Madras Agric. J., 100 (1-3): 167-170, March 2013
https://doi.org/10.29321/MAJ.10.001264

Response of Sweet Sorghum [*Sorghum bicolor* (L.) Moench] to Tillage and Spentwash on Juice Quality and Economics

M.T. Malagi[1*], S.S. Angadi[1], N.D. Yogendra[2], S.P. Dineshkumar[1], A.C. Mahendra[2] and Y.H. Sujay[3]
[1]Department of Agronomy, U.A.S, Dharwad -580 005
[2]Department of Soil Science and Agricultural Chemistry, U.A.S, G.K.V.K, Bengaluru
[3]Department of Entomology, U.A.S, Raichur

A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the effect of spentwash and tillage on juice quality and economics of sweet sorghum under rainfed condition. Results revealed that deep tillage recorded significantly higher ethanol yield (769.6 l/ha), juice yield (9644.0 l/ha), extractability (269.73 ml/kg), extraction per cent (31.84%), brix$_0$ (18.25$_0$) and pol per cent (12.76%) of sweet sorghum as compared to shallow tillage. Among the different spentwash levels, 150 kg N per ha through spentwash recorded significantly higher ethanol yield (750.2 l/ha), juice yield (9567.3 l/ha), extractability (273.95 ml/kg), extraction per cent (32.30%), brix$_0$ (17.99$_0$) and pol per cent (12.71%) as compared to 75 kg N per ha through spentwash and control, but was on par with 100 kg N per ha through spentwash recommended dose of fertility and 125 kg N per ha through spentwash. The study indicated that a treatment combination of deep tillage with 100 kg N per ha through spentwash was found to be suitable for juice quality of sweet sorghum over other treatment combinations. Based on economics, this treatment was found to be suitable for higher gross returns (Rs. 35486.9/ha), net returns (Rs. 21644.9/ha) and B: C ratio (2.56) with minimum cost of cultivation (Rs. 13842.0/ha) as compared to other treatment combinations. The enormous quantities of plant nutrients present in spentwash offers an excellent opportunity to use it as a liquid fertilizer along with irrigation water, thus enabling the farmers to save cost incurred on fertilizers and at the same time achieve higher yields of crops.

Key words*: Distillery effluent, Spentwash, Sweet sorghum, Ethanol, Tillage*

Sweet sorghum is similar to common grain sorghum with sugar rich stalk. Apart from grain and fodder, several alternate products can be prepared by sweet sorghum unlike other kinds of sorghum like grain sorghum and fodder sorghum. Sweet sorghum has been investigated as a potential source of fermentable sugars for fuel ethanol production, wider adaptability, drought resistance, tolerance to water logging and relatively low water and fertilizer requirements. Presently, industrial need and demand of ethanol for transport can be met largely (75%) by sugarcane molasses. But, in future demand for sugarcane production may exert pressure due to its lengthier growing season and higher fertilizer requirements (Reddy and Reddy 2003). So, sugarcane may be supplemented by other raw material sources like sweet sorghum for ethanol production. Ethanol obtained from stalk juice of sweet sorghum is considered as one of the best fuels to reduce pollution as it contains 35 per cent of oxygen that helps in complete combustion of fuel and reduces harmful emissions and trophospheric ozone pollution (Wyman, 1994). In India, it is allowed to mix 5 per cent of ethanol with petrol, but recently Government of India (GOI) is hiking it to 10 per cent. By this import of petroleum can be reduced by 10 per cent (Reddy *et al.*, 2005).

In order to meet out the food, fodder and fuel requirement of growing population of human and livestock, the greatest challenge is to establish a balance between environment and resource base. So, tillage and spentwash are such an efforts made in the present study for better growth, yield and juice quality of sweet sorghum.

