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Integrated nutrient management of lady's finger (*Abelmoschus esculentus* L.Moench) in Dankuni basin

R. RAY; S. K. PATRA* AND S. K. SAHOO

Department of Soil and Water Conservation,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741 252
**AICRP on Water Management, BCKV, Gayeshpur – 741 234, Nadia*

ABSTRACT

Two sets of field experiments were conducted at medium land situation in Dankuni Basin of Hooghly river in West Bengal during *rabi* season of 2002-03 to assess the benevolent effects of two non-symbiotic N- fixing bacteria, *Azotobacter* and *Azospirillum* in presence or absence of FYM (15 t ha^{-1}) and two levels of graded NPK fertilizers (50-25-25 and 25-12.5-12.5 kg N, P_2O_5, K_2O/ ha) on the growth and fruit yield of lady's finger (*Abelmoschus esculentus* L. Moench) and the availability status of N, P and K in soil. The results of the study showed that integration of *Azospirillum* or *Azotobacter* inoculation supplemented with 15 t ha^{-1} of FYM and 25-12.5-12.5 kg N, $P2O_5$, K_2O ha^{-1} was much beneficial for increasing plant growth, higher fruit yield and N- saving up to 25 kg ha^{-1} to crop, besides enhancing available pool of N, P and K in soil.

Key Words*:* FYM, chemical fertilizers, *azotobacter* and *azospirillum*, lady's finger, Dankuni basin

Dankuni Basin of Hooghly River is an important agro-ecosystem in West Bengal. The area has enormous potential to increase the crop productivity due to its higher soil fertility status. The resource poor farmers cannot afford the optimum levels of costly mineral fertilizers especially the nitrogen to sustain the soil and crop productivity. This results in low crop yields and depletion of soil fertility. The beneficial use of nitrogen fixing microorganism viz. *azotobacter* and *azospirillum*, as a supplementary source of N-nutrition to crops is well documented (Subba Rao, 1986; Oken and Gonzalez, 1994; Barakart and Gabr, 1998). These non-conventional nitrogen sources are cost-effective and simultaneously boost up the productivity of soil and crop (Konde and Shinde, 1986; Patra *et al*., 1989). The present investigation was aimed undertaken to find out the effectiveness of two biofertilizers namely, *azotobacter* and *azospirillum* either alone or in conjunction with FYM and two levels of NPK fertilizers on the growth and yield of lady's finger (*Abelmoschus esculentus* L. Moench) in the well-drained medium land of Dankuni basin and the consequent transformation of available N, P and K status of soils.

MATERIALS AND METHODS

Two sets of field experiments were conducted during the *rabi* season of 2002–2003 in the well-drained medium land of Dankuni basin. The experimental soil was clay loam with pH 7.55, organic carbon 0.75%, available N 268.7 kg ha^{-1}, available P 21.8 kg ha^{-1} and available K 182.15 kg ha^{-1}. The first set of experiment was laid out in a randomized block design with 10 treatments (15 t FYM ha^{-1} i.e. Control, 50% recommended dose of chemical fertilizers (RDF), 100% RDF, 15 t FYM ha^{-1} + 50% RDF, 15 t FYM ha^{-1} + 100% RDF, 15 t FYM ha^{-1} + *Azospirillum*, 50% RDF + *Azospirillum*, 100% RDF + *Azospirillum*, 15 t FYM ha^{-1} + 50% RDF + *Azospirillum* and 15 t FYM ha^{-1} +100% RDF + *Azospirillum*) and 3 replications. In the second set of experiment, *Azotobacter* was taken instead of *Azospirillum* in the desired treatments. The standard culture of *Azotobacter chroococcum* and *Azospirillum brasilense* were prepared separately by mixing 20 g culture in 40 ml of water per kg of seed. The seeds after drying in shade were sown in line. Nitrogen, phosphorus and potassium were applied in the form of urea, single superphosphate and muriate of potash, respectively. Full P and K and 50% N as per treatments were applied as basal and the remaining 50% N was topdressed at 30 days after sowing. Well decomposed FYM @ 15 t ha^{-1} was applied during final land preparation in the selected plots. Crop variety Pankaj was sown on 26.11.2002 at a spacing of 30 cm x 30 cm. Harvesting was completed within March, 2003 after five pickings. The net plot size of each treatment was 3 m x 4 m. Number of fruits per plant, plant height of five randomly selected plants in each plot at 30, 45 and 60 days after sowing and fruit yield per plot were recorded. Surface soil samples (0–20 cm) after crop harvest was analyzed for pH, organic carbon, available N, P and K following the standard procedures as outlined by Jackson (1967).

