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Variable Nutrient Environment Influence on Sweet Sorghum Stalk and Grain Yield

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Abstract

Sweet sorghum is found to be one of the best sources for Ethanol production due to less irrigation requirement and cost of cultivation, at times Indian government had introduced the policy of blending ethanol with petrol and diesel. The present study was aimed to identify suitable sweet sorghum cultivar and quantify the influence of nitrogen and potassium on stalk and grain yield. The results indicated that a significant improvement in total and stripped stalk weight, juice yield, brix value and grain yields were observed with nitrogen fertilization @ 80 kg N ha^{-1} alone (N_1K_0). The combined effect of 80 kg N and 40 K_2O was found significant on total and stripped stalk weight in 2008 and juice yield in 2009. The cultivar SSV 84 produced higher mean grain yield of 4.01 t ha^{-1} in 2008 and PAC 52093 with 2.86 t ha^{-1} in 2009 over CSH 22SS. But this trend was reverse in terms of in total and stripped stalk weight and juice yields. The cultivar CSH 22SS recorded higher brix value (15.4) during drought year 2009 over its preceding wet year 2008. The highest net returns and B:C ratio were recorded with the conjunctive use of N and K_2O at their recommended levels during both the years. The cultivars SSV 84 and PAC 52093 were found superior to CSH 22 SS in terms of net returns and B:C ratios during their respective years of study.

Keywords: Nutrient management, nitrogen, potassium and sweet sorghum

1. Introduction

United States, Brazil and the European Union contributes lion's share to biofuel production in the world. The production witnessed five times increase starting from 17 billion liters to 83.1 billion liters over a period of thirteen years since 2000 (WBA GBS report, 2014). Among the biofuels, ethanol and biodiesel are the two major ones. The feedstock that is being used to produce ethanol mainly includes sugarcane in Brazil, corn in the US and sugarbeet in the European Union (Huligol et al., 2004). Government of India had introduced the policy of blending ethanol with petroleum keeping in view increasing cost of non-renewable petroleum products,. The possible ethanol production from available sugarcane molasses and other sources is 2000 million litres yr^{-1} against the requirement of ethanol in order to blend with petrol (10%), diesel (5%) and other purposes is 5000 million litres yr^{-1} leaving a deficit of 3000 million l yr^{-1} of ethanol in India. The present fuel policy has renewed interest in sweet sorghum because it is best suited for ethanol production due to low water requirement, less cost of production, higher total reducing sugars and poor sugar content compared to sugarcane juice (Huligol et al., 2004). With respect to plant nutrition, imbalance application is one of the most important problems facing in agriculture (Regeo et al., 2013). Nitrogen plays a significant role in plant growth and development. Further, most of the farmers are not applying potassium fertilizer with a perception that Indian soils are rich in K and need no of extraneous application (Tewari, 2006). If total soil K content is adequate, the release rate in most cases has not been enough to meet crop requirement (Hunsigi, 2001). In the present day intensive and high yield oriented agriculture, there is negative K balance and consequently, the soils are mined of the essential nutrient (Roy, 2000). The response to K application is site and crop specific and in many cases, economic as well (Stauffer et al., 1995). Pholsen and Sornsungneon (2000) reported that, increase in N and K_2O levels significantly increased most growth parameters of the sorghum crop. The synergistic interaction of N and K was well explained by Aulakh and Mahli (2005) in different crops. Although the effect Potassium on growth and yield of other crops reported, but there is a limited reports regarding effect of K on growth and juice yield of sweet sorghum which has economic value. Therefore the current experiment was carried out to know effect of different N and K levels on stalk, juice and grain yield and brix value sweet sorghum cultivars.

