

RESPONSE OF THREE SWEET SORGHUM VARIETIES TO POTASSIUM MINERAL - AND BIO - FERTILIZATION

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Abstract

Two field trials were conducted during the summer seasons of 2009 and 2010 on sweet sorghum at Giza Agricultural Research Station, Agricultural Research Center, Giza Governorate, to study the effect of three treatments of potassium fertilization, viz., 24 and 30 kg K₂O/fed as potassium sulfate 48% K₂O as a mineral fertilizer, both of them with 2 bags bio-fertilizer (potassium Mag/fed as a recommended dose) and 36 kg K₂O/fed without bio-fertilizer on yield/fed and chemical composition of three sweet sorghum varieties, namely, Honey, Brandes and Sorgo. Sweet sorghum varieties differed significantly for stripped stalk, juice and surup yields/fed, TSS, purity and extracted juice% as well as chemical composition, i.e. sucrose% and reducing sugars% in juice and syrup. Sorgo variety was the best as compared to Brandes and Honey. The highest values of the most aforementioned traits were obtained at 30 kg K₂O/fed with 2 bags of biofertilizer. The interaction between all studied traits were insignificantly affected in both seasons. Therefore, these results give evidence to the use of sweet sorghum for syrup production instead of sugar cane, to reduce the vast gab between sugar production and consumption.

Key words: Sweet sorghum, potassium, biofertilization, syrup and TSS%.

INTRODUCTION

Sweet sorghum is cultivated mainly for its syrup, which is called Black honey. It is predicted to be one of the major sources for syrup production in the near future if the sorghum syrup quality improved. Good sorghum syrup is light colored and mild and has a characteristic of flavor. (Osman *et. al.* 2005 and Mohamed *et. al.* 2006). Therefore this leads to save cane yield for sugar production and reduce the vast gab between sugar production and consumption which reached about 1.10 million ton. It is still imported annually (CCSC 2010). Sweet sorghum productivity and quality are affected greatly by many factors. Variety selection is one of the most important decisions in the production of sweet sorghum syrup. There is a great variation among sorghum varieties in stalk height, diameter, number of internodes, syrup production and yield and its components (Miller and Creelman 1982 and Chawdhury and Rahman 1990 and Mohamed *et. al.* 2006). In this respect, Nour El Hoda *et. al.* (1994) and Mohamed *et. al.* (2006) illustrated that stripped stalk yield, was the effective

parameter on juice and syrup yield, in addition to the chemical characteristics which in turn affect syrup quality of sweet sorghum varieties. Ismail *et. al.* (2007) and Aly *et. al.* (2008) reported that sweet sorghum varieties show significant differences in leaf area, leaf area index, plant height and diameter, TSS%, sucrose%, purity%, juice and syrup extraction%, stripped stalk, juice and syrup yields.

Potassium is known for its role in sucrose translocation and accumulation in storage tissues of plants. In this respect, potassium fertilizer increases the sucrose % without significant reduction in purity%. potassium fertilizer for sweet sorghum supply 40 pounds for each unit of K₂O/acre is essential to get high yields. A five to seven tons/acre sorghum crop will remove about 180 lb K₂O/acre (Undersander *et. al.* 1990). El-Zeny (2004) found that juice extraction%, juice yield, syrup extraction%, syrup yield, total soluble solids, sucrose% were significantly increased by applying potassium fertilizer at 30 kg K₂O/fed. Mohamed *et. al.* (2006) found that maximum stripped stalk and syrup yield of sweet sorghum were obtained using potassium fertilization at the rate of 24 kg K₂O/fed for both varieties. Meantime, such treatment enhanced greatly juice and syrup quality. This work was carried out to obtain the highest yield and quality of some sweet sorghum varieties by applying different doses of potassium mineral fertilizer and biofertilizer.

MATERIALS AND METHODS

Two field trials were conducted during the summer seasons of 2009 and 2010 on sweet sorghum (*Sorghum bicolor* L. Moench) at Giza Agricultural Research Station. Agricultural Research Center, (Giza Governorate), to study the effect of three levels of potassium fertilizer (24 and 30 kg K₂O/fed potassium sulfate as a mineral fertilizer both of them with 2 bags of biofertilizer potassium Mag/fed as a recommended dose) and 36 kg K₂O/fed without biofertilizer on yields/fed and chemical compositions of three sweet sorghum varieties, viz., Honey, Brandes and Sorgo. A split plot design with four replications was used, potassium and biofertilizer levels i.e., the three levels of potassium fertilizer were allocated to the main plots and the three sorghum varieties to the sub plots. Plot size was 14 m² (1/300 fed) and consisted of four rows, 7 m long and 50 cm apart. Sowing date was 1st of May and harvest was done after four months from sowing in both seasons. Seeds were inoculated before sowing with potassium Mag (recommended dose 2 bags/fed) in a shadow place pre planting and immediately sown and irrigated. The biofertilizer was provided by the Biofertilization Unit, Soil, Water and Environment Research Institute, Agricultural Research Center. Nitrogen fertilizer (as urea 46.5% N), was added at the recommended rate of 60 kg

