618	53.176	39.429	46.216	49.394	45.013
MN4080	49.636	43.517	43.638	45.597	38.382	45.793	46.711	43.628
Umbreella	44.975	44.611	45.241	44.942	39.441	42.151	46.24	42.611
Brandes	45.864	43.834	46.518	45.405	40.794	44.7	47.245	44.246
MN1500	46.142	42.376	50.731	46.416	40.745	44.907	46.226	43.959
SS301-1	38.361	42.366	50.267	43.664	42.575	41.992	44.293	42.953
Mean	48.502	43.764	47.335		40.227	44.293	46.685	
LSD 0.05								
A				Ns				1.56
B				Ns				0.76
AB				Ns				1.31

Table 6: Effect of nitrogen fertilizer rates on Juice yield (t/fed.) of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	Juice yield (t/fed.)							
	2018 season				2019 season			
Genotypes	Nitrogen rates (kg) /fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	7.55	7.849	9.82	8.406	5.329	8.93	11.369	8.543
MN4080	6.628	8.014	10.352	8.331	5.448	9.045	11.458	8.65
Umbreella	5.949	8.762	10.813	8.508	5.675	9.13	11.879	8.895
Brandes	6.153	8.887	12.572	9.204	6.013	9.723	13.733	9.823
MN1500	7.396	9.262	14.173	10.277	6.067	9.78	13.817	9.888
SS301-1	6.412	10.216	14.466	10.365	6.75	11.267	14.101	10.706
Mean	6.681	8.832	12.033		5.88	9.646	12.726	
LSD 0.05								
A				1.39				0.26
B				0.98				0.16
AB				0.70				0.27

Table 7: Effect of nitrogen fertilizer rates on ethanol yield (litter/fed.)of some sweet sorghum genotypes in 2018 and 2019 seasons.

Treatment	Ethanol yield (litter/fed.)							
	2018 season				2019 season			
Genotypes	Nitrogen rates (kg) /fed.							
	60	90	120	Mean	60	90	120	Mean
Rex	414.75	476.93	613.91	501.86	328.51	577.22	798.46	568.06
MN4080	404.57	530.45	714.97	550.00	344.03	635.86	849.39	609.76
Umbreella	412.66	629.61	850.02	630.76	413.32	720.46	1010.23	714.67
Brandes	453.33	664.39	999.50	705.74	453.06	813.95	1222.61	829.87
MN1500	583.33	742.19	1184.16	836.56	480.04	851.25	1261.85	864.38
SS301-1	531.22	883.03	1279.56	897.94	553.93	1028.43	1304.89	962.41
Mean	466.64	654.43	940.35		428.82	771.19	1074.57	
LSD 0.05								
A				97.60				44.73
B				65.62				23.73
AB				113.65				41.11

تأثير معدلات السماد النيتروجيني على إنتاج الإيثانول لبعض أصناف الذرة الرفيعة السكرية

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الملخص العربي

اجريت تجربتان حقليتان بالمزرعة البحثيه بالمركز خلال موسمي الزراعة ٢٠١٨ و ٢٠١٩ لدراسة تأثير معدلات السماد النتروجيني (٦٠ ،١٢٠،9 كجم ن/فدان) على انتاج الإيثانول لبعض اصناف الذرة الرفيعة (Umbreella ، MN4080 ، Rex ، Brands ، MN1500 ، SS301-1 –) وقد تم تصميم التجربة في قطع منشقه مرة واحده حيث وضعت اصناف الذرة الرفيعة السكرية في القطع الرئيسية والمعدلات السمادية في القطع الشقية في ثلاث مكررات. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى : أظهرت النتائج تأثيرا ًمعنويا لمعدلات السماد النيتروجينى على طول العيدان ،النسبة المنوية للسكروز، محصول العيدان بعد التقشير، محصول العصير ومحصول الايثانول في كلا الموسمين.وصفه النسبه المئويه لاستخلاص العصيرفى الموسم الثانى فقط كما اثبتت النتائج ايضا ان تسميد نباتات الذرة الرفيعة السكرية ب١٢٠ كجم ن/فدان اعطى اعلى قيم لمعظم الصفات المدروسة، بينما أقل القيم بالنسبة لتلك الصفات كانت موضحه من التسميد بمعدل ٦٠كجم ن/فدان في كلا الموسمين . كما اظهرت النتائج ايضًا ان الاختلافات بين أصناف الذرة الرفيعة السكرية المدروسة كانت معنويه في كلا الموسمين، اكدت النتائج أن زراعة صنف الذرة السكرية SS301-1 اعطى اعلى القيم لمعظم الصفات المدروسة في كلا الموسمين، بينما اعطى الصنف Rex &MN1500 اعلى القيم لصفة النسبة المئوية لاستخلاص العصير في الموسم الثانى فقط. كان للتفاعل بين معدلات السماد النيتروجين واصناف الذرة السكرية تأثيراً معنوياً لمعظم الصفات المدروسة في كلا

الموسمين، وأدى تسميد نباتات الذرة السكرية الصنفSS301-1 بمعدل ١٢٠ كجم ن /فدان الى زيادة النسبة المنوية للسكروز وناتج الإيثانول تحت ظروف أرض التجربة.

الكلمات الاسترشادية: أصناف الذرة الرفيعة الحلوة، التسميد النتروجيني، الإيثانول الحيوي.