The Andhra Agric. J 61(4):729-732, 2014

Effect of Stages of Harvest and Nutrient Management Practices on Juice Yield and Juice Quality Parameters of Sweet Sorghum (*Sorghum bicolor*)

R Srinivasa Rao, Pratapkumar Reddy, S S Rao and M Ramprasad
Department of Agronomy, College of Agriculture, Rajendranagar, Hyderabad 500 030

ABSTRACT

A field experiment was conducted during *kharif* 2011 and 2012 to study the influence of nitrogen, potassium levels and stages of harvest on sweet sorghum for juice yield and its quality parameters. Among stages of harvest significantly higher stalk yield (42.0 and 40.3 t ha^{-1}) brix (16.0 and 16.6%) sucrose (11.6 and 9.9%), Purity (59.2 and 72.5%) and maximum juice yield (17547 and 15662 L ha^{-1}) were recorded at physiological maturity stage compared to other stages of harvest. Application of 120 kg N and 40 kg K_2O ha^{-1} resulted in significantly higher stalk yield (41.0 and 37.8 t ha^{-1}), juice extraction (40.0 and 37.8%), Juice yield (19183 and 16848 L ha^{-1}), brix (15.2 and 15.0%), sucrose (10.8 and 8.8%) and purity (57.2 and 71.0%). Application of higher dose of nitrogen and potassium nutrient levels did not prove significantly advantageous in all parameters. The lowest stalk, juice, brix, sucrose and purity were recorded with application of 60 kg N and 40 kg K_2O ha^{-1} at all the stages of sweet sorghum

Key words : Brix, Juice extraction, Purity, Sucrose, Sweet sorghum.

The sweet sorghum or more appropriately called sweet stalk sorghum is a biofuel crop that accumulates sugars (10 to 15%). It is similar to sugarcane, but it also produces grains like normal food or feed types of sorghum. Ethanol is produced from stalk juice as similar to molasses based ethanol production process. It is an important crop grown around the world for syrup, ethanol, power, food, forage, etc.. India is the largest producer of sorghum in the world with an area of 8.47 m ha and a 7.15 million tonns production occupying of (DES, 2007).

Now a days the sugarcane molasses rates have become highly fluctuating, varying from Rs 3000 t^{-1} to Rs 7000 t^{-1} which results in instability of the price of alcohol. This condition not only makes sweet sorghum as sustainable substrate for ethanol production but also can act as supplements to sugarcane molasses (Arbatti 2001). However, due to recent hike in the cost of molasses, it has become necessary to search for cheaper substrate for ethanol production in India (Blum *et al* 1975.) There are various factors that influence the sweet sorghum yield and quality. Among them, identification of appropriate harvesting stages and nutrient management plays important role on biomass yield and quality of the crop and ultimately ethanol production. The stage of harvest plays an important role on biomass yield, quality of the juice and stubble sprouting. There is scarcity of information on the agro-techniques for sweet sorghum production in Andhra pradesh where sugarcane is the major substrate for sugar and alcohol production. The experiment was conducted keeping in view above said problem. Hence the present investigation was carried out to study the stages of harvest and nutrient management practices on juice yield and juice quality parameters of sweet sorghum.

MATERIALS AND METHODS

A field experiment was conducted during Kharif 2011 and 2012 on sandy clay loam soils at College Farm, College of Agriculture, Rajendranagar, Hyderabad (Acharya N.G. Ranga Agricultural University). The soil was sandy clay loam, medium is available N (376.6 $kgha^{-1}$) ,high in available phosphorus (42.4 kg P_2O $kgha^{-1}$) and medium in available potassium (268.2 kg K_2O $kgha^{-1}$) with neutral pH (6.8) and EC (0.18 dS m^{-2}).The experiment was laid out in split plot design, replicated thrice with spacing of 60 cm X 15 cm and plot size 3m X6 m . The twenty eight treatment combinations consisted of three stages of harvest viz., S_1 (50% flowering), S_2 (hard dough stage), S_3 (Physiological maturity) and eight levels of nutrient management practices viz., N_1K_1 (60 kg N 40 kg K_2O ha^{-1}), N_1K_2 (60 kg N 80 kg K_2O ha^{-1}), N_2K_1 (90 kg N 40 kg K_2O ha^{-1}) N_2K_2, (90 kg N 80 kg K_2O ha^{-1}), N_3K_1 (120 kg N 40 kg K_2O ha^{-1}), N_3K_2 (120 kg N 80 kg K_2O ha^{-1}), N_4K_1 (150 kg N 40 kg K_2O ha^{-1}), N_4K_2 (150 kg N 80 kg K_2O ha^{-1}).

