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Effect of farmyard manure, fertility levels and bio-fertilizers on growth, yield and quality of sorghum (*Sorghum bicolor*)

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ABSTRACT

A field experiment was conducted during the rainy seasons (*kharif*) of 1997 and 1998 to assess the effect of farmyard manure (FYM), fertility levels and bio-fertilizers and their combined effect on the productivity and quality of sorghum [*Sorghum bicolor* (L.) Moench]. Two levels of farmyard manure (0, and 10 tonnes FYM/ha), 4 fertility levels [control, 50% recommended dose of fertilizer (RDF), 75% RDF and 100% RDF] and 4 biofertilizers [control, *Azospirillum*, phosphate-solubilizing bacteria (PSB) and co-inoculation of *Azospirillum* and PSB] were compared. Application of 10 tonnes FYM/ha significantly increased leaf-area index (LAI), chlorophyll content at flowering, plant height, dry-matter accumulation, grain yield and protein content in grain over the control. Application of fertilizer at 50%, 75% and 100% RDF enhanced flowering as well as improved various growth parameters, viz. plant height, dry-matter accumulation (DMA), LAI and chlorophyll content in leaves over the control. Grain yield was significantly improved up to 75% RDF, showing an increase of 32.35 and 11.96% over the control and 50% RDF respectively. Inoculation of *Azospirilllum* alone and in combination with PSB increased grain yield to the extent of 5 to 7% only. Grain yield obtained with 50% RDF in conjunction with 10 tonnes FYM/ha was at par with that of 100% RDF. Biofertilizers, i.e. *Azospirillum* + PSB with 10 tonnes FYM/ha significantly increased grain yield of sorghum over their individual effect.

Key words : FYM, Fertility, *Azospirillum*, PSB, Sorghum

Sorghum is an exhaustive crop and responds well up to 120 kg N/ha and 60 kg P_2O_5/ha. Nutrient requirement further increases with the use of high-yielding hybrids. Sorghum yielding 44.74 q/ha grain, removed as much as 130 kg N, 33 kg P and 81 kg K/ha (Jadav, 1990). However, in the present energy crises and increased cost of fertilizers, the current emphasis is on the integrated use of different sources of plant nutrients such as organic manure and biofertilizers in combination with chemical fertilizers. Organic manure and biofertilizers being less expensive, easily available and eco-friendly, expected to improve soil fertility crop yield and quality. Therefore, the present investigation was conducted to find out the effectiveness of organic manure and biofertilizers, i.e. *Azospirillum* and phosphate-solubilizing bacteria (PSB), in combination with chemical fertilizers on growth yield and quality of sorghum under prevailing agro-climatic condition of south Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted during the rainy seasons of 1997 and 1998 at Rajasthan College of Agriculture, Udaipur. The soil of experimental plot was clay loam in texture, medium in organic carbon (0.67 and 0.69%), available nitrogen (285 and 291 kg/ha) and phosphorus (19.3 and 19.6 kg/ha) and high in potassium (382 and 391 kg/ha), with pH 7.9 and 7.8 in 1997 and 1998 respectively. The treatments consisted of 2 levels of farmyard manure (0 and 10 tonnes/ha), 4 fertility levels (control, 50% RDF, 75% RDF and 100% RDF) and biofertilizers [control, *Azospirillum* inoculation, phosphate-solubilizing bacteria (PSB), *Azospirillum* + PSB co-inoculation]. The recommended dose of fertilizer (RDF) for the region is 80 kg N and 40 kg P_2O_5/ha for sorghum crop. *Azospirillum brasilense* and phosphate-solubilizing bacteria (PSB), i.e. *Bacillus megatherium* var *phosphaticum,* were used as biofertilizer for fixing atmospheric nitrogen and increasing phosphorus availability respectively. These treatments were evaluated in split-plot design with 3 replications. Sorghum variety 'CSH 9' was sown on 14 July 1997 and 6 July 1998 in furrows at 45 cm row spacing using a seed rate of 12 kg/ha. The crop was harvested after 105–110 days. Total amount of rainfall during the crop-growth period was 484 and 565 mm in rainy seasons of 1997 and

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1998 respectively.

RESULTS AND DISCUSSION

Farmyard manure

Plants under the influence of 10 tonnes/ha farmyard manure (FYM) significantly attained higher leaf-area index (LAI), chlorophyll content and plant height than no FYM application, showing an increase of 15.31, 6.09 and 4.47% respectively (Table 1). Incorporation of FYM results in improvement of soil physical properties (water-holding capacity, porosity and bulk density) and also increased organic carbon, available P and K status of soil. Kumar (1993) also observed improvement in LAI and plant height with FYM application.