N/fed in two equals doses, the 1st one was after one month from sowing and the 2nd one 15 days later. Phosphorus fertilizer (as calcium superphosphate 15.5% P₂O₅), was added at the recommended rate of 15 kg/fed during seed bed preparation. Potassium fertilizer (as potassium sulphate 48% K₂O), was added at the 24, 30 with biofertilizer and 36 kg K₂O/fed without biofertilizer in two equal doses with nitrogen fertilizer. All Agricultural practices were done as recommended by Sugar Crops Research Institute. Some physical and chemical properties of the experimental soils were analyzed according to Jakson (1967) and shown in Table (1).

Table 1. Some physical and chemical analyses of the experimental soils*.

Particle size %				Soil texture	**E.C. ds/m	Soil pH***	Organic matter %	CaCO ₃ %		
Sand	Silt	Clay	Fine sand							
11.20	25.70	60.10	3.00	Clay	3.20	8.00	1.89	1.60		
Soluble Cations (meq/L)				Soluble anions(meq/L)				Total available contents (ppm)		
Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻	N	P	K
5.10	2.60	16.30	0.35	0.10	2.90	9.40	13.30	36.0	6.91	280.51

* Each value represents the average of 4 samples at both seasons.

** EC = Electrical conductivity was measured in a soil – water extract (1:5).

*** pH was measured in a soil – water suspension (1: 2.5).

Recorded data

At the dough stage (content of seeds are firm and easily crushed between thumb and index fingers), the plants were harvested after 120 days from sowing. A sample of twenty stalks from each subplot was taken at random to determine the following parameters:

- Yield and extracted juice

- Yield and juice extracted were determined from plants taken from the two middle rows of each sub plot to avoid the border effect. Sample size of 10 plants/plot was used to determine stripped stalk, juice and syrup (tons/fed) according to AOAC (2005).

- Extraction juice %

- Brix% was determined by Brix hydrometer standardized at 20°C.

- Purity% was determined by the following equation:

$$\text{Purity\%} = \text{Sucrose \%} \times 100/\text{TSS\%}.$$

- Juice and syrup extraction (JSE)% was estimated from the following formula:

$$\text{JSE\%} = \text{juice or syrup yield ton/fed} \times 100/\text{stripped stalk yield ton/fed}.$$

- Chemical composition

- Extraction juice and syrup% were chemically analyzed for sucrose%, reducing sugars% which were determined according to methods described by AOAC (2005). Als, pH value was measured by a Beckman pH meter according to Collins *et. al.* (1987).

Data were statistically analysed at 5% level of probability according to Snedecor and Cochran (1981).

RESULTS AND DISCUSSION**I. Varietal effects****-Yields and extracted juice**

The results obtained in Table (2) revealed that varieties significantly differed in stripped stalks, juice and syrup yields/fed in both seasons. The highest values of studied traits were recorded by variety Sorgo as compared with the other varieties, i.e. Brandes and Honey. The differences in these traits among genotypes might be due to the differences in their genetic the make-up. (Nour El Hoda *et. al.* 1994 and Mohamed *et. al.* 2006).

Table 2. Effect of varieties on yield/fed and extracted juice %.

2009 season						
Sweet sorghum	Yields (ton/fed)			Extracted juice		
Varieties	Stripped stalk	Juice	Syrup	Total soluble solids%	Purity%	Juice extraction%
Honey	28.25	12.89	1.45	20.41	53.41	45.63
Brandes	29.31	13.94	2.59	19.94	58.98	47.56
Sorgo	30.33	14.92	2.89	18.17	67.86	49.19
LSD 5%	1.45	0.54	0.19	1.10	4.78	1.29
2010 season						
Honey	29.12	13.74	1.59	21.65	51.04	47.18
Brandes	30.22	14.44	2.12	20.11	63.80	47.78
Sorgo	31.39	15.59	2.86	19.38	69.35	49.67
LSD 5%	0.84	0.17	0.15	0.75	4.25	0.93

- Extracted juice

The results in Table (2) indicated that TSS, purity% and extraction juice% traits significantly differed between the three varieties in both seasons. Variety Honey

produced the highest values of TSS% of juice. While, variety Sorgo had the highest purity and extraction juice% compared to the other varieties. This result might be mainly due to the fact that the non sugar substances % of juice and fiber content were lower for Honey variety than Brandes and Sorgo. Similar findings were obtained by Nour El Hoda *et. al.* (1994) and Mohamed *et. al.* (2006).