Materials and Methods

A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experiment was laid out in split plot design with three replications on medium deep black soil with pH of 7.70 and EC of 0.21ds/m and available macronutrients of 205.60, 27. 30 and 443.70 kg/ha N, P_2O_5 and K_2O respectively. Experiment involves two main plots *viz*.,

M_1: Deep tillage (45 cm) and M_2: Shallow tillage (15 cm) and six sub plots *viz*., S_1: 75 kg N/ha through

*[1]Corresponding author email: mallikarjunagro@gmail.com

spentwash; S_2 : 100 kg N/ha through spentwash; S_3 : 125 kg N/ha through spentwash; S_4:150 kg N/ha through spentwash; S_5 : RDF (100:75:37.5 kg N, P_2O_5, K_2O kg/ha) and S_6: Control. Spentwash was analyzed for its physical and chemical properties, which indicated the presence of the essential plant nutrients including both major and micro-nutrients (Table 1). In the present investigation, crop nutrition was on the basis of nitrogen content of spentwash. Sweet sorghum received varied levels of N (i.e., 75, 100, 125 and 150 kg N/ha) and constant level of P_2O_5 and K_2O (*i.e.*, 75 and 37.5 kg/ha) were supplied through spentwash and fertilizers. For all sub -plot treatments except S_5 and S_6 full dose of N and K_2O and partial dose of P_2O_5 were supplied through different quantities of spentwash in splits at different periods of crop growth (Table 3). Phosphorus supply through spentwash was lower than the recommended which was supplemented through single superphosphate (SSP).

Results and Discussion

Significantly higher ethanol yield (Table 4) was recorded in deep tillage (769.6 l/ha) as compared to shallow tillage (570.3 l/ha). The increase in ethanol yield in deep tillage was to an extent of 34.96 per cent as compared to shallow tillage. The increase in ethanol yield in deep tillage was attributed to significant increase in extractability (14.5%), extraction per cent (15.5%), juice yield (41.6%), green biomass yield (24.1%), brix$_0$ (7.8%) and pol per cent (6.0%). Further, increase in ethanol yield attributes (Table 4) might be due to enhanced soil moisture content at all the stages of crop growth (Table 3) and nutrient availability as evidenced by higher available nutrients in soil at harvest (Table 3). Similarly, brix$_0$ and pol per cent of juice differed significantly (Table 4) with tillage practices. Deep tillage recorded significantly higher brix$_0$ (18.25$_0$) and pol per cent (12.76%) as compared to shallow tillage (16.93$_0$ and 12.03% respectively,). The increase in brix$_0$ and pol per cent was attributed to corresponding increase in total soluble solids (TSS) and conversion of deposited glucose into sucrose. Similarly, Muzzamil Hussain *et al.* (1999) and Khodphuwiang *et al.* (2008) noticed increase in sucrose content (pol per cent) and brix$_0$ of sugarcane juice with increase in the depth of tillage.

Table 1. Physical and chemical properties of secondary treated spentwash

Characteristics	Values
Colour	Dark brown
Odour	Bad
pH	8.59
EC (dS/m)	19.90
BOD (mg/L)	5400.00
COD (mg/L)	14000.00
Total N (mg/L)	1000.00
Total P_2O_5 (mg/L)	200.00
Total K_2O (mg/L)	11500.00
Total Mg (mg/L)	790.00
Total Ca (mg/L)	2160.00
Total Fe (mg/L)	75.20
Total Zn (mg/L)	10.50
Total Cu (mg/L)	4.15
Total Mn (mg/L)	9.60
Total Na (mg/L)	130.00
Total SO_4^{2-} (mg/L)	1500.00

Similarly, juice quality parameters differed significantly with nitrogen levels through spentwash. Significantly higher ethanol yield was obtained with 150 kg N per ha through spentwash (750.2 l/ha), but was on par with 100 kg N per ha through spentwash (706.7 l/ha), RDF (717.4 l/ha) and 125 kg N per ha through spentwash (743.79 l/ha). Significantly lowest ethanol yield was recorded with control (488.1 l/ha). The increase in ethanol yield with graded levels of spentwash was attributed to corresponding significant increase in extractability, extraction per cent, juice yield, green biomass yield, pol per cent and brix$_0$. Further, increase in these ethanol yield attributes with graded levels of spentwash application might be due to its rapid mineralization and supply of all essential plant nutrients apart from supplying nitrogen as evidenced by higher available N, K_2O and lower available P_2O_5 (which may be due to yield proportional uptake at phosphorus from applied constant level of 75 kg P_2O_5 per ha through spentwash and chemical fertilizer) at harvest (Table 3). Whereas, RDF supplied only recommended N, P_2O_5 and K_2O.