2. Materials and Methods

The present study was mainly aimed at quantifying the influence of nitrogen and potassium nutrients on recently developed sweet sorghum cultivars. The trial was conducted for two years during maghi (late *kharif*) season of 2008–09 and 2009–10 at Agricultural Research Station (ARS), Madhira in Khammam district, Telangana State. The soil of the experimental site was of medium to deep black soil with 8.33 pH (Glass electrode pH meter by Jackson, 1967), EC was 0.055 dS m^{-1} (Conductivity bridge method by Jackson, 1967), organic carbon was 0.41 (Walkley and Black's modified method by Jackson, 1967) and available N was 205 kg ha^{-1} (Alkaline permanganate method by Subbaiah and Asija, 1956), available K was 175 kg ha^{-1} (Olsen's method by Olsen et al., 1954) and available P was 30.4 kg ha^{-1} (Neutral ammonium acetate method Flame Photometer by Jackson, 1967). The experiment included two levels of nitrogen (N) 0 and 80 kg ha^{-1} and three levels of potassium (K) 0, 40 and 80 kg ha^{-1} as the main plot treatments and sweet sorghum cultivars CSH 22SS and SSV 84 used in 2008 and CSH 22SS and PAC 52093 used in 2009 as sub-plot treatments. It was conducted in a split plot design with three replications. The date of sowing during 2008 was 20th September and during 2009 was 2nd September, while date of harvest was 12th January and 3rd January, during 2008 and 2009 respectively. The crop was raised under rainfed conditions and was managed free from pest and diseases. The gross plot size was 9×6 m^2 and net plot size was 7.8×5.6 m^2. At harvest, the earhead was separated from the stalk and the total fresh weight was recorded, while the fresh stalk weight was recorded after stripping the leaves. Juice was immediately extracted from the stripped stalk by using sugar cane crushers procured from local cane juice vendors so as to record the brix value using a refractometer and the volume was measured by using a measuring jar. The earheads were threshed, separated and the grain yield was recorded.

3. Results and Discussion

The pooled statistical analysis (Table 1) using a split plot design indicated that the yields varied significantly and hence the data was summarized for individual years separately. The results in Table 2 revealed that, application of either 40 kg or 80 kg K_2O ha^{-1} alone did not significantly influence biomass, juice yield, brix value and grain yield in sweet sorghum during

Table 1: Results of pooled analysis of two years

Pooled	TFY	SFY	GY	JY	BV
Years (2008 and 2009)	Sig	Sig	Sig	Sig	Sig
Main plots (Nitrogen and potassium levels-6)	Sig	Sig	Sig	Sig	Sig
Sub plots (Cultivars-2)	NS	NS	Sig	Sig	Sig
Interaction (NK×C)	NS	NS	NS	NS	NS

TFY: Total fresh yield (t ha^{-1}); SFY: Stalk fresh yield (t ha^{-1}); GY: Grain yield (t ha^{-1}); JY: Juice yield (l ha^{-1}); BV: Brix value (%); Sig: Significant; NS: Non significant

Table 2: Total plant weight, stripped stalk weight, juice yield, brix value and grain yield response of sweet sorghum cultivars to nitrogen and potassium levels

Treatments	Total plant weight (t ha^{-1})		Stripped stalk weight (t ha^{-1})		Juice yield (l ha^{-1})		Brix value		Grain yield (t ha^{-1})	
Years	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Main plots										
N_0K_0	31.75	24.20	17.05	15.39	6549	3559	13.1	12.4	3.29	2.32
N_0K_1	31.08	25.32	19.52	15.85	6456	3668	14.1	12.8	3.30	2.37
N_0K2	31.60	25.10	17.89	17.63	6849	3702	14.2	13.3	3.31	2.30
N_1K_0	33.87	33.50	22.98	21.45	7683	5117	15.5	13.9	4.36	3.08
N_1K1	40.04	35.90	25.12	23.25	8240	5665	15.6	14.0	4.46	3.22
N_1K_2	41.04	34.70	26.30	23.12	8353	5951	15.7	14.8	4.49	3.31
SEm±	0.85	1.28	0.79	1.39	254	116	0.4	0.3	0.11	0.10
CD (p=0.05)	2.70	4.10	2.54	4.44	809	369	1.4	1.0	0.34	0.31
Sub plots										
CSH 22 SS	35.04	30.96	22.40	21.38	7438	5145	13.9	15.4	3.72	2.67
SSV 84/ PAC 52093	34.75	28.62	20.56	17.52	7272	4075	15.5	11.7	4.01	2.86
SEm±	0.65	0.90	0.56	0.62	150	127	0.3	0.2	0.06	0.07
CD (p=0.05)	NS	NS	1.26	NS	NS	NS	0.9	0.5	0.19	NS