RESULTS AND DISCUSSION

1.1 Effect of *azospirillum* on lady's finger

The data presented in Table 1 reveals that the

farmers' conventional practice of adding 15 t FYM ha^{-1} to crop registered significantly the lowest fruit yield of 51.8 q ha^{-1}. On the other hand, application of graded doses of chemical fertilizers either alone or in conjunction with FYM, microbial inoculants or both increased fruit yield of 8.7 to 30.2% over farmers' practice. The economic yields consistently and significantly increased to about 61.3 and 63.3 q ha^{-1} at 50 % and 100 % of recommended NPK doses, respectively. The fruit yields further increased significantly when recommended fertilizer doses were supplemented with FYM. Similarly, *azospirillum* inoculated either with FYM or 50 % or 100 % RDF doses recorded an appreciable increase in yields superior to the sole treatments. Further, application of both *azospirillum* and FYM in combination with 50% or 100% RDF doses increased the fruit yields to 67.2 and 67.5 q ha^{-1}, respectively and were superior to the rest of the treatments under study. These two treatments, however, were on par in respect of yields This amply demonstrates that the activity of *azospirillum* in promoting fruit yield was more pronounced when it was enriched with organic manure, the more so when it was further supplemented with low doses of mineral fertilizers (Patra *et al*., 1989; Oken and Gonzalez, 1994; Ganeshe *et al*., 1998). This was mainly due to the ability of the microorganism to fix atmospheric nitrogen to the soil and made available to the growing plants, besides secretion of growth promoting substances which were partly responsible for the enhanced plant growth and yield (Rao, 1981).It also reveals to the fact that correct bacterization along with judicious application of FYM and chemical fertilizers could save at least 50 % N (i.e., 25 kg N ha^{-1}) which is going to be a costlier proposition in the present day agriculture. In the present study, bio-inoculation with *azospirillum* in conjunction with FYM and 50 % RDF doses were found much beneficial in augmenting the fruit yields of lady's finger.

Plant height at three different growth stages and number of fruits/ plant were also significantly influenced by the treatment combinations and followed more or less the same trend as in fruit yield. However, the higher crop growth and increased number of fruits/ plant were observed in the treatment provided with bioinoculant, FYM and chemical fertilizers.

1.2 Effect on soil properties

Application of graded doses of chemical fertilizers registered a decrease in soil pH (Table 3). On the contrary, addition of FYM alone or in combination with chemical fertilizer levels and / or *azospirillum* recorded variable increases in soil pH (Table 2). The augmentation of soil pH was more pronounced when organic manure either alone or integrated with *azospirillum* or *azospirillum* plus 50 % RDF was incorporated into the soil. Similar trend was observed for organic carbon also. However, the status was relatively high in the soil provided with FYM, *azospirillum* and 50 % RDF. Application of graded levels of chemical fertilizers exhibited the depletion of organic carbon status in soil.

The variable builds up of availability of N and K in soil was observed in the treatments provided with FYM, FYM integrated either with bioinoculant or bioinoculant plus RDF levels. Application of both FYM and *azospirillum* to soil rendered two-folds increase of available N over the sole application of FYM. However, combined application of FYM, *azospirillum* and graded fertilizer levels increased the available pool of N and K manifolds over the prevalent practice. Addition of chemical fertilizer levels alone or its combination with *azospirillum* inoculation demonstrated the depletion of available N and K in soil.

Available soil P status in general was more when adequate FYM was incorporated. The value increased considerably when FYM integrated with both *azospirillum* and RDF levels was incorporated to soil. The magnitude of increase in available P was, however, marginal wherever only chemical fertilizers added. These findings are in conformity with Prasad and Rokima (1992) who reported the increased level of available N and P contents in soil with the integrated use of organic, inorganic and biofertilizer, however, contrary to their observations on the depletion of available K content.

2.1 Effect of *azotobacter* on lady's finger

The crop yields due to application of graded chemical fertilizer levels alone or its combinations with FYM, *azotobacter* or both were increased by 10.3 to 30.8% over the conventional farmers' practice (Table 2). Application of FYM @15 t ha^{-1} significantly produced the lowest fruit yield of 52.7 q ha^{-1}. The yields, however, increased consistently and significantly when half and full-recommended doses of NPK fertilizers were added to the crop. FYM incorporation along with the graded levels of chemical fertilizers also augmented the crop yields superior to their sole application. Similarly, *azotobacter* inoculation enriched with FYM or chemical fertilizer levels recorded significantly the higher yields over the respective treatments. However, the effects were more conspicuous when both *azotobacter* and FYM along with 50 or 100% recommended chemical fertilizers were applied to the crop. The later two treatments of the integrated uses of biofertilizer, organic manure and mineral fertilizers at two graded levels in enhancing fruit

yields were at par, but superior to the remaining treatments under study. This proved to the fact that *azotobacter* enriched with FYM and half recommended NPK doses was as good as *azotobacter* enriched with FYM and full recommended NPK doses, thereby saving at least 25 kg ha^{-1} chemical fertilizer N. This indicates the benevolent effect of *azotobacter* in promoting crop yield under the environment of adequate FYM level and low doses of NPK fertilizers especially of nitrogen. In view of escalating cost of nitrogenous fertilizer, the integrated uses of *azotobacter*, 15 t ha^{-1} FYM ha^{-1} and 50% recommended NPK dose was found more advantageous in augmenting the fruit yield of lady's finger.

Plant height at three growth stages and number of fruits/ plant were also influenced significantly by various treatments and followed more or less the same trend as in fruit yield. However, the better growth and higher number of fruits/ plant was observed in the treatment combinations provided with *azotobacter*, FYM and graded chemical fertilizers. Higher availability of atmospheric elemental nitrogen to the growing plant by non-symbiotic *azotobacter* in presence of organic manure and low doses of chemical fertilizers were chiefly responsible for promoting better growth and yield of crop (Subba Rao, 1986).

2.2 Effect on soil properties

Application of graded doses of chemical fertilizers alone resulted gradual decrease in soil pH. On the contrary, addition of FYM alone or in combinations with chemical fertilizer levels and /or *azotobacter* recorded variable increases in soil pH, although the magnitude of increases was different (Table 3). Maximum increase was observed when the soil was inoculated with *azotobacte*r enriched with FYM or with FYM + low doses of chemical fertilizers. The organic carbon status was found to be relatively higher wherever FYM applied. However, there was a depletion of soