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Nutrient balance of sorghum (*Sorghum bicolor*) - wheat (*Triticum aestivum*) cropping sequence under integrated nutrient management system

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Abstract: A field experiment was conducted during 1997-98 and 1998-99 at Rajasthan College of Agriculture, Udaipur to evaluate the impact of integrated nutrient management on soil fertility under sorghum + wheat sequence. The treatments consisted of two levels of farm yard manure (FYM) (0 and 10 t ha^{-1}) four levels of each of fertilizers (control, 50% RDF, 75% RDF and 100% RDF i.e. 80 kg N and 40 kg P_2O_5) and biofertilizers (control, *Azospirillum* inoculation, phosphate solubilizing bacteria (PSB). *Azospirillum* + PSB coinoculation). Results showed that the application of 10 t FYM ha^{-1} increased available N and P in soil after sorghum harvest by 4 and 16% over no FYM application while application of fertilizer and biofertilizers increased only available P status of soil after sorghum harvest. Available P content in soil after wheat harvest was significantly influenced by FYM and fertility levels. Balance sheet showed in deficit balance for available N and positive balance for available P in soil at the end of sorghum and wheat crop. The magnitude of decrease was less with FYM application and higher with no fertilizer application. However the magnitude of positive balance of P increased with FYM application and increased levels of fertility.

Key Words: Sorghum + Wheat sequence, Available N and P, FYM, Biofertilizers.

Introduction

The utilization of added nitrogen and phosphorus varies with the cropping sequence. Nitrogen use efficiency for different crops ranges from 30 to 60 per cent and utilization efficiency of applied phosphorus seldom exceeds 15 per cent (Roy *et al.* 1978). Similarly, small fraction of nutrients in organic manures may become available to the immediate crop and rest to subsequent crops (Gaur, 1982). In multiple cropping system, it is of considerable importance to assess the utilization of residual N and P by the succeeding crop. Sorghum-wheat is one of the important cropping sequences in India and the maintenance of optimum soil fertility is an important consideration for obtaining higher and sustainable yield due to a large turn over of nutrients in soil-plant system. The long term sustainability of productivity in intensive cropping system could be achieved only through integrated nutrient supply system (Hegde, 1996). The effect of integrated nutrient management, if investigated systematically may be of help to regularise the demand of nutrients for the crops. Therefore, knowledge of balance of soil nutrients for evaluating the impact of integrated nutrient management on sustained crop production is necessary.

Materials and Methods

A field experiment was conducted in *kharif* and *rabi* season during 1997 and 1998 respectively at Rajasthan College of Agriculture, Udaipur situated at 24.30°N latitude and 74.42°E longitude at an altitudes of 579.5 meter above mean sea level. The zone was typical subtropical, sub-humid climate with mild winter, moderate summer and high relative humidity during July-September. Total amount of rainfall received during the crop growth period was 484 and 565 mm in *kharif* 1997-98 and 1998-99, respectively. 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^{-1}) and high in potassium (382 and 391 kg ha^{-1}) with pH 7.9 and 7.8 in the year 1997 and 1998 respectively. Treatments consisted of two levels of farm yard manure (0 and 10 t ha^{-1}) four levels of each of fertilizers (control, 50% RDF, 75% RDF and 100% RDF

Table 1. Balance sheet of available N and P (kg ha⁻¹) as influenced by different treatment after *kharif* sorghum (mean of 2 year)

