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Characterizing Nutrient Management Effect on Yield of Sweet Sorghum Genotypes

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Abstract: Consequences of crop management and cultivar choice strategies are important to attain higher stalk and juice yield in sweet sorghum. Here we characterize and contrast the management responses for stalk yield, extractable juice and brix content of open pollinated sweet sorghum genotypes bred in the *A*ll India *C*oordinated *S*orghum *I*mprovement *P*roject (AICSIP). Field experiments were undertaken at four locations i.e., Coimbatore, Solapur, Akola and Pantnagar in India using a combination of cultivars, plant populations and nutrient treatments. Detailed measurements of stalk and juice yield were recorded at harvest time. The pooled analysis indicated that except for the variability due to nitrogen rate application, the other two factors (culivar and plant population) were statistically non-significant in terms of cane yield, juice yield and brix reading. Both cane and juice yield increased with increasing rates of nitrogen application. The association between stalk yield and juice yield were explained using a linear regression model.

Key words: Sweet sorghum % Nutrient management % Brix

INTRODUCTION

The All India Coordinated Sorghum Improvement Project (AICSIP) has the national mandate of improving sorghum productivity across different sorghum growing states in India. A multi-disciplinary approach has been the strength of the multi-location testing program. Knowledge based specialized tools available across disciplines were integrated so as to synergize the crop improvement and management processes. The crop improvement activity aims at attaining a higher productivity, while management helps attain the potential by providing an enabling environment. Of the various inputs that improved the efficiency of a cultivar in realizing its potential, fertilizers (nitrogen-N in particular) play a crucial role in both irrigated and rainfed environments. Two major components of uptake efficiency and utilization efficiency contributed to the variation in nitrogen use efficiency [1,2]. The first was related to the capability of location specific soil to supply the essential nutrient, while the second was related to the adaptive root related genetic trait [3].

Day and Sarkar [4] found that the sweet sorghum juice does not ferment as well as sugarcane juice and hence suggested a need for further research on fermentations of alcohol from this feedstock and for a re-evaluation of proposed schemes and economics for fuel production from this crop. Smith and Buxton [5], identified the factors that could effect maximum sugar yield of sweet sorghum (*Sorghum bicolor* (L.) Moench) at temperate zone locations. Four sweet sorghum cultivars were tested for fermentable sugar production potential under irrigated and non-irrigated conditions with 0, 84 and 186 kg ha^{-1} of added nitrogen fertilizer at two temperate zone locations (40.8 and 42°N latitude). Added nitrogen fertilizer had little discernible effect on increasing fermentable sugar production. Subramanian *et al*. [6] narrated the policy and planning issues for utilization of ethanol and bio-diesel in automotive diesel engines in Indian context in view of environmental benefits, energy self-sufficiency and boosting of the rural economy as well as measures related to implementation and barriers.

In this study, we characterise the plant population and nutrient responses open pollinated sweet sorghum

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genotypes. Field experiments were undertaken in Akola (Maharashtra State) and Pantnagar (Uttaranchal State) in India. Measurements of stalk and juice yield were recorded and general functional relations were regressed to predict juice yield in sweet sorghum across genotypes and variable nutrient environments.

MATERIALS AND METHODS

The trial was conducted at four locations of Coimbatore, Solapur, Akola and Pantnagar during rainy (kharif) season in the year 2007. Three factor variability was induced by varying inter-row spacing and nitrogen rates across two sweet sorghum cultivar. The design of the experiment was split-split plot, with plant population as main plot treatments, cultivars as sub-plot treatment and nitrogen levels as sub-sub-plot treatment. The treatments were randomized among the three replications.

Main plot treatments (A): Plant populations

45cm x 15cm (1,48,000 plants ha^{-1})
60 cm x 15cm (1,11,000 plants ha^{-1})

Sub plot treatments (B): Cultivars

SSV 84
RSSV 9.

Sub-sub plot treatments (C): Nitrogen levels

30 kg N ha^{-1}
60 kg N ha^{-1}
90 kg N ha^{-1}
120 kg N ha^{-1}

At crop maturity observations on sweet sorghum stalk and juice yields were recorded across all the treatments and replications. Brix of the extracted juice was taken using a brix meter. Pooled analysis combined over locations was done using a customized statistical package called IndoStat.

