Influence of Levels of Chemical Fertilizer and Microbial Inoculants on Yield Attributes Nutrient Uptake and Quality of Sweet Sorghum

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Field experiment was conducted at Sorghum research Station, Marathwada Agricultural University, Parbhani, during monsoon season of 2011, to study the influence of levels of chemical fertilizer and microbial inoculants on yield attributes, nutrient uptake and quality of Sweet Sorghum (*Sorghum bicolor* (L.) Moench) grown on Vertisol. Application of graded levels of chemical fertilizers upto 100% RDF along with dual inoculation of *Azospirillum* + *Gluconacetobacter* significantly increased grain, dry matter, green stalk, total biomass and milliable cane yield of sweet sorghum over the control. Juice quality attributes of sweet sorghum i.e. ^{0}brix, TSS, juice yield, juice extraction %, reducing sugar, non reducing sugar and total sugar were also improved with 100% RDF along with dual inoculation of *Azospirillum* + *Gluconacetobacter*. Almost trend was also observed in NPK uptake.

Key words : Sweet sorghum, chemical fertilizer, *Azospirillum* inoculation, *Gluconacetobacter* inoculation, yield attributes, nutrient uptake, quality.

Sweet Sorghum (*Sorghum bicolor* (L.) Moench) is an important crop for jaggery, syrup, sugar, alcohol (Most importantly gasohol, which is ethanol blended with petrol) fodder, fuel, bedding, roofing, fencing, paper and chewing. Sweet sorghum is potential, particularly under conditions of poor resources base against sugarcane because it requires less water and fertilizers than sugarcane. A number of reports have shown that sweet sorghum is a potential source of sugar and a multipurpose industrial crop. Besides having wide adaptability, rapid growth and high sugar accumulation and biomass production potential, sweet sorghum is tolerant to drought, water logging, soil salinity and acidity toxicity. So, sweet sorghum has emerged as a supplementary crop to sugarcane in dry land pockets. Sweet sorghum harvested at particular physiological maturity stage for sweet juice from stalks and grains from ear heads. Thus, keeping this in the view the study was undertaken to elaborate the effect of chemical fertilizers along with biofertilizers on yield, nutrient uptake and quality of sweet sorghum.

MATERIAL AND METHODS

A field experiments was conducted at Sorghum Research Station, Marathwada Agricultural University, Parbhani (Maharashtra) during monsoon (*kharif*) season of 2011on Vertisol (*Typic Haplustert*) using split-plot design with three replications. There were five treatments of chemical fertilizers in main plots, viz T_0-Control, T_1-25% RDF (20:15:10 kg ha^{-1} of NPK) , T_2-50% RDF (40:30:20 kg ha^{-1} of NPK) , T_3-75% RDF

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(60:45:30 kg ha^{-1} of NPK) , T_4-100% RDF (80:60:40 kg ha^{-1} of NPK) and in the subplots four levels of biofertilizers treatments were given, viz. B_0-no biofertilizer, B_1-*Azospirillum* inoculation, B_2-*Gluconacetobacter* inoculation, B_3-*Azospirillum + Gluconacetobacter* inoculation. The recommended dose of N through urea i.e. 50 per cent; and full dose of P_2O_5 through single super phosphate and K_2O through muriate of potash was applied at the time of sowing and remaining 50 per cent of N dose was applied after one month of sowing. The seeds of sweet sorghum variety 'RSSV 9' treated with biofertilizers as seed treatment @ 250 g/10 kg before sowing. The crop was harvested at physiological maturity. Grain and fodder yields were recorded. Juice yield was recorded in litre, TSS by hand refractometer, pH by pH-meter, total sugar, reducing and non-reducing sugar by using DNS method[1], juice extractability and uptakes of nutrients were calculated using respective formulae.

RESULTS AND DISCUSSION

Grain yield

It is observed from the data given in Table 1 that the application of 75 percent recommended dose of fertilizer had significantly increased the grain yield of sorghum (797 kg ha^{-1}) followed by 100 per cent RDF(795 kg ha^{-1}) and these were statistically at par with each other. Similarly, Grain yield of sweet sorghum was also influenced by microbial inoculants showing highest grain yield (753 kg ha^{-1}) in *Azospirillum + Gluconacetobacter* treated plot followed by single inoculation of *Azospirillum* (748 kg ha^{-1}). These results are in agreement with the previous findings[2]. Increase in grain yield of sweet sorghum with increasing levels of chemical fertilizers may be due to supply of needed quantity of NPK in their balance doses. However, enhanced grain yield with bio fertilizers treatment might be owing to increased supply to plant hormones by microorganism, which improved the vegetative growth and resulted in higher grain yield. This finding is in accordance with the findings of Patidar and Mali[3].

