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Residual effect of farmyard manure, fertilizer and biofertilizer on succeeding wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted during the rainy and winter seasons in 1997–98 and 1998–99, to evaluate the residual effect of integrated nutrient management in sorghum [*Sorghum bicolor* (L.) Moench] on succeeding wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crop. Two farmyard manure (FYM) levels (0 and 10 tonnes FYM/ha), 4 fertility levels (control, 50%, 75% and 100% recommended dose of fertilizer) and 4 biofertilizer treatments (control, *Azospirillum*, phosphate-solubilizing bacteria (PSB) and co-inoculation of *Azospirillum* and PSB) were compared. Application of 10 tonnes/ha FYM and nitrogen and phosphorus fertilizer up to 75% of recommended level significantly enhanced grain and fodder yields of sorghum. *Azospirillum* alone and in combination with phosphate-solubilizing bacteria increased sorghum yield by 6–7%. Both available P and N status in soil after sorghum harvest were improved with FYM application, while fertility levels and PSB inoculation increased only P status of soil after sorghum harvest over the control. Residual effect of FYM, 75% and 100% recommended level of fertilizer (N and P) significantly enhanced growth, yield attributes, yield and nutrient uptake of wheat by 9–12% but biofertilizers did not show any residual effect on wheat. Available P status in soil after wheat harvest was also significantly influenced by residual effect of FYM and fertility levels.

Key words : Residual effect, FYM, fertility levels, Biofertilizers, Sorghum, Wheat

In recent years the emphasis has been shifted from individual crop to cropping system as a whole since the responses in component crop of the cropping system are influenced by the preceding crops and the inputs applied to them. Organic manure and phosphatic fertilizers have carry-over effect on succeeding crops. About less than 30% of nitrogen and small fraction of phosphorus and potash in organic manure may become available to immediate crop and rest to subsequent crops (Gaur, 1982). The

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utilization efficiency of applied phosphatic fertilizer seldom exceeds 15% by the first crop but substantial amounts are left as residue for next crop (Roy *et al.* 1978). Sorghum–wheat is one of the important cropping systems in the region and maintenance of optimum soil fertility is an important consideration for obtaining higher and sustainable yield due to large turn-over of nutrients in soil–plant system. Since the information on residual effect of integrated nutrient supply system on wheat grown after sorghum is lacking for agro-climatic region of south Rajasthan, the present study was conducted to assess the effectiveness of residual effect of farmyard manure, fertilizer and biofertilizers on soil fertility, crop growth and yield of wheat.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season 1997–98 at Rajasthan College of Agriculture, Udaipur. The zone has typical sub-tropical, sub-humid climatic with mild winter, moderate summer and high relative humidity during July–September. The soil was clay loam 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 levels of each fertilizers (control, 50%, 75% and 100% recommended dose of fertilizer (RDF), i.e. 80 kg N and 40 kg P_2O_5/ha) and biofertilizers [Control, *Azospirillum* inoculation, phosphate-solubilizing bacteria (PSB) *Azospirillum* + PSB coinoculation]. *Azospirillum brasilense* and PSB (*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. The sorghum variety 'CSH 9' was grown during the rainy season. After sorghum harvest, wheat var. 'Raj 3077' was raised on residual fertility. An uniform dose of 60 kg/ha was applied. Row spacing was kept at 22.5 cm and seed rate of 100 kg/ha was uniformly used. The crop was sown in the second fortnight of November and harvested after 130–135 days. Available N and P content in soil at 20 cm depth from each plot after sorghum and wheat harvest were estimated. Observations on growth and yield parameters of wheat were recorded.

RESULT AND DISCUSSION

Grain and fodder yield of sorghum

Application of 10 tonnes/ha FYM significantly increased grain and fodder yield by 12.5 and 9.4% respectively. The favourable effect of FYM on chemical, physical and biological properties of soil might have resulted in higher yield. Application of fertility levels up to 75% RDF significantly increased the grain and fodder yields of sorghum (Table 1). There was no further improvement in grain and fodder yields of sorghum with 100% RDF. The significant increase in grain of fodder yield with increasing of fertility levels could be attributed to conducive effect of fertilizer (N and P) on plant growth. The results confirm the findings of Niranjan and Arya

(1992). Among biofertilizers dual inoculated crop gave significantly higher grain and fodder yield compared with the control and single inoculation of PSB. However, this treatment was at a with *Azospirillum* inoculation alone. The existence of favourable nutritional environment under the influence of biofertilizers had a positive influence on crop growth and yield. These findings corroborate the results of Pradhan and Mohan (1998).