Further, nitrogen applied through spentwash above 100 kg N per ha (125 kg N (S_3) and 150 kg N (S_4) was not able to bring any significant difference.

Table 2. Nitrogen supplied through spentwash in sub plots

Sub plot treatments	Spentwash applied (litre/ha)	Number of splits and time of application
S_1 : 75 kg N per ha through spentwash	75,000	One time application (15 DBS)
S_2 : 100 kg N per ha through spentwash	1,00,000	Two equal splits (15 DBS and 30 DAS)
S_3 : 125 kg N per ha through spentwash	1,25,000	Three equal splits (15 DBS, 30 DAS and 60 DAS)
S_4 : 150 kg N per ha through spentwash	1,50,000	Three equal splits (15 DBS, 30 DAS and 60 DAS)

DBS: days before sowing DAS: days after sowing

Significantly higher brix$_0$ (17.99$_0$) and pol per cent (12.71%) were recorded with 150 kg N per ha through spentwash, but was on par with 100 kg N per ha through spentwash (17.91$_0$ and 12.69% respectively,), RDF (17.90$_0$ and 12.69% respectively,).

Similarly, Singandhupe *et al.* (2009) observed that judicious use of spentwash increased the juice quality of sugarcane. With respect to interaction treatment combination of deep tillage and 150 kg N per ha through spentwash recorded higher ethanol

Table 3. Soil moisture content (%) and available nutrients of soil as influenced by tillage and spentwash

Treatment	Soil moisture content (%)									Available nutrients at harvest								
	At 60 DAS			At 50 per cent flowering			At harvesting			Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
S_1	18.50	16.60	17.55	17.88	16.25	17.07	13.19	11.76	12.48	54.27	44.87	49.57	1095	1091	1093	1095	1091	1093
S_2	17.89	16.16	17.03	17.34	15.78	16.56	12.79	11.33	12.06	52.10	42.80	47.45	1138	1117	1127.5	1138	1117	1127.5
S_3	17.84	16.11	16.98	17.28	15.76	16.52	12.75	11.28	12.02	50.70	41.53	46.12	1158	1126	1142	1158	1126	1142
S_4	17.80	16.09	16.95	17.24	15.72	16.48	12.71	11.20	11.96	48.59	42.19	45.39	1176	1134	1155	1176	1134	1155
S_5	17.88	17.12	17.00	17.30	15.77	16.54	12.76	11.29	12.03	51.96	42.83	47.40	507	503	505	507	503	505
S_6	19.07	17.10	18.09	18.40	16.70	17.55	13.74	11.16	12.95	24.40	20.60	22.50	436	428	432	436	428	432
Mean	18.16	16.36	17.26	17.57	16.00	16.79	12.99	11.50	12.25	47.00	39.14	43.07	918.33	899.83	909.08	918.33	899.83	909.08

For comparing means of	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)
M	0.02	0.06	0.04	0.13	0.04	0.12	0.47	1.50	2.83	9.05	2.83	9.05
S	0.03	0.10	0.03	0.10	0.04	0.11	0.70	2.08	4.87	14.35	4.87	14.35
SXM	0.05	NS	0.05	NS	0.05	NS	1.00	NS	6.88	NS	6.88	NS
MXS	0.05	NS	0.06	NS	0.06	NS	1.02	NS	6.89	NS	6.89	NS

M_1: Deep tillage (45 cm); M2: Shallow tillage (15 cm); S_1:75 kg N/ha through spentwash; S_2 : 100 kg N/ha through spentwash; S_3 : 125 kg N/ha through spentwash; S_4:150 kg N/ha through spentwash; S_5 : RDF (100:75:37.5 kg N, P_2O_5, K_2O kg/ha) ; S_6: Control NS: Non-significant; DAS: Days after sowing

yield (854.0 l/ha), but was on par with deep tillage and 100 kg N per ha through spentwash (802.4 l/ha), deep tillage and RDF (819.0 l/ha) and deep tillage and 125 kg N per ha through spentwash (852.0 l/ha).