Dry matter yield

Dry matter yield of sweet sorghum as influenced by different treatments (Table2) indicated that 100 % RDF recorded highest dry matter yield (7997 kg ha^{-1}) . Similarly, bioinoculants also influenced the dry matter yield of sweet sorghum significantly indicating highest value in *Azospirillum + Gluconacetobacter* treated plot (7803 kg ha^{-1}). Interactive effect of Chemical fertilizer with biofertilizer on dry matter yield was significant and treatment T_4X B_3 recorded highest dry matter yield (8111 kg ha^{-1}). These results are in agreement with the findings of previous studies, who reported that increasing RDF increased dry matter yield[4]. The increase in total dry matter yield with biofertilizer might be due to increased N involved in increasing the protoplasmic constituents and accelerating the process of cell division and elongation. However, the increase in dry matter yield of sweet sorghum might be a result of improvement in soil fertility with application of inorganic fertilizer along with biofertilizer in an integrated manner. These results are also supported by the earlier work[5].

Green stalk yield, total fresh biomass, millable cane yield

Green stalk yield, total fresh biomass ,

Table 1. Grain and dry matter yield of sweet sorghum (kg ha^{-1}) as influenced by various levels of chemical fertilizers and microbial inoculants

Treatment	Grain Yield (kg ha^{-1})	Dry Matter Yield (kg ha^{-1})
Chemical Fertilizers (T)		
T_0-Control	665	7179
T_1-25% RDF	717	7502
T_2-50% RDF	751	7712
T_3-75% RDF	797	7888
T_4-100% RDF	795	7997
SE±	0.81	1.90
CD at 5%	2.36	5.5
Bioinoculants (B)		
B_0-Control	736	7476
B_1-*Azospirillum*	748	7689
B_2-*Gluconacetobacter*	743	7605
B_3-*Azo + Glu*	753	7803
SE ±	1.22	4.5
CD at 5%	3.54	13.20
Interactions (TXB)		
SE ±	2.74	10.20
CD at 5%	NS	29.52

Recommended dose of fertilizer (80:60:40 kg ha^{-1} as N, P_2O_5 and K_2O respectively).

Table 2. Green Stalk yield, total fresh biomass and millable cane yield of sweet sorghum ($Mg\ ha^{-1}$) as influenced by various levels of chemical fertilizers and microbial inoculants

Treatment	Green Stalk Yield ($Mg\ ha^{-1}$)	Total Fresh Biomass ($Mg\ ha^{-1}$)	Millable cane Yield ($Mg\ ha^{-1}$)
Chemical Fertilizers (T)			
T_0-Control	22.74	23.84	21.89
T_1-25% RDF	23.13	24.18	22.16
T_2-50% RDF	23.48	24.58	22.37
T_3-75% RDF	24.21	25.22	22.48
T_4-100% RDF	24.86	25.77	22.70
SE±	0.024	0.038	0.037
CD at 5%	0.076	0.107	0.105
Bioinoculants (B)			
B_0-Control	23.48	24.46	22.15
B_1-*Azospirillum*	23.72	24.69	22.39
B_2-*Gluconacetobacter*	23.64	24.75	22.29
B_3-*Azo + Glu*	23.90	24.98	22.45
SE ±	0.018	0.034	0.033
CD at 5%	0.052	0.095	0.093
Interactions (TXB)			
SE ±	0.041	0.077	0.076
CD at 5%	0.117	0.215	NS

Recommended dose of fertilizer (80:60:40 $kg\ ha^{-1}$ as N, P_2O_5 and K_2O respectively).

Table 3. Effect of various levels of chemical fertilizers and microbial inoculants on uptake of N, P, K ($kg\ ha^{-1}$) by sweet sorghum grain and stover at harvest

