Indian J. Agron. **40** (1) : 14–19 (March 1995)

Direct and residual effects of bio-organic and inorganic fertilizers in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system

A. L. RATHORE, S. J. CHIPDE AND A. R. PAL[2]

Indira Gandhi Krishi Vishwa Vidyalaya, Campus Bilaspur 495 001, Madhya Pradesh

Received: February 1993

ABSTRACT

A field experiment was carried out for 2 years to find out the optimum combination of chemical fertilizers with blue-green algae and farmyard manure in rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Rice-grain yield was statistically similar under treatments of blue green algae @ 10 kg culture/ha and farmyard manure @ 5 tonnes/ha, but was significantly higher (16–17%) than the unfertilized control. Organic manure and blue green algae combined with 60 kg N + 37.5 kg P_2O_5 + 22.5 kg K_2O/ha as inorganic fertilizers proved superior to other treatments and showed significantly higher yield and crop nutrient uptake than other treatments. The residual effect of blue green algae and organic manure with inorganic fertilizer was significant on grain yield of wheat and on N, P and K uptake by the crop. Residual fertility in terms of organic carbon and available P increased under blue green algae and farmyard manure with and without inorganic fertilizers, whereas these sources had no impact on build-up of N and K in the soil.

High cost of fertilizers and the low-purchasing power of peasants restrict the use of costly fertilizer inputs. Under such a condition there is need to explore the possibilities of using the expanding native sources of plant nutrition. The bio- and organic sources such as blue-green algae (Singh and Singh, 1987) and organic manure (Chakraborty *et al.*, 1988) are gaining global importance for rice (*Oryza sativa* L.) culture. Blue-green algae can contribute 20–30 kg N/ha to rice crop (Hermelink and Kramer, 1986) and can be used alone or in combination with fertilizers.The benefits of organic manure for rice are well known (Singh, 1984). Hence it was intended to find out the optimum combination of fertilizers with blue green algae and farmyard manure to rice and their residual effect on wheat (*Triticum aestivum* L. emend. Fiori & Paol.) grown after rice.

MATERIAL AND METHODS

A field experiment was conducted during 1987–88 and 1989 at campus Bilaspur of the IGKVV. The field had loam soil with 6.8 pH, 0.33% organic carbon, 233 kg/ha alkaline potassium permanganate-extractable nitrogen, 8.8 kg/ha available P

A part of Ph D thesis of senior author

Present address: [1,2]Department of Land and Water Management, IGKVV, Raipur, Madhya Pradesh 492 012

Table 1. Yield and yield components of rice as influenced by blue green algae with and without fertilizers

Treatment	Panicles/ m^2		Grains/ panicle		1,000-grain weight (g)		Grain yield (tonnes/ha)	
	1987	1988	1987	1988	1987	1988	1987	1988
Control	238	263	70.77	59.67	17.7	20.2	2.82	3.34
BGA F_0	320	338	77.70	66.82	19.0	21.7	3.33	3.93
FYM F_0	318	345	77.32	66.37	19.1	21.6	3.32	3.88
BGA F_1	378	413	82.87	72.25	19.6	22.7	3.79	4.64
FYM F_1	383	415	81.75	73.37	19.6	22.6	3.85	4.68
BGA F_2	443	470	37.10	82.67	20.1	23.7	4.25	5.18
FYM F_2	443	468	87.02	81.05	20.1	23.6	4.58	5.19
BGA F_3	496	533	95.10	82.67	20.1	23.7	4.25	5.57
FYM F_3	495	536	94.02	87.37	20.6	23.9	4.61	5.59
BGA F_4	497	535	96.00	90.42	20.6	24.6	4.63	5.68
FYM F_4	498	533	95.40	88.00	20.6	24.1	4.71	5.69
BGA F_5	498	535	97.82	91.57	20.7	24.8	4.68	5.71
FYM F_5	499	540	97.15	89.55	20.7	24.7	4.77	5.77
CD (P = 0.05)	50	54	3.32	4.74	0.69	1.12	0.245	0.328