Treatment combination of deep tillage and 150 kg N per ha through spentwash recorded significantly higher gross returns (Rs. 37339.1/ha) and net returns (Rs. 22940.8/ha), but was on par with treatment combination of deep tillage and 125

Table 4. Juice quality parameters of sweet sorghum as influenced by tillage and spentwash

Treatment	Juice extractability (ml/kg)			Juice extraction per cent			Juice yield (l/ha)			Ethanol yield (l/ha)			Brix°			Pol per cent		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
S_1	254.30	221.20	237.75	29.97	25.90	27.93	8337.3	5938.2	7137.8	712.6	514.1	613.3	17.88	16.63	17.26	12.46	11.73	12.10
S_2	279.20	244.40	261.80	32.67	28.67	30.67	10352	7361.6	8856.8	802.4	611.1	706.7	18.58	17.23	17.91	13.05	12.32	12.69
S_3	286.10	253.13	269.62	34.73	29.25	31.99	10846.1	7732.6	9289.4	852.0	635.6	743.8	18.64	17.27	17.96	13.07	12.32	12.70
S_4	291.60	256.30	273.95	35.15	29.45	32.30	11178.7	7955.8	9567.3	854.0	646.4	750.2	18.68	17.30	17.99	13.08	12.33	12.71
S_5	282.10	247.30	264.70	33.40	28.94	31.17	10616.7	7553.4	9085.5	819.0	615.8	717.4	18.61	17.25	17.93	13.06	12.32	12.69
S_6	225.07	191.70	208.38	25.10	23.14	24.12	6533.2	4303.8	5418.8	577.0	398.8	488.1	17.13	15.93	16.53	11.84	11.14	11.49
Mean	269.73	235.67	252.70	31.84	27.56	29.70	9644.0	6807.6	8225.8	769.6	570.3	670.0	18.25	16.93	17.59	12.76	12.03	12.39

For comparing means of	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)	SEm+	CD (0.05)
M	0.02	0.06	0.04	0.13	0.04	0.12	0.47	1.50	2.83	9.05	2.83	9.05
M	4.51	14.88	0.69	2.13	288.99	953.66	11.14	35.64	0.18	0.53	0.12	0.39
S	4.56	13.46	0.64	1.90	257.86	760.69	20.55	60.62	0.10	0.31	0.14	0.41
SXM	6.45	NS	0.91	NS	364.67	NS	29.06	NS	0.15	NS	0.20	NS
MXS	7.42	NS	1.08	NS	440.84	NS	28.77	NS	0.23	NS	0.22	NS

M_1: Deep tillage (45 cm); M_2: Shallow tillage (15 cm); S_1:75 kg N/ha through spentwash; S_2 : 100 kg N/ha through spentwash; S_3 : 125 kg N/ha through spentwash; S_4:150 kg N/ha through spentwash; S_5 : RDF (100:75:37.5 kg N, P_2O_5, K_2O kg/ha) ; S_6: Control ; NS: Non-significant

kg N per ha through spentwash (Rs. 36915.8 and 22417.1/ha gross and net returns respectively,) and deep tillage and RDF (Rs. 35936.8 and 20794.5/ha gross and net returns respectively,) and deep tillage and 100 kg N per ha through spentwash (Rs. 35486.9 and 21644.9/ha gross and net returns

Table 5. Grain yield, ethanol yield, cost of cultivation, gross returns, net returns and B: C ratio of sweet sorghum as influenced by tillage and spentwash