The data on plant height, millable stalk yield, grain yield and juice quality parameters were recorded at 50% flowering, hard dough stage and at physiological maturity. The millable stalk yield per hectare was computed based on the weight of 15 plants harvested at random at the respective stages of harvest. The juice was extracted from the stalks using two-roller crusher and collected in a breaker. It was filtered through the muslin cloth and then analyzed for various juice quality parameters.

Brix (degrees), sucrose percent of juice, reducing sugars (RS) and ethanol were analyzed/ calculated as per the procedure outlined by Iswaran, (1981); Lane and Eynon (1970) respectively.

RESULTS AND DISCUSSIONS

Juice yield and its quality parameters were significantly influenced by stages of harvest(Table.1). The data indicated that significantly higher stalk yield (42.0 and 40.3 t ha^{-1}), brix (16.0 and 16.6%), sucrose (11.6 and 9.9%) and purity (59.2 and 72.5%) were observed at physiological maturity stage (S_3) over 50% flowering (S_1) and hard dough stage S_2, similarly highest Juice extraction per cent (40.0 and 37.2%) was recorded at 50% flowering stage due to high content juicy and fleshyness at early stages of sweet sorghum, lowest juice extraction (35 and 32.7) obtained at physiological maturity stage (S_3) due to photosynthates that are translocated from source to sink and reduce juice content at later stages , the lowest stalk yield (32.8 &30.8 t ha^{-1}), maximum juice yield (16340 and 13939 L $ha^{-}1$), brix (11.2 and10.0), sucrose (6.8 and 4.8) and purity (48 and 60.7) due to acid invertase enzyme activity which is more at early stages. The higher millable stalk yield, juice yield at physiological maturity stage was mainly attributed to the prolonged growth period, higher accumulation of drymatter in stem (Almodares *et al.*, 2006 and 2007). Similarly in case of juice quality parameters were superior over 50% flowering and hard dough stage due to sugar accumulation in plant by two enzymes viz., acid invertase and neutral invertase. However at the later part of the crop growth period neutral invertase enzyme dominates and favours accumulation of sugars resulting in better quality. Application of 120 kg N and 40 kg K_2O ha^{-1} recorded significantly higher stalk yield (41.0 and 37.2 t ha^{-1}), juice extraction (40 and 37.8%), Juice yield (19183 and 16848 L ha^{-1}), brix (15.2 and 15.0%), sucrose (10.8 and 8.8%) and purity (57.2 and 71.0%) at all stages over 60 kg N and 40 & 80 kg K_2O ha^{-1} (N_1K_1 and N_1K_2) and 90 kg N and 40 & 80 kg K_2O ha^{-1} (N_2K_1 and N_2K_2) due to adequate supply of balanced nutrition at correct time which improved the metabolic reaction of sweet sorghum. Application of higher dose of nitrogen and potassium levels) did not prove significant improvement in juice yield and quality parameters. The lowest stalk yield (32 and 31 t ha^{-1}), juice extraction 34 and 31.3) , juice yield (13406 &11641 L ha^{-1}), brix (12 and 11.8), sucrose (7.2 and 6.0) and purity (48.7 and 60.0) due to lower drymatter production , neutral invertase enzyme activity is very low at early growth stages of sweet sorghum. The reverse trend of occured in quality parameters with application 150 kg N and 40 and 80 kg K_2O ha^{-1} .Similar results also were areported by Bhairappanavar and Sharanappa(2011), Channanaik and Jayakumar (1994) and Hugar (2010).

Conclusion

Among three stages, physiological maturity stage (S_3) was found suitable stage of harvest for maximing stalk, juice yield, brix, and purity leading to higher sugar and bio-ethanol yields..Application of 120 Kg N 40 Kg K_2O ha^{-1} was foud the optimum dose of nitrogen and potassium to obtain higher stalk, sugar and ethanol yield in sweet sorghum .Application of higher dose of nitrogen and potassium did not improve the juice quality parameters and reduced the sucrose content in the juice.

Table 1. Effect of stages of harvest, nitrogen and potassium levels on juice yield and juice quality parameters.