Control, Unfertilized control; BGA F_0, blue green algae; BGA F_1, blue green algae + 20 kg N + 12.5 kg P_2O_5 + 7.5 kg K_2O/ha; BGA F_2, blue green aglae + 40 kg N + 25.0 kg P_2O_5 + 15.0 kg K_2O/ha; BGA F_3, blue green algae + 60 kg N + 37.5 kg P_2O_5 + 22.5 kg K_2O/ha; BGA F_4, blue green algae + 80 kg N + 50.0 kg P_2O_5 + 30.0 kg K_2O/ha; BGA F_5, blue green algae + 100 kg N + 62.5 kg P_2O_5 + 37.5 kg K_2O/ha; FYM F_0, farmyard manure; FYM F_1, farmyard manure + 20 kg N + 12.5 kg P_2O_5 + 7.5 kg K_2O/ha; FYM F_2, farmyard manure + 40 kg N + 25.0 kg P_2O_5 + 15.0 kg K_2O/ha; FYM F_3, farmyard manure + 60 kg N + 37.5 kg P_2O_5 + 22.5 kg K_2O/ha; FYM F_4, farmyard manure + 80 kg N + 50.0 kg P_2O_5 + 30.0 kg K_2O/ha; and FYM F_5, farmyard manure + 100 kg N + 62.5 kg P_2O_5 + 37.5 kg K_2O/ha

(Olsens' P) and 418 kg/ha 1 N ammonium acetate (pH 7.0)-extractable K in soil surface layer (0–15 cm). Blue green algae (BGA) and farmyard manure (FYM) with and without fertilizers formed a set of 13 treatments (Table 1), which was laid out in randomized block design with 4 replications. The FYM-treated plots received 5 tonnes/ha (dry) of the manure through mixing with soil 15 days before the transplanting. In the BGA-treated plots, the BGA culture was applied @ 10 kg/ha 7 days after transplanting of 'IR 36' rice. The FYM contained 0.6% N, 0.2% P_2O_5 and 0.5% K_2O. Half dose of N as urea and full dose of P_2O_5 as superphosphate and K_2O as muriate of potash were applied and mixed with soil just before transplanting rice. Rest of N was given in 2 equal splits, first at tillering and second at the panicle-initiation stage by broadcasting. The test rice crop was established by transplanting 25-day-old seedlings in the last week of July at 20 cm row-to-row and 10 cm hill-to-hill spacings.

After rice, individual plots without changing the layout were prepared for 'Sonalika' wheat after light irrigation and sown in 20 cm rows at 100 kg/ha seed rate during the second week of December. Rice received irrigation as and when required to maintain 3–5 cm flooding and wheat was irrigated on depletion of soil moisture to about 50% of field capacity as judged by observing the soil. Grain and straw samples of 2 crops were collected at harvest and analysed for total N (micro-kjeldahl's method), P (calorimetric molybdenum blue method) and K (flame photometer). Soil samples were collected after the harvest of rice (0–15 cm) and analysed for organic carbon, available N, Olsens' P and 1 N ammonium acetate (pH 7.0)-extractable K.

RESULTS AND DISCUSSION

The grain yield and its components, viz. number of panicles/m^2, grains/panicle and 1,000-grain weight, were significantly higher in BGA- and FYM-treated plots compared with the unfertilized control (Table 1). The effect may be attributed to supply of nutrients, particularly N through BGA and FYM, which can be explained by increase in plant uptake of 8–14 kg N/ha and 3–4 kg P/ha in BGA-treated and 9–12 kg N and 3 kg P/ha in FYM-treated plots compared with the control (Table 2). Higher P availability to rice may be ascribed to the solubilizing effect of carbonic acids formed

Table 2. Nutrient uptake by rice crop as influenced by blue green algae and farmyard manure with and without fertilizers

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1987–88	1988–89	1987–88	1988–89	1987–88	1988–89
Control	46.10	51.37	7.6	9.18	75.02	84.01
BGA F_0	53.41	65.01	10.14	12.75	88.48	107.58
FYM F_0	55.40	62.95	10.48	12.52	85.92	105.02
BGA F_1	62.55	79.11	12.66	15.46	102.66	123.06
FYM F_1	64.74	79.57	13.42	15.54	104.54	124.42
BGA F_2	73.56	94.04	16.13	19.94	125.46	143.13
FYM F_2	73.26	95.84	16.36	20.54	121.84	145.80
BGA F_3	81.25	104.78	18.58	23.30	141.10	162.49
FYM F_3	81.36	104.55	19.72	23.52	146.99	163.48
BGA F_4	86.88	110.17	22.15	26.86	158.82	168.60
FYM F_4	86.57	110.90	22.33	26.92	160.12	169.18
BGA F_5	89.71	113.65	22.89	27.60	170.56	175.60
FYM F_5	91.11	115.12	23.10	27.83	171.75	176.88
CD (P = 0.05)	5.19	5.12	1.13	1.10	6.13	6.95