CSH 22SS and PAC 52093 were tested during 2008-09; SSV 84 and PAC 52093 during 2009-10 both years of study. However, a significant improvement in stalk yield, juice yield, brix value and grain yields were observed with nitrogen fertilization @ 80 N ha^{-1} alone (N_1K_0) when compared to no fertilizer (N_0K_0) or application of K_2O alone either @ 40 kg ha^{-1} (N_0K_1) or 80 kg ha^{-1} (N_0K_2). The combined effect of 80 kg N and 80 kg K_2O (N_1K2) was found significant on total and stripped stalk weight and juice and seed yield as compared to that of N_0K_0, N_0K_1, N_0K_2, however, at par with N_1K_1 (80 kg N and 40 kg K_2O ha^{-1}) during both the years and N_1K_0 for total plant weight during 2009 and juice yield in 2008 only. Mengal and Kirbay (2001) reported that, corn and sorghum yields increased by 41 and 19% respectively, with application of N fertilizer. Pholsen and Sornsungneon (2004) were reported that, combined influence of nitrogenous and potassium fertilizers was significant and positive in increasing most of the growth parameters in sorghum plant. Among the cultivars studied, SSV 84 produced higher mean grain yield of 4.01 t ha^{-1} in 2008 and PAC 52093 with 2.86 t ha^{-1} in 2009 over CSH 22SS. But this trend was reverse in terms of total fresh stalk, stripped stalk and juice yields indicating favored partitioning towards the grain. The cultivar CSH 22SS was recorded higher brix value of 15.4 in 2009 which was drought year over its preceding wet year 2008 (13.9) indicating its advantage even during drought year. The linear relationship between fresh stalk yield and juice yield had an R^2 value of 0.55 (Figure 1). The variation in cultivar response due to interaction effect of N and K_2 O was not significant. These results are in line with the finding of Buah et al. (2012) who did not observe any significant interactions of fertilizer N, P, and K to affect any

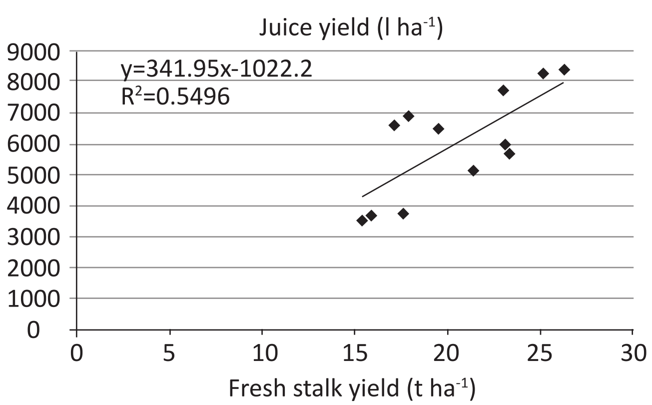

Figure 1: Relationship between fresh stalk yield and juice yield

parameter of sorghum, which might be due to the difference in genotypes used in the two studies. Zia-ul-hassan et al. (2016) concluded that the sorghum genotypes varied widely for their growth and biomass production, however, this variation was independent of their K accumulation.

The highest net returns of ₹ 47101 and ₹ 32990 ha^{-1} and benefit:cost ratio of 3.37 and 2.37, were recorded with the combined application of N and K_2O at their recommended levels of 80 kg N and 40 kg K_2O ha^{-1} (N_1K_1)) during 2008-09 and 2009−10, respectively. Among the tested genotypes, the cultivars SSV 84 and PAC 52093 were found superior over CSH 22 SS in terms of net returns and benefit cost ratios during their respective years of study (Table 3).

Table 3: Monetary returns of sweet sorghum as influenced by nutrients and varieties

Treat-ments	Gross returns (₹ ha^{-1})		Net returns (₹ ha^{-1})		B:C ratio	
Main plots	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
N_0K_0	45420	33170	33020	20770	2.66	1.68
N_0K_1	45250	33980	32560	21290	2.57	1.68
N_0K2	45590	33160	32610	20180	2.51	1.56
N_1K_0	56190	44650	42540	31000	3.12	2.27
N_1K_1	60950	46930	47010	32990	3.37	2.37
N_1K_2	60870	47140	46640	32910	3.28	2.31
Sub plots						
CSH22SS	50980	39530	37665	26395	2.83	1.98
SSV 84/ PAC 52093	53760	40040	40445	26725	3.04	2.01

CSH 22SS and PAC 52093 were tested during 2008–09; SSV 84 and PAC 52093 during 2009−10; *The price of fresh stalk ₹ 500 t^{-1} and grain ₹ 9 kg^{-1}

4. Conclusion

The combined application of 80 kg N and 40 kg K_2O ha^{-1} can be recommended for sweet sorghum due to realisation of higher stalk and juice and grain yields besides net returns and B:C ratio. SSV 84 and PAC 52093 were found to be the suitable cultivars for sweet sorghum production.

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