Treatment	Initial nutrients status A		Nutrient added B		Nutrient uptake balance C		Expected nutrient balance D=(A+B)-C		Actual nutrient E		Apparent gain/loss status E-D		Diff. between initial and final E-A	
	N	P	N	P	N	P	N	P	N	P	N	P	N	P
FYM (t ha^{-1})														
0	288	19.45	45.0	9.83	121.05	38.24	211.95	-8.96	237.25	20.0	25.3	29	-50.75	0.55
10	288	19.45	96.0	19.87	141.56	43.62	242.44	-4.30	258.55	23.2	16.11	27.5	-29.45	3.75
Fertility levels														
Control	288	19.45	25.5	5.02	98.44	32.38	214.96	-7.91	235.34	17.8	20.38	25.71	-52.67	-16.5
50% RDF	288	19.45	65.5	13.72	126.12	39.38	227.37	-6.81	245.75	21.3	18.37	28.11	-42.25	1.85
75% RDF	288	19.45	85.5	18.12	147.02	44.60	226.49	-7.3	252.25	22.5	25.765	29.53	-35.75	3.05
100% RDF	288	19.45	105.5	22.52	156.6	47.06	236.9	-5.06	258.04	24.9	21.14	29.96	-29.96	5.45
Biofertilizers														
Control	288	19.45	75.5	14.72	125.34	39.25	233.16	-4.98	243.89	20.8	10.73	25.78	-44.11	1.35
Azospirillum	288	19.45	75.5	14.82	137.16	41.82	221.34	-7.55	251.42	20.8	30.075	28.35	-36.59	1.35
PSB	288	19.45	75.5	14.82	127.71	44.43	230.80	-6.16	245.55	22.2	14.75	28.36	-42.46	2.75
Azospirillum + PSB	288	19.45	75.5	14.82	138.00	42.18	220.50	-7.91	251.25	22.6	30.75	30.51	-36.75	3.15

Recommended dose of fertilizers (RDF) of zone in 80 kg N/ha and 40 kg P_2O_5 ha^{-1}
Available N and P content in FYM : 0.51% & 0.23%

i.e. 80 kg N and 40 kg P_2O_5) and biofertilizers (control, *Azospirillum* inoculation, phosphate solubilizing bacteria (PSB) and *Azospirillum* + PSB coinoculation). The recommended dose of fertilizer (RDF) for the region is 80 kg N and 40 kg P_2O_5 /ha^{-1} 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. Seed inoculation was done with biofertilizer at the rate of 30 g. per kg seed. These treatments were evaluated in split plot design with three replications. The sorghum variety CSH-9 was sown on 14.07.97 and 06.07.98 at 45 cm in row spacing in furrows using a seed rate of 12 kg ha^{-1}. The crop was harvested on 28.10.97 and 26.10.98. Wheat crop was raised using var. Raj. 3077 on residual fertility and a uniform dose of 50% of recommended N level was applied. Row spacing was kept at 22.5 cm and seed rate of 100 kg ha^{-1} was uniformly used. The crop was sown on 24.11.97 and 12.11.97 and harvested on 06.04.98 and 31.03.99. Soil samples to a depth of 20 cm were drawn at the end of each crop and were analysed for available N and P content. Grain and straw yields were recorded. Nitrogen and phosphorus content in grain and straw were determined and balance for soil N and P was worked out for each treatments.

Table 2. Balance sheet of available N and P (kg ha^{-1}) as influenced by different treatment in sorghum – wheat cropping after wheat harvest (mean of 2 year)

Treatment	Initial nutrients status A		Nutrient added B		Nutrient uptake balance C		Expected nutrient balance D=(A+B)-C		Actual nutrient E		Apparent gain/loss status E-D		Diff. between initial and final E-A	
	N	P	N	P	N	P	N	P	N	P	N	P	N	P
FYM (t ha^{-1})														
0	288	19.45	105	9.83	214.14	60.21	178.86	-30.90	219.86	19.2	41.00	50.1	-68.14	-0.26
10	288	19.45	156	19.67	242.86	67.99	201.14	-28.67	222.24	20.3	21.09	48.97	-65.77	0.85
Fertility levels														
Control	288	19.45	85.5	5.02	186.3	53.72	187.2	-29.25	217.56	17.6	30.36	46.85	-70.45	-1.85
50% RDF	288	19.45	125.5	13.72	218.21	61.32	195.29	-28.15	219.22	18.6	23.93	46.75	-68.78	-0.85
75% RDF	288	19.45	145.5	18.12	247.22	68.25	186.28	-30.68	222.14	20.3	35.86	50.98	-65.86	-0.85
100% RDF	288	19.45	165.5	22.52	262.34	72.79	191.16	-30.82	225.0	22.3	33.85	53.12	-63.0	2.85
Biofertilizers														
Control	288	19.45	130.5	14.02	220.64	62.28	197.87	-28.01	221.4	19.6	23.53	47.61	-66.61	0.15
Azospirillum	288	19.45	130.5	14.02	233.18	64.84	185.3	-30.57	220.5	19.5	35.17	50.07	-67.5	0.05
PSB	288	19.45	130.5	14.02	224.17	63.55	194.34	-29.28	221.16	19.8	26.82	49.08	-66.85	0.35
Azospirillum + PSB	288	19.45	130.5	14.02	235.94	65.68	182.56	-31.41	221.14	20.0	38.85	51.41	-66.86	0.55