RESULTS AND DISCUSSION

The pooled analysis indicated that except for the variability due to nitrogen rate application, the other two factors were statistically non-significant in terms of stalk yield, juice yield and brix reading (Table 1). Both stalk and juice yield increased with increasing rates of nitrogen application. The extant of increase with application of 120 kg N over 90 kg N ha^{-1} was to an extant of 8 and 18%, respectively for stalk and juice yield in sweet sorghum. Since sweet sorghum juice is extracted from the stem the highest green stalk yield the highest would be the juice yield (Fig. 1). Any input or management technology that helps the cultivar attain its potential green stalk yield can help increase the juice yield in sweet sorghum.

Conversion efficiency of sweet sorghum juice to ethanol is related to both juice yield and the sucrose content in the juice, which in turn is indicated by the brix reading. The management treatments had lesser influence on brix count as compared to the cultivar, wherein SSV 84 had 34% higher brix count as compared to RSSV 9. The lowest brix reading in RSSV 9 was compensated by higher juice yield which was higher to an extant of 22% over SSV 84. Hence breeders approach in sweet sorghum should be targeted both at increased juice yield (quantity) and sucrose content (quality) so as to attain economically

Table 1: Pooled analysis of variance across locations and mean values for observed data

Main effects	Green stalk yield*	Extractable juice yield**	Brix count (%)
45x15cm	34104.00	10014.00	14.82
60X15cm	29020.00	8802.00	14.82
S C.D. (5%) Ai-Aj	12161.00	4827.00	3.30
F (Prob)	0.23	0.09	1.00
SSV 84	31398.00	8486.00	16.99
RSSV 9 #	31726.00	10330.00	12.65
C.D. (5%) Bi-Bj	3922.00	6151.00	5.42
F (Prob)	0.84	0.33	0.09
30 kgN	28464.00	7291.00	15.07
60 kgN	30206.00	8636.00	14.60
90 kgN	32419.00	9934.00	14.86
120 kgN	35159.00	11771.00	14.75
C.D. (5%) Ci-Cj	2061.00	1472.00	1.73
F (Prob)	0.00	0.00	0.95

* Unit kg ha^{-1}, ** Unit liters ha^{-1}

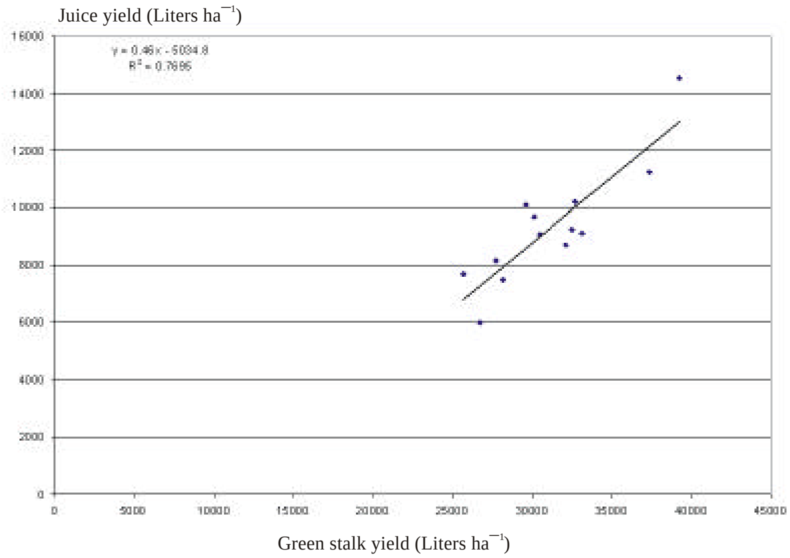

Fig. 1: Positive linear relation between green stalk yield and juice yield in sweet sorghum

viable levels of ethanol production from sweet sorghum stalk.

CONCLUSIONS

Adaptability of sorghum to seasons and regions has its intrinsic strength that can be nurtured through development of sturdy sweet stalks, facilitating supply of fermentable sugars. Improving the operational scheming of breeding approach to quantitatively increase the juice yield and qualitatively the fermentation efficiency through increased sucrose content can help meet the energy requirements of future generations. Management in terms of nitrogen inputs is critical to increase the green stalk yield which is linearly and positively related to juice yield.

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