The FYM 10 tonnes/ha increased dry matter/plant by 6.21% over no FYM treatment (Table 1). The significant improvement in LAI along with chlorophyll content in the leaves seems to have resulted higher photosynthetic activity, resulting higher accumulation of photosynthates and dry matter. The LAI had positive correlation with dry matter/plant (r=0.849) and plant height with dry matter/plant (r=0.935).

Application of FYM at 10 tonnes/ha also registered yield advantage of 5.1 q/ha compared to no FYM (Table 1). Significant improvement in grain yield owing to FYM application could be ascribed to its favourable effect on plant growth and yield attributes. Devarajan *et al.* (1987) concluded that application of 10 tonnes FYM/ha increased grain yield of sorghum by 24%. Application of FYM also significantly increased protein content in grain during both the years. The mean protein content in grain was 10.90% with 10 tonnes FYM/ha compared with 10.41% under no FYM treatment.

Available N and P in soil after sorghum harvest with 10 tonnes FYM application was higher by 9 and 16% respectively, over no FYM application (Table 1). The increase in N status was solely attributed to the decomposition of N bearing organic compounds in applied FYM, while the enhanced P availability was the combined effect of released organic acids and organic anions on decomposition of FYM. Vaidya and Gabhane (1998) also reported increased N and P status of soil after harvest of sorghum due to FYM application.

Fertility levels

The leaf-area index (LAI) at flowering stage of sorghum was significantly improved with successive increase in fertility levels up to 100% RDF (Table 1) which may be attributed to explanded leaf area as result of increased cell-devision and enlargement by N and P nutrition. Application of 100% RDF significantly increased chlorophyll content in leaves over lower levels. Fertility levels, i.e. 50% RDF and 75% RDF, also proved effective over the control. The improvement in nitrogen status of plant with increasing fertility levels resulted in greater synthesis of chlorophyll in the leaves. Further, phosphorus fertilization also improves the various metabolic and physiological processes in the plant system. Fertility levels caused significant effect on days to 50% flowering, wherein plants under the influence of 50%, 75% and 100% RDF attained early flowering compared to the control. The mean of 2 years indicates that 100% RDF, 75% RDF and 50% RDF reduced the duration to 50% flowering by 5, 4 and 3 days compared with the control. Higher concentration and uptake of nutrients by plants under fertilizer application resulted in greater synthesis of protein and earlier flower primordia development which ultimately resulted in earlier flowering. Plant height and dry-matter accumulation/plant showed a significant improvement up to 50% RDF, accounting to increase of 5.5 and 8.5%, respectively, over the control. The improvement in morphological as well as photosynthetic parameters (LAI and chlorophyll content) due to fertilizer application might have resulted in better interception and utilization of radiant energy leading towards higher photosynthesis and finally more accumulation of dry matter of individual plant.

Fertility level, i.e. 75% RDF significantly stepped up grain yield by 32.4 and 12% over the control and 50% RDF respectively. Application of 50% RDF also proved superior to no fertilizer. Significant improvement in production of crop up to application of 75% could be ascribed 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 formation. Sharma *et al.* (1999) indicated that the response fertilizer ratio was maximum (7.29) at recommended level under irrigated conditions, while the same ratio was obtained at 50% of recommended level of fertilizer under rainfed conditions. Significant increase in protein content of grain was recorded up to 100% RDF. The improvement in protein content in grain was owing to increase in N content of grain with FYM and fertilizer application.

Maximum available P was recorded with 100% RDF, which was significantly higher over lower levels during both the years. The difference between graded fertility in this respect was found significant. The improvement in status of P in soil at sorghum harvest might be owing to build up of phosphorus in soil as result of addition of P. Besides, on addition of fertilizer P to the soils there might be some sort of triggering action on native soil P resulting in increased its availability.

Table 1. Effect of farmyard manure, fertility levels and biofertilizers on morpho-physiological parameters, grain yield and protein content of sorghum and nutrient status in soil after harvest (mean data of 2 years)

Treatment	Leaf-area index	Chlorophyll content (mg/g) of leaf	Days to 50% bloom	Plant height (cm)	Dry matter (g/plant)	Grain yield (q/ha)	Protein content (%)	Available nutrient in soil after harvest (kg/ha)	
								N	P
FYM (tonnes/ha)									
0	3.9	2.0	59.2	191.7	121.5	40.6	10.4	237.6	20.0
10	4.5	2.1	58.6	200.6	129.0	45.7	11.0	258.7	23.2
CD (P=0.05)	0.2	0.07	0.9	4.3	3.1	1.3	0.22	8.3	0.7
Fertility level									
Control	3.6	1.9	61.6	185.2	115.0	35.4	9.9	235.3	17.8
50% RDF	4.1	2.0	59.1	195.2	124.7	41.9	10.6	245.8	21.3
75% RDF	4.4	2.1	58.0	200.9	128.8	46.9	10.9	252.3	22.5
100% RDF	4.8	2.2	56.9	203.9	132.4	48.3	11.2	258.0	24.9
CD (P=0.05)	0.3	0.1	1.2	6.1	4.3	1.9	0.3	NS	0.9
Biofertilizer									
Control	4.0	2.0	59.0	192.9	121.8	41.6	10.5	243.7	20.8
Azospirillum	4.2	2.1	58.8	197.9	127.0	44.1	10.8	251.4	20.8
PSB	4.1	2.0	59.1	195.3	124.5	42.2	10.6	245.6	22.2
Azospirillum+PSB	4.4	2.1	58.9	198.5	127.6	44.5	10.8	251.3	22.6
CD (P=0.05)	0.2	NS	NS	3.4	3.0	1.5	NS	NS	0.8