Treatment details are given under Table 1

during the decomposition of organic matter, which promotes the release of organic phosphorus for crop uptake (Beresteskii *et al.*, 1986). The effect of BGA and FYM alone and in combination with given level of inorganic fertilizers was statistically similar on grain yield and uptake of nutrients by rice. Application of fertilizer NPK to BGA- and FYM-treated plots proved beneficial and resulted in higher yield of rice. Increasing levels of inorganic fertilizers with 2 sources improved the grain yield but significant response was obtained up to 60 kg N + 37.5 kg P_2O_5 + 22.5 kg K_2O/ha and it was not significant beyond this level for the crop production under the prevailing condition. The plant uptake of N, P and K followed the pattern of grain yield. The positive correlation between grain yield and crop N, P and K uptake (r = 0.97, 0.95 and 0.92 during 1987 and 0.99, 0.95 and 0.98 during 1988 respectively) substantiated fact that crop N, P and K uptake increased with increased grain yield of rice. The higher nutrients uptake could enable the rice plant to produce more number of panicles/m^2, grain/panicle and 1,000-grain weight, which were also positively correlated with the yield (r = 0.99, 0.98 and 0.98 during 1987 and 0.99, 0.95 and 0.98 during 1988 respectively).

The BGA and FYM with and without fertilizer NPK considerably improved organic carbon and available P after rice harvest (Table 3). Soil-test status of N and K improved slightly on fertilizer application with BGA and FYM, may be due to their higher uptake by rice crop and losses by leaching, volatilization or fixation in soil. Perhaps increase in nutrient status was due to more mineralization and release of soil nutrients and or due to the left-over residues of applied fertilizers (Shinde, 1981; Kanwar, 1981). BGA and FYM with and without fertilizers did not exhibit their residual effect on succeeding wheat crop during 1987–88 (Table 4). This could be due to less nutrient (NPK) availability for plant uptake as appeared from the total nutrient uptake by the crop (Table 5). During 1988–89 the cumulative effect of BGA and FYM with and without fertilizers resulted in significantly more grain yield than the control. Higher uptake of 6 to 13 kg N, 1 to 3 kg P and 2 to 7 kg K/ha than the unfertilized control explained the residual effect on these treatments. Gaur *et al.* (1984) also reported the residual effect of BGA and FYM, applied to preceding rice, on grain yield of succeeding crops.

Table 3. Residual fertility of soil as influenced by blue green algae and farmyard manure with and without inorganic fertilizers at harvest of rice during 1988

Treatment	Organic carbon (%)	Available nutrient (kg/ha)		
		N	P	K
Control	0.35	236	7.5	427
BGA F_0	0.45	244	11.3	434
FYM F_0	0.45	246	12.1	436
BGA F_1	0.50	248	13.1	439
FYM F_1	0.51	248	14.6	438
BGA F_2	0.51	250	14.8	440
FYM F_2	0.54	250	14.8	444
BGA F_3	0.51	243	15.1	436
FYM F_3	0.58	247	14.2	437
BGA F_4	0.51	248	14.5	439
FYM F_4	0.58	252	14.8	440
BGA F_5	0.50	253	15.0	441
FYM F_5	0.58	255	15.1	446

Details of treatments are given under Table 1

Table 4. Residual effect of blue green algae and farmyard manure with and without fertilizer NPK on yield and yield components of wheat