- Chemical composition

Results in Table (3) showed that sweet sorghum varieties differed significantly in chemical composition in both seasons. The obtained results in Table (3) indicate that sucrose% and reducing sugars% in extracted juice and syrup as well as extracted syrup% were significantly affected by sweet sorghum varieties, while, pH values did not differ significantly in both seasons. It is important to mention that Sorgo was the best variety where, it gave the highest value of sucrose% and the lowest value of reducing sugars%. This variation among genotypes may be due to the differences in their genetic make-up. Such data are in the same trend with Nour El Hoda *et. al.* (1994), Osman *et. al.* (2005) and Mohamed *et. al.* (2006).

Table 3. Effect of varieties on chemical composition .

2009 season						
Sweet sorghum	Chemical composition					
	Extracted juice			Extracted syrup		
Varieties	Sucrose%	Reducing sugars%	pH value	Sucrose%	Reducing sugars%	Syrup extraction %
Honey	10.90	2.35	3.83	28.27	30.78	5.13
Brandes	11.76	2.17	3.73	29.80	29.84	8.83
Sorgo	12.33	2.00	3.78	30.04	28.81	8.54
LSD 5%	0.48	0.05	NS	0.65	0.75	2.02
2010 season						
Honey	11.05	2.54	3.83	27.20	31.81	5.46
Brandes	12.83	2.39	3.73	28.83	30.84	7.02
Sorgo	13.44	2.17	3.78	29.02	29.83	9.11
LSD 5%	0.32	0.10	NS	0.85	0.55	1.95

II: Potassium mineral fertilizer and biofertilization

- Yields and extracted juice

The results in Table (4) showed a significant increase in yields of stripped stalks, juice and syrup/fed with potassium mineral fertilizer and biofertilization application at the rate of 30 kg K₂O/fed + 2 bags Mag/fed followed by 36 kg K₂O/fed without biofertilizer and 24 kg K₂O/fed + 2 bags Mag/fed in both seasons. This could

be attributed to the positive effect of potassium on stalk weight, which showed low fiber content and high water content with the application of potassium. These results revealed the importance of mineral fertilizer and biofertilizers for increasing yield and juice extracted of plants.

Table 4. Effect of potassium mineral fertilizer and biofertilization on yield/fed and juice extracted % .

2009 season						
Potassium	Yields (ton/fed)			Juice extracted		
(mineral and biofertilizer Mag kg/fed.)	Stripped	Juice	Syrup	Total soluble solids %	Purity %	Juice extraction %
24 K ₂ O + 2 bags Mag/fed	27.67	14.53	1.26	21.59	50.95	52.51
30 K ₂ O + 2 bags Mag/fed	29.81	16.20	2.93	18.15	71.74	54.34
36 K ₂ O	28.50	15.03	2.48	20.78	62.37	52.74
LSD 5%	0.68	0.50	0.11	0.57	0.89	0.18
2010 season						
24 K ₂ O + 2 bags Mag/fed	28.67	13.10	1.35	21.76	56.02	45.69
30 K ₂ O + 2 bags Mag/fed	30.94	15.99	3.16	18.25	78.08	51.68
36 K ₂ O	29.47	14.69	2.07	20.13	65.57	49.85
LSD 5%	0.41	0.25	0.08	0.37	0.74	2.12

- Extracted juice

Results in Table 4 show that treatment with 30 kg K₂O/fed + 2 bags of Mag/fed or 36 kg K₂O/fed without biofertilizer had a significant increase in purity and juice extraction as compared with 24 kg K₂O/fed + 2 bags Mag/fed in both seasons. The increase in purity% might be due to the increase in sucrose% and decrease in non sugar substances% of sorghum juice with potassium fertilization and syrup extraction % (SEP) of sorghum syrup as compared with the control treatment. These results revealed the importance of potassium (mineral fertilizer twice) and biofertilization for physical properties of extracted juice. These results may be due to role of potassium (mineral fertilizer) in increasing photosynthesis activity and subsequently carbohydrate synthesis and its accumulation which is reflected on the TSS%. Role of potassium biofertilizer may be due to increasing available nutrients for growth and subsequently juice quality. These results are in agreement with those reported by El-Zeny (2004), Mohamed *et. al.* (2006) and Moustafa *et. al.* (2006).