Soil fertility after sorghum harvest

An application of FYM had significant effect on available N and P status of soil. Available N and P in soil after sorghum harvest with 10 tonnes/ha FYM application was higher by 9 and 16% respectively, over no FYM application (Table 1). The increase in N and P status in soil was owing to release of N and P on decomposition of FYM. These results confirm the findings of Vaidya and Gabhane (1998).

The available N status of soil after sorghum harvest was not significantly affected by fertility levels and biofertilizers (Table 1). However, significant variation in available P status of soil after sorghum harvest was recorded under fertility levels. Maximum available P was recorded with 100% RDF, being significant higher over lower levels. The difference between

Table 1. Effect of farmyard manure, fertility levels and biofertilizers on sorghum yield and soil fertility after sorghum harvest (mean data of 2 years)

Treatment	Yield (q/ha)		Available nutrient status in soil after sorghum harvest (kg/ha)	
	Grain	Fodder	N	P
FYM (tonnes/ha)				
0	40.6	93.8	237.6	20.0
10	45.7	102.6	258.7	23.2
CD (P=0.05)	1.33	3.26	8.29	0.65
Fertility levels				
Control	35.4	82.9	235.3	17.8
50% RDF	41.9	95.9	245.8	21.3
70% RDF	46.9	105.8	252.3	22.5
100% RDF	48.3	108.2	258.0	24.9
CD (P=0.05)	1.88	4.62	NS	0.92
Biofertilizers				
Control	41.6	94.4	243.7	20.8
Azospirillum	44.1	100.4	251.4	20.8
PSB	42.2	96.6	245.6	22.2
Azospirillum + PSB	44.5	101.4	251.3	22.6
CD (P=0.05)	1.48	3.19	NS	0.8

PSB, Phosphate-solubilizing bacteria

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

graded fertility in this respect was found significant. Thus compared with the control, application of 50%, 75% and 100% RDF improved mean available P status of soil by 20.0, 26.4 and 39.5% respectively. The significant improvement in status of P in soil at sorghum harvest might be due to build up of phosphorus in soil as a result of addition of P.

Biofertilizers treatments significantly affected available P in soil after sorghum harvest. The PSB alone and in combination with *Azospirillum* significantly enhanced available P status of soil by 6.8 and 8.6%, respectively, over the control. However, inoculation of *Azospirillum* alone did not bring significant variations in available P status of soil at sorghum harvest. The increase in P availability with PSB inoculation alone or in combination with *Azospirillum* might be attributed to increase solubility of phosphate due to PSB inoculation. Gaur and Gained (1992) reported higher available phosphorus in PSB-inoculated plots due to more solubilization of native as well as applied phosphorus.

Yield attributes of wheat

Plant height of wheat at harvest significantly increased owing to the FYM application in preceding season. Residual effect of FYM significantly increased the grains/ear by 6%. However, test weight of wheat was unaffected. The increase in plant height and grains/ear of wheat was owing to increased in nutrient availability through FYM (Table 2), as it releases major and minor nutrients slowly during entire growing season.

Fertilizer application in preceding crop had significant carry-over effect on grains/ear of succeeding wheat, but its effect on plant height and test weight was not perceptible. Application of 75% and 100% RDF in sorghum significantly increased grains/ear of wheat over the control though they were at par with each other. However, application of 50% RDF did not show residual effect. The results of soil analysis after harvest of sorghum crop revealed significant increase in available P content in the soils with the increasing fertility levels (Table 2). The build up in available phosphorus status attributed to the residual effect of applied fertilizers.