Recommended dose of fertilizers (RDF) of zone in 80 kg N/ha and 40 kg P_2O_5 ha^{-1}
Available N and P content in FYM : 0.51% & 0.23%

Results and Discussion

Soil fertility after sorghum harvest

FYM application had significant effect on available N and P status of soil during both the years. Available N and P in soil after sorghum harvest with 10 t 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 (Singh and Ram, 1977). The increased N and P status of soil after harvest of sorghum due to FYM application was also reported by 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 and biofertilizers inoculation. Maximum available P was recorded with 100% RDF which was significantly higher over lower levels in both the years. The difference between graded fertility in this respect was found significant during both the years except the effect of 50% and 75% RDF was at par during 1997. Thus, compared to control, application of 50%, 75% and 100% RDF improved mean available P status of soil by 19.96, 26.43 and 39.48%, respectively. The significant improvement in status of P in soil at sorghum harvest might be due to buildup of phosphorus in soil as the 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 increasing its availability.

Data further showed that biofertilizer treatments significantly affected available P in soil after sorghum harvest during both the years. PSB alone and in combination with *Azospirillum* significantly enhanced available P status of soil by 6.82 and 8.62 per cent, respectively over control. However, inoculation of *Azospirillum* alone did not bring about 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 increased solubility of phosphate due to PSB inoculation. The increase in P availability with PSB inoculation of sorghum was also reported by Rangaswamy and Morachan (1974). Gaur and Gaind (1972) reported higher available phosphorus in PSB inoculated plots due to more solubilization of native as well as applied phosphorus.

Soil fertility after wheat harvest

Application of FYM, fertilizers and biofertilizers in *kharif* season did not significantly 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 20.26 kg ha^{-1} with FYM treatments as against 19.19 kg ha^{-1} without FYM. This increase in available P may be due to chelating effect of organic matter through FYM application. Further application of 75% and 100% RDF to sorghum resulted in higher available P in soil after wheat harvest. However, fertility level at 50% RDF did not improve the available P in soil after wheat harvest. 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 two years earlier was 18% as effective as fresh P on vertisol. Biofertilizers did not alter P status in soil after wheat harvest.

Nitrogen balance

The results presented in Table 1 indicated that on an average available N in soil showed a deficit balance at the end of sorghum crop to the extent of 40 kg N ha^{-1}. The magnitude of decrease from initial level was least with application of 10 t FYM ha^{-1} (-29.45 kg ha^{-1}) and highest with no fertilizer application (-52.67 kg ha^{-1}). The influence of fertility levels on N indicated that net loss in soil N status was reduced with increasing fertility levels. Available N balance at the end of wheat (Table 2) crop grown after sorghum also showed a deficit balance irrespective of the treatments being maximum with no fertilizer application and least with 100% of RDF. However apparent gain was observed with all treatments showing the highest with *Azospirillum* and PSB coinoculation. This clearly indicates that crop utilized atmospheric N in addition to that was taken up from the soil under *Azospirillum* inoculation. More *et al.* (1986) also recorded a negative N balance after sorghum and wheat crop in rotation.

Phosphorus balance

Results indicated (Table 1) a positive balance of available P status in soil at the end of sorghum with all the treatments except no fertilizer application where a mean deficit of 1.68 kg ha^{-1} was noted. The magnitude of positive balance of P increased with FYM application and increasing levels of fertility. The highest mean positive P balance of 5.45 kg ha^{-1} was recorded at 100% of RDF followed by 3.77 kg ha^{-1} under FYM application. This might be due to the residual effect of nutrient applied through fertilizer and mobilization of soil phosphorus under FYM application. Among biofertilizer a marginal increase in positive P balance was noted under PSB inoculation alone and in combination with *Azospirillum*. This could be assigned to solubilization of phosphorus by PSB. Soil P balance in sorghum wheat sequence (Table 2) showed a slight mean positive balance of 0.8 kg ha^{-1} with FYM application and deficit of 0.2 kg ha^{-1} with no FYM treatment. The effect of fertility levels indicates that the deficit of P balance was recorded upto 50% RDF and positive with 75% and 100% RDF.

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