Treatment	Nitrogen ($kg\ ha^{-1}$)			Phosphorus ($kg\ ha^{-1}$)			Potassium ($kg\ ha^{-1}$)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Chemical Fertilizers (T)									
T_0-Control	10.29	33.76	44.06	1.60	7.17	8.74	9.40	45.13	54.53
T_1-25% RDF	11.35	37.56	48.92	1.75	8.06	9.82	10.28	49.57	59.93
T_2-50% RDF	12.08	41.39	52.64	1.87	8.65	10.53	11.06	53.41	64.46
T_3-75% RDF	13.04	44.98	58.02	2.01	9.28	11.29	12.10	56.34	68.44
T_4-100% RDF	13.88	45.12	60.00	2.03	9.91	11.94	12.35	61.20	73.55
SE±	0.240	0.664	0.340	0.004	0.011	0.019	0.012	0.047	0.049
CD at 5%	0.692	1.916	0.981	0.012	0.034	0.056	0.036	0.137	0.143
Bioinoculants (B)									
B_0-Control	11.63	37.64	49.27	1.80	8.03	9.84	10.64	49.69	60.33
B_1-*Azospirillum*	12.19	42.04	53.57	1.87	8.80	10.67	11.22	54.35	65.52
B_2-*Gluconacetobacter*	12.24	40.25	52.07	1.83	8.47	10.31	10.92	52.17	63.21
B_3-*Azo + Glu*	12.33	42.31	55.99	1.89	9.15	11.02	11.37	56.30	67.67
SE ±	0.160	0.656	0.371	0.002	0.011	0.018	0.019	0.048	0.045
CD at 5%	0.463	NS	1.070	0.008	0.032	0.053	NS	0.138	0.132
Interactions (TXB)									
SE ±	0.359	1.468	0.830	0.006	0.025	0.041	0.042	0.107	0.102
CD at 5%	NS	NS	NS	0.018	0.072	0.012	NS	0.310	0.296

Recommended dose of fertilizer (80:60:40 $kg\ ha^{-1}$ as N, P_2O_5 and K_2O respectively).

millable cane yield of sweet sorghum as influenced by different treatments (Table 2) indicated that 100 per cent RDF recorded highest green stalk yield (24.86 Mg ha^{-}1) , total fresh biomass (25.77 Mg ha^{-}1) and milliable cane yield (22.70 Mg ha^{-1}) also. The Green stalk yield, total fresh biomass , millable cane yield increased progressively in *Azospirillum + Gluconacetobacter* treated plot (23.90 Mg ha^{-1}, 24.98 Mg ha^{-1}, 22.45 Mg ha^{-1}), respectively. Interactive effect of chemical fertilizer with biofertilizer on yield parameter was significant and treatment receiving 100 % RDF X dual inoculation of *Azospirillum + Gluconacetobacter* recorded highest green stalk yield (25.10 Mg ha^{-1}) and total fresh biomass(26.09 Mg ha^{-1}). Patidar and Mali (2004) also found maximum yield parameters with increasing levels of chemical fertilizers[3]. The highest green stalk , milliable cane yield were observed due to profound influence of N and P fertilization on vegetative and reproductive growth of the crop due to increase in nutrient accumulation and their translocation towards the yield production as well as the existence of favorable nutritional environment under the influence of biofertilizer which had a positive influence on vegetative and reproductive growth, which ultimately led to realization of higher yield. These results are in good conformity with the results obtained by other researchers[6-7].

Nutrient uptake

The data on uptake of nitrogen, phosphorus, potassium at maturity is presented in table 3. Uptake of nitrogen, phosphorus and potassium by sorghum was increased significantly with the application of increasing levels of chemical fertilizer over control, thereby indicating the highest with 100 % RDF (80:60:40 kg ha^{-1} of NPK) . Highest uptake of nitrogen in grain (14.88 kg ha^{-1}) and stover (45.12 kg ha^{-1}) , Phosphours in grain (2.03 kg P ha^{-1}) and stover(9.91 kg P ha^{-1}), Potassium in grain (12.35 kg ha^{-1})and stover(61.20 kg ha^{-1}). Similarly, highest and significantly more uptake of nitrogen, phosphorus, potassium was observed with the dual inoculants i.e. *Azospirillum + Gluconacetobacter* and showed maximum N uptake in grain and stover (12.33 kg ha^{-1}, 42.31 kg ha^{-1}), P uptake in grain and stover (1.89 kg ha^{-1} 9.15 kg ha^{-1}) and K uptake in grain and stover (11.37 kg ha^{-1}, 56.30 kg ha^{-1}) respectively. It has been reported that application of 100% RDF and seed treatment with biofertilizers might have resulted in more and easy availability of nutrients and

Table 4. pH of juice, ^{0}brix, juice yield and juice extraction (%) of sweet sorghum as influenced by various level of chemical fertilizers and microbial inoculants

Treatment	pH of juice	TSS(^{0}Brix)	Juice yield(Ltr/ha)	Juice extraction (%)
Chemical Fertilizers (T)				
T_0-Control	4.39	14.84	5074	27.12
T_1-25% RDF	4.65	15.65	5358	30.61
T_2-50% RDF	5.05	16.74	5809	33.02
T_3-75% RDF	5.25	18.45	6171	34.03
T_4-100% RDF	5.57	18.45	6523	35.35
SE±	0.02	0.01	5.11	0.05
CD at 5%	0.07	0.05	14.14	NS
Bioinoculants (B)				
B_0-Control	4.87	16.52	5663	30.93
B_1-*Azospirillum*	5.06	16.64	5764	31.73
B_2-*Gluconacetobacter*	4.94	17.00	5843	32.44
B_3-*Azo + Glu*	5.06	17.15	5877	33.01
SE±	0.01	0.01	4.57	0.04
CD at 5%	0.03	0.04	12.65	0.12
Interactions (TXB)				
SE±	0.02	0.03	10.22	0.09
CD at 5%	0.07	0.11	28.29	NS