Treatments	Stalk yield ($t\ ha^{-1}$)		Juice Extraction (%)		Juice yield ($L\ ha^{-1}$)		Brix (%)		Sucrose (%)		Purity (%)	
Stages of harvest	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
S_1:50% Flowering	32.8	30.8	40.0	37.2	16340	13939	11.2	10.0	6.8	4.8	48.0	60.7
S_2: Hard dough stage	37.3	34.8	38.0	34.8	17018	14602	12.3	13.9	8.7	7.6	51.7	70.7
S_3: Physiological maturity	42.0	40.3	35.0	32.7	17547	15662	16.0	16.6	11.6	9.9	59.2	72.5
SEm±	1.3	1.6	0.4	0.98	760	1059	0.46	0.34	0.72	0.34	1.0	0.82
C.D.(P=0.05)	2.6	4.5	1.2	2.72	2134	2940	1.07	0.94	2.10	0.97	2.8	2.2
Nitrogen & potassium levels												
N_1K_1: 60 kg N 40 Kg $K_2O\ ha^{-1}$	32.0	31.0	34.0	31.3	13406	11641	12.0	11.8	7.2	6.0	48.7	60.0
N_1K_2: 60 kg N 80 Kg $K_2O\ ha^{-1}$	33.0	31.0	34.2	31.4	13980	11815	12.2	12.3	7.4	6.4	50.1	60.6
N_2K_1: 90 kg N 40 Kg $K_2O\ ha^{-1}$	33.5	31.6	34.7	32.4	14452	12417	12.5	12.9	7.8	6.7	50.3	62.4
N_2K_2: 90 kg N 80 Kg $K_2O\ ha^{-1}$	34.4	32.4	35.0	33.4	14868	13069	13.0	13.5	8.3	7.0	50.1	63.8
N_3K_1: 120kg N 40 Kg $K_2O\ ha^{-1}$	41.0	37.8	40.0	37.8	19183	16848	15.2	15.0	10.8	8.8	57.2	71.0
N_3K_2: 120 kg N 80 Kg $K_2O\ ha^{-1}$	41.3	39.2	40.2	37.3	19553	17034	14.6	14.4	9.4	8.1	55.3	64.3
N_4K_1: 150 kg N 40 Kg $K_2O\ ha^{-1}$	41.7	39.5	40.5	37.1	19910	17145	14.3	14.1	9.0	7.9	54.7	62.9
N_4K_2: 150 kg N 80 Kg $K_2O\ ha^{-1}$	42.0	40.0	41.0	38.4	20395	17904	14.0	13.9	8.6	7.7	54.4	61.4
SEm±	1.4	1.5	1.3	1.33	1182	1165	0.46	0.44	0.84	0.51	2.3	2.8
C.D.(P=0.05)	4.0	4.5	3.5	3.74	3330	3327	1.22	1.26	2.21	1.48	6.4	7.3
Interaction (SXNK)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

LITERATURE CITED

Almodares A, Taheri R, Hadi MR and Fathi M 2006 The effect of Nitrogen and potassium fertilizers on the growth parameters and the yield components of two sweet sorghum cultivars. *Pakistan Journal of Biological Sciences,* 9(12) : 2350-2353.

Almodares A, Hadi M R, Ranjbar M and Taheri R 2007 The effect of nitrogen treatments, cultivars and harvest stages on stalk yield and sugar content in sweet sorghum. *Asian Journal of plant sciences,* 6(2):423-426.

Arbatti S S V, 2001 brief review of alcohol industry . Bharatiya Sugar, March pp,119-121.

Bhairappanavar S T and Sharaappa 2011 Bio-ethanol production potential of sweet sorghum (sorghum bicolor) cultivars under different spacing and harvest stages. *Indian journal of Agronomy,* 56(1):52-56.

Blum A, Feldhay H, and Dor Z 1975 Sweet sorghum for sugar production. Sorghum News letter 18: 72.

Channanaik D and Jayakumar B V 1994 Effect of time of harvest of sweet sorghum (Sorghum bicolor L.) genotypes on its yield and juice quality for jiggery. *Indian Journal of Agronomy,* 39(3):415-417.

D E S 2007 Directorate of Economics and statistics, Department of Agriculture and co-operation, Ministry of Agriculture Govt of India.

Hugar A Y 2010 Influence of nitrogen and harvest stages on dry matter and millable cane yield of sweet sorghum Agriculture Science Digest 30(1):19-22.

IswarnV 1981 Alaboratory Hand book for Agricultural Analysis. To day and Tomorrow publication pp 300-301.

Lane and Eynone 1970 Encyclopedia of Industrial chemical analysis 10:562-563.

(Received on 09.12.2012 and revised on 19.03.2013)