RDF, Recommended dose of fertilizers for the zone is 80 kg N/ha and 40 kg P_2O_5/ha

Biofertilizers

Co-inoculation of *Azospirillum* and PSB significantly increased LAI over the control during both the years. Single inoculation of *Azospirillum* increased the LAI over the control. However, biofertilizers did not show significant effect on chlorophyll content in leaves. *Azospirillum* inoculation alone and in combination with PSB significantly increased plant height. The effectiveness of *Azospirillum* to increase LAI is ascribed to non-symbiotic nitrogen fixation and production of growth hormones. *Azospirillum* inoculation resulted in significantly higher dry matter plant over the control and it was found at par with dual inoculation. The beneficial effect of *Azospirillum* on dry-matter production was also reported by Kumar (1993). *Azospirillum* alone and in combination with PSB significantly increased grain yield by 6.1 and 6.9, respectively, over the control. The existence of favourable nutritional environment under the influence of biofertilizers had a positive influence on vegetative and reproductive growth, which ultimately led to realization of higher yield. Further dual inoculation of *Azospirillum* and PSB showed beneficial effect on plant growth and productivity, indicating a positive interaction between 2 groups of organisms (Alagawadi and Gaur, 1988). The PSB alone and in combination with *Azospirillum* significantly enhanced available P status of soil by 6.82 and 8.62%, respectively, over the control (Table 1). Higher available phosphorus in PSB-inoculation plots was due to more solubilization of native as well as applied phosphorus.

Fertility levels × farmyard manure

Grain yield of sorghum was significantly increased with application of 100% RDF at 0 level of FYM and 75% RDF and 10 tonnes FYM (Table 2). The highest grain yield of 49.8 q/ha was recorded with combined effect of 100% RDF and 10 tonnes/ha FYM application which was significantly higher over rest of treatments but at par with the combined effect of 10 tonnes/ha and 75% RDF. The significant interactive effect as a consequence of FYM and

Table 2. Interaction effects farmyard manure and fertility levels on grain yield (q/ha) (mean data of 2 years)

Treatment	FYM (tonnes/ha)		
	0	10	Mean
Fertility levels			
Control	30.7	40.1	35.4
50% RDF	40.2	43.7	41.9
75% RDF	44.7	49.0	46.9
100% RDF	46.8	49.8	48.3
Mean	40.6	45.7	
CD (P=0.05)			
FYM	1.3		
Fertility levels	1.9		
Interaction	2.7		

Table 3. Interaction effect of farmyard manure and biofertilizers on grain yield (q/ha) (mean data of 2 years)

Treatment	FYM (tonnes/ha)		
	0	10	Mean
Biofertilizer			
Control	40.4	42.8	41.6
Azospirillum	40.8	47.5	44.1
PSB	40.5	44.0	42.2
Azospirillum+PSB	40.7	48.3	44.5
Mean	40.6	45.7	
CD (P=0.05)			
FYM		1.3	
Biofertilizer		1.5	
Interaction		2.1	

fertilizer application is attributed to the favourable nutritional status of soil, resulting in increased biomass production of the crop. The favourable effect of FYM on microbial activity and root proliferation in soil caused solubilizing effect on native phosphorus and other nutrient

FYM x biofertilizers

Grain yield of sorghum was influenced by combined effect of biofertilizers and 10 tonnes FYM/ha (Table 3). The maximum grain (48.3 q/ha) was recorded with combined effect of 10 tonnes FYM/ha and *Azospirillum* + PSB coinoculation, followed by *Azospirillum* inoculation under the influence of 10 tonnes FYM/ha (47.5 q/ha grain yield). The yield obtained under aforesaid treatment combination was significantly higher over the individual effect of FYM and biofertilizers. This clearly shows the beneficial effect of biofertilizers was increased with FYM application, as it supplies carbon for the growth and activity of micro-organisms in soil. Addition of FYM considerably enhanced nitrogenase activity associated with sorghum and millet roots (Wani *et al.*, 1984).

Application of 10 tonnes FYM/ha and dual inoculation of *Azospirillum* and PSB along with 75 % RDF maximized sorghum yield and economized fertilizer use to the extent of 25% of recommended level.

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