Recommended dose of fertilizer (80:60:40 kg ha^{-1} as N, P_2O_5 and K_2O respectively).

recorded higher uptake of NPK[8]. It ws noticed that inoculation with biotertilizer increased uptake of NPK which might be due to effective root system and increased concentration of nutrients in soil solution[9]. *Gluconacetobacter* inoculation also increased the uptake of nutrients[10]. This might be due to more abundance of population of ammonifying and nitrifying bacteria in the soil. This result is also in good conformity with the previous reports[11].

pH of Juice and °Brix

The pH of juice ranged from 4.39 to 5.57(Table 4). The maximum pH value and °Brix was recorded with 100 per cent RDF (5.57, 18.45), respectively as well as in concerned with bioinoculants the highest pH of juice 5.06 and the highest °Brix of juice(17.15) was recorded with dual inoculation i.e. *Azospirillum* + *Gluconacetobacter.* Interactive effect of chemical fertilizer with biofertilizer on pH of juice and °Brix was significant and treatment T_4 X B_3 and T_4 X B_1 recorded highest pH (5.63) and Significantly highest ^{0}brix of juice was recorded in combination of dual inoculation and 100% RDF (18.75).

Juice yield and Juice extraction percentage

The results reported in Table 4 indicated that , the highest juice yield(6523 Ltr/ha). and juice extraction percentage (33.35) was observed with 100% RDF. Similarly, the highest juice yield (5877 Ltr) and highest juice extraction percentage (33.01) was recorded with dual inoculation. . Interactive effect of chemical fertilizer with biofertilizers on juice yield was significant and treatment receiving 100 % RDF X dual inoculation of *Azospirillum* + *Gluconacetobacter* recorded highest juice yield (6610 Ltr)[12-13]. Increased juice yield and juice extraction percentage with increasing levels of chemical fertilizer may be due to increased fresh stalk yield. The pH of juice, ^{0}brix decreased numerically with decreased fertilizer levels. The pH increase with TSS might be a result of more salt contents at higher level of fertilizers. Similar impact of chemical fertilizer and microbial inoculants on quality parameter of juice was also reported[7]. The results are in conformity with the results reported by above workers.

Table 5. Reducing sugar, non-reducing sugar and total sugar of sweet sorghum juice (%) as influenced by various levels of chemical fertilizers and microbial inoculants

Treatment	Reducing sugar (%)	Non Reducing sugar (%)	Total sugar (%)
Chemical Fertilizers (T)			
T_0-Control	1.62	13.44	15.02
T_1-25% RDF	2.04	14.27	16.33
T_2-50% RDF	2.37	14.80	17.17
T_3-75% RDF	2.60	15.31	17.92
T_4-100% RDF	2.95	15.73	18.68
SE±	0.02	0.124	0.127
CD at 5%	0.07	0.345	0.351
Bioinoculants (B)			
B_0-Control	2.18	14.43	16.64
B_1-*Azospirillum*	2.27	14.62	16.85
B_2-*Gluconacetobacter*	2.39	14.83	17.22
B_3-*Azo + Glu*	2.42	14.96	17.39
SE ±	0.01	0.11	0.11
CD at 5%	0.03	0.308	0.314
Interactions (TXB)			
SE ±	0.02	0.24	0.25
CD at 5%	0.07	NS	NS

Recommended dose of fertilizer (80:60:40 kg ha^{-1} as N, P_2O_5 and K_2O respectively).

Reducing sugar, non reducing sugar and total sugar

The higher percentage of reducing sugar (2.95%), non reducing sugar (15.73%) and total sugar (18.68%) in green cane juice was observed with 100% RDF (Table5), Similarly, microbial inoculants also influenced sugar percentage significantly. The highest reducing sugar (2.42%), non-reducing sugar (14.96%) and total sugar (17.39%) was recorded with dual inoculation. The Interaction effect with respect to reducing sugar was found significant, whereas in respect of non-reducing and total sugar it was found non significant. Significantly higher reducing sugar (3.11%) of sweet sorghum was recorded in combination of 100% RDF X dual inoculation. Highest reducing sugar was observed with higher doses of NPK, it increased significantly with increase in nutrient levels. Similar results was also reported in previous studies [7, 12-13], and found ^{0}brix was positively correlated with content of sucrose and reducing sugar .Total sugar and non reducing sugar also increase with increasing RDF[14].

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