Treatment	Grain yield (q/ha)	Ethanol yield (l/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
M_1 S_1	16.3	712.6	13009.9	30584.7	17574.8	2.35
M_1 S_2	19.4	802.4	13842.0	35486.9	21644.9	2.56
M_1 S_3	19.9	852.0	14498.7	36915.8	22417.1	2.55
M_1 S_4	20.3	854.0	14398.3	37339.1	22940.8	2.59
M_1 S_5	19. 6	819.0	15141.7	35936.2	20794.5	2.37
M_1 S_6	12.6	577.0	11229.0	24146. 5	12917.5	2.15
M_2 S_1	12.4	514.1	10460.4	22715.7	12255.3	2.17
M_2 S_2	14.9	611.1	11303.2	27088.2	15785.0	2.40
M_2 S_3	15.3	635.6	11899.9	28045.9	16146.0	2.36
M_2 S_4	15.6	646.4	11814.8	28534.6	16719.8	2.41
M_2 S_5	15.0	615.8	12571.1	27315.3	14744.2	2.17
M_2 S_6	9.2	398.8	8739.0	17209.9	8470.9	1.97
SEm±	0.73	28.77	-	837.9	792.96	0.06
CD(0.05)	NS	NS	-	2471.7	2339.24	0.17

M_1: Deep tillage (45 cm); M_2: Shallow tillage (15 cm); S_1:75 kg N/ha through spentwash; S_2 : 100 kg N/ha through spentwash; S_3 : 125 kg N/ha through spentwash; S_4:150 kg N/ha through spentwash; S_5 : RDF (100:75:37.5 kg N, P_2O_5, K_2O kg/ha) ; S_6: Control; NS: Non-significant respectively,). The increase in gross returns in these treatment combinations was attributed to corresponding increased crop yields (grain yield and ethanol yield) and lower cost of cultivation (Table 5) as compared to other treatment combinations. Similar increase in net returns in these treatment combinations was attributed to corresponding increased crop yields, gross returns and lower cost of cultivation as compared to other treatment combinations (Table 5). Significantly lowest gross and net returns were recorded with shallow tillage + control (Rs. 17209.9 and 8470.9/ha gross and net returns respectively,).

Similarly, B:C ratio followed similar trend as that of gross returns and net returns, except significantly lower B:C ratio recorded with treatment combination of deep tillage and RDF (2.37) as compared to deep tillage and 100 kg N per ha through spentwash (2.56), deep tillage and 125 kg N per ha through spentwash (2.55), deep tillage and 150 kg N per ha through spentwash (2.59), but was on par with deep tillage and 75 kg N per ha through spentwash (2.35) and significantly higher than deep tillage and control (2.15). These results are in conformity with the findings of Bhukia *et al*. (2009). The results indicated that application of 100 kg N through secondary aerated spentwash with deep tillage may be adopted for higher sweet sorghum yield and returns.

References

Bhukia, T.D., Patil, S.G. and Angadi, S.S. 2009. Crop nutrition through distillery spentwash in maize (*Zea mays* L.). *J. Environ. Sci. Engg.,* **51**: 87-92.

Khodphuwiang, J., Prammanee, P. and Weerathaworn, P., 2008, Economic consideration of different soil improvement and fertilizer recommendation for sugarcane in north-east Thailand. *Sugar-Tech.*, **9**: 166-169.

Muzzamil Hussain, Mustaq Ali, Abdul Ruzzaq and Shahid Afghun, 1999. Interacted influence of deep tillage and nitrogen management on the qualitative traits of sugarcane. *Pakistan Sugar J*., **14**: 7-13.

Reddy, B.V.S. and Reddy, P.S. 2003. Sweet sorghum: characteristics and potential. *Int. Sorgh. Mill. News.*, 44: 26-28.

Reddy, B.V.S., Ramesh, S., Reddy, P.S., Ramaiah, B., Salimath, P.M. and Kachapur, R. 2005. Sweet sorghum - A potential alternate raw material for bio-ethanol and bio-energy. *Int. Sorgh. Mill. News.*, **46**: 79-86.

Singandhupe, R.B., Das, M., Chakraborthy, H. and Aswini Kumar, 2009. Effect of different levels of distillery effluents on growth, yield and soil health in sugarcane crop in Orissa. *Indian J. Agric. Sci.,* **79**: 1030-1035.

Wyman, C.E. 1994. Ethanol from lingo-cellulosic biomass technology, economics and opportunities. *Bio resource Technol.*, **50**: 3-16.

Received: November 10, 2012; Accepted: March 14, 2013