Treatment	Spikes/ m^2		Weight of spike (g)		Grains/ spike		Grain yield (tonnes/ha)	
	1987–88	1988–89	1987–88	1988–89	1987–88	1988–89	1987–88	1988–89
Control	356	378	1.36	1.40	17.07	15.7	0.77	0.79
BGA F_0	358	384	1.43	1.63	17.79	18.83	0.86	0.93
FYM F_0	358	384	1.40	1.62	17.92	18.81	0.85	0.91
BGA F_1	359	394	1.51	1.74	18.95	18.95	0.89	1.01
FYM F_1	358	393	1.52	1.74	19.32	18.86	0.89	1.07
BGA F_2	359	408	1.55	1.76	19.37	19.7	0.97	1.09
FYM F_2	350	308	1.73	1.87	19.42	19.8	0.94	1.07
BGA F_3	360	406	1.76	1.84	19.07	20.9	0.97	1.05
FYM F_3	360	405	1.71	1.79	18.90	19.9	9.97	1.09
BGA F_4	361	404	1.71	1.82	18.95	21.2	0.97	1.04
FYM F_4	360	408	1.76	1.82	18.90	21.0	0.98	1.09
BGA F_5	362	401	1.66	1.77	18.70	21.1	0.97	1.04
FYM F_5	361	409	1.77	1.86	18.82	21.2	0.98	1.09
CD (P = 0.05)	NS	25	NS	0.25	1.21	1.22	NS	0.14

Details of treatment are given under Table 1

Table 5. Nutrient uptake by wheat as affected by residual effect of blue green algae and farmyard manure with and without inorganic fertilizers

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1987–88	1988–89	1987–88	1988–89	1987–88	1988–89
Control	15.18	19.32	2.44	3.22	6.92	10.13
BGA F_0	20.88	26.25	3.33	4.80	8.41	13.15
FYM F_0	20.53	25.66	3.22	4.68	8.29	12.63
BGA F_1	23.31	29.68	3.85	5.16	9.80	13.92
FYM F_1	23.18	30.11	3.60	5.36	9.64	14.86
BGA F_2	25.47	32.27	4.46	6.16	11.52	16.62
FYM F_2	24.53	30.95	4.44	5.70	10.84	15.72
BGA F_3	25.10	30.86	4.48	5.95	11.87	16.32
FYM F_3	25.53	31.64	4.58	6.38	11.26	17.12
BGA F_4	24.71	29.63	4.65	5.98	11.72	16.33
FYM F_4	25.06	31.85	4.70	6.43	12.29	17.59
BGA F_5	24.53	29.30	4.64	6.21	11.29	15.77
FYM F_5	26.26	32.08	4.91	6.52	12.97	17.86
CD (P = 0.05)	3.14	2.85	0.50	0.82	1.26	1.21

Details of treatments are given under Table 1

The results indicate that in rice–wheat cropping system, application of 60 kg N + 37.5 kg P_2O_5 + 22.5 kg K_2O/ha as inorganic fertilizers to BGA- or FYM-treated plots proved beneficial to rice crop, besides enrichment of the organic matter and available P content of the soil. Wheat following rice is benefited to great extent; however the yield levels in general were low. It suggests that the crop should also receive fertilizer directly to achieve higher productivity.

REFERENCES

Berasteskii, O. A., Andreeva, N. A. and Patyak, V. K. 1986. Nitrogen fixing cyanobacteria in the rhizoshpere of rice grown continuously and in crop rotation. *Soviet Agriculture Biology* I, *Plant Biology* No. 3, pp 120–124.

Chakraborty, P. K., Mandal, L. N. and Majumdar, A. 1988. Organic and chemical sources of nitrogen : its effect on nitrogen transformation and rice productivity under submerged conditions. *Journal of Agricultural Science, the UK* **11** (1) : 91–94.

Gaur, A. C., Neelakantan, S. and Dargan, K. S. 1984. *Orgnanic Manures*, pp. 122–146. Indian Council of Agricultural Research, New Delhi.

Hermelink, P. and Kramer, W. 1986. Imporance of N fixation by BGA and Azofla-Anabaena symbiosis in lowland rice cultivations. Tropendland Writ., 11–18 April 1987.

Kanwar, J. S. 1981. *Soi Fertility : Theory and Practices*, pp. 156–201. Indian Council of Agricultural Research, New Delhi.

Shinde, J. E. 1981. Residual N-fertilizer in soil and its availability in a rice–wheat cropping system. *International Rice Research Newsletter* **6** : 22–23.

Singh, A. L. and Singh, P. K. 1987. Nitrogen fixation and balance studies of rice soil. *Biology and Fertility of Soil* **4** (1–2) : 15–19.

Singh, N. T. 1984. Green manures as sources of nutrients in rice production. (In) *Organic Matter and Rice*, pp. 217–228. International Rice Research Institute, Los Banos, Philippines.