- Chemical composition

Results in Table (5) showed a significant increase in chemical composition with potassium (mineral fertilizer) and biofertilization. Potassium (mineral fertilizer) and biofertilizer application at 30 kg K₂O/fed + 2 bags Mag/fed significantly increased sucrose% in the extracted juice and syrup than other treatments in both seasons. However, the same treatment gave the lowest reducing sugars%. There are a variety of reasons to explain the effect of potassium application on sucrose content, one of them may be due to improving the functional quality of sugar beet which could be seen in stimulation of assimilation and translocation of sugar from leaves to the beet. Potassium also prepares osmotically the beet cells to store large amounts of sugars (Krauss, 2000).

Table 5. Effect of potassium mineral fertilizer and biofertilization on chemical composition.

2009 season						
Potassium (mineral and biofertilizer Mag kg/fed.)	Chemical composition					
	Juice extracted			Syrup extracted		
	Sucrose%	Reducing sugar%	pH value	Sucrose %	Reducing sugar%	Syrup extraction %
24 K ₂ O + 2 bags Mag/fed	11.00	3.26	4.65	28.24	29.63	4.55
30 K ₂ O + 2 bags Mag/fed	13.02	1.99	4.85	30.40	27.25	9.83
36 K ₂ O	12.96	2.98	4.85	29.48	28.56	8.70
LSD 5%	0.39	0.13	NS	0.61	0.31	3.49
2010 season						
24 K ₂ O + 2 bags Mag/fed	12.19	3.31	4.65	29.27	30.91	4.71
30 K ₂ O + 2 bags Mag/fed	14.25	1.02	4.85	31.27	28.23	10.21
36 K ₂ O	13.20	2.03	4.85	30.51	29.34	7.02
LSD 5%	0.31	0.12	NS	0.55	0.65	4.77

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استجابة ثلاثة اصناف من الذرة الرفيعة السكرية للتسميد البوتاسى المعدنى والحيوى

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اقيمت تجربتين حقليتين بمركز البحوث الزراعية (محطة بحوث الجيزة) فى صيف 2009 و2010 بتصميم القطع المنشقة مرة واحدة لدراسة تأثير ثلاثة مستويات من التسميد البوتاسى المعدنى والحيوى وهى 24 و30 كجم بوتاسيوم/فدان بالاضافة الى بوتاسيوم حيوى (بوتاسيوم ماج 2 كيس/فدان) الموصى به و36 كجم بوتاسيوم معدنى بدون تسميد حيوى على محصول العيدان والعصير والعسل والصفات الكيميائية للعصير والعسل المنتج من اصناف الذرة السكرية وهى هانى وبراندز وسورجو.

كانت النتائج كالاتى:

1. اختلفت الاصناف معنويا فى الصفات المحصولية وهى محصول العيدان النظيفة والشراب والعصير (طن/فدان) والمواد الصلبة الذائبة الكلية للعصير ونسبة النقاوة ومستخلص العصير وايضا المركبات الكيميائية مثل النسبة المئوية للسكرز والسكريات المختزلة فى العصير والشراب وقد تفوق الصنف سورجو ثم الصنف براندز ثم الصنف هانى فى كلا الموسمين.
2. استخدام السماد البوتاسى بمعدل 30 كجم بو 2 /أفدان + 2 كيس (بوتاسيوم ماج) حيوى بوتاسيوم الى زيادة معنوية فى معظم الصفات السالفة الذكر.
3. لم يكن للتداخل بين الاصناف والتسميد البوتاسى المعدنى والحيوى تاثير معنوى على اى من الصفات السابقة فى كلا الموسمين.

يوصى هذا البحث بأنه لزيادة المحصول وتحسين معظم خواص العصير والشراب الناتج عن طريق زيادة محتواهما من السكرز وإنتاج العسل ذو المواصفات الحسنة وتوفير قصب السكر لإنتاج السكر بدلا من العسل الاسود ينصح بإضافة 30 كجم بو² / فدان + 2 كيس (بوتاسيوم ماج) حيوى بوتاسيوم واستخدام صنف الذرة الرفيعة السكرية سورجو ثم براندز ثم الصنف هانى على التوالى.