Grain and straw yield of wheat

The FYM applied at 10 tonnes/ha to sorghum significantly enhanced grain and straw yields of wheat to the extent of 8.81 and 6.62%, respectively, over no FYM application (Table 2). Higher yield of wheat was owing to better plant growth and higher yield attributes as a result of improvement in soil physical and chemical properties with FYM application. Residual effect of fertility levels showed significant variation in grain and straw yields of wheat. Application of 75% and 100% RDF to sorghum significantly increased grain and straw yields of wheat over the control. However, 50% RDF had no clear edge over the control in this respect. Based on mean data the increase was 10.7 and 16.2% in grain yield and 8.2 and 12.3% in straw yield owing to residual effect of 75% RDF and 100% RDF, respectively, over the control. Superiority of 75% and 100% RDF appears to have resulted on account of improved crop growth and better

Table 2. Residual effect of farmyard manure, fertility levels and biofertilizers on yield attributes, yield and nutrient uptake of wheat, and soil fertility after wheat harvest (mean data of 2 years)

Treatment	Plant height (cm)	Grains/ ear	1,000-grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Nutrient uptake (kg/ha)		Available nutrient status in soil after wheat harvest (kg/ha)	
						N	P	N	P
FYM (tonnes/ha)									
0	68.4	36.4	40.4	36.8	56.9	91.5	21.9	219.9	19.2
10	70.9	38.4	40.9	40.1	60.7	101.3	24.4	220.2	20.3
CD (P=0.05)	1.49	1.09	NS	1.14	1.54	2.92	0.73	NS	0.65
Fertility levels									
Control	68.2	35.4	39.7	35.8	55.4	87.8	21.4	217.6	17.7
50% RDF	68.9	36.6	40.7	37.8	57.5	92.1	21.9	219.2	18.6
75% RDF	70.6	38.5	40.9	39.7	29.9	100.0	23.7	222.4	20.3
100% RDF	70.9	39.1	41.1	41.5	62.6	105.8	25.8	225.0	22.3
CD (P=0.05)	NS	1.54	NS	1.62	2.18	4.12	1.03	NS	0.93
Biofertilizers									
Control	69.2	37.2	40.6	38.1	58.7	95.6	23.0	221.4	19.6
Asospirillum	69.8	37.3	40.5	38.2	59.0	95.9	23.0	220.5	19.5
PSB	69.5	37.4	40.7	38.6	59.1	96.5	23.1	221.2	19.8
Asospirillum + PSB	70.2	37.7	40.8	38.9	58.6	97.5	23.5	221.1	19.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

PSB, Phosphate-solubilizing bacteria

expression of yield components and finally higher yields owing to improved phosphorus nutrition. These results corroborate the findings of Goswami *et al.* (1990). Biofertilizers did not show perceptible variation in grain and straw yields of wheat.

Nutrient uptake by wheat

The uptake of N and P by wheat increased significantly due to residual effect of 10 tonnes/ha by 10.8 and 11.02%, respectively, over no FYM application (Table 2). This may be attributed to increase their availability in soil and increased biomass production as result of residual effect of FYM.

Sorghum fertilized at 75% RDF and above had carry-over effect of N and P accumulation by wheat, but application of fertilizer at 50% RDF to sorghum was not superior to that of the control. Residual effect of 75% and 100% RDF increased N accumulation in wheat by 14.0 and 20.5% and P accumulation by 10.8 and 20.7% over the control. The increase in available P in soil resulted marked increase in the concentration of nutrient and their uptake by wheat. The improvement in concentration of P in the plants with residual effect of fertility levels seems to be an account of its pivotal role in formation of roots, their proliferation and improvement in their functional activities. This might have induced higher extraction of nutrients from soil environment.

Soil fertility after wheat harvest

Application of FYM, fertilizers and biofertilizers in the rainy season did not influence available nitrogen status in soil after wheat harvest (Table 2). However, available P content in soil after wheat harvest was significantly influenced by FYM and fertility levels. It was found that the mean available P in soil after wheat harvest was 20.3 kg/ha with FYM treatments compared with 19.2 kg/ha without FYM. This increase in available P may be due to effect of organic matter through FYM application. Further application of 75% and 100% RDF to sorghum resulted in higher available P in soil after harvest of wheat. The increase in available P with 75% and 100% RDF may be due to residual effect of applied fertilizer. Sahrawat *et al.* (1995) opined that P applied in previous year was 58% as effective as fresh P and P applied 2 years earlier was 18% as effective as fresh P on Vertisols. Biofertilizers did not alter P status in soil after wheat harvest.

It was concluded that application of 10 tonnes FYM/ha and 75% or 100% recommended dose of fertilizer (N and P) to sorghum during rainy season had significant residual effect on succeeding wheat crop and increased grain yield of wheat 9–16%. However, the effect of biofertilizers was limited to the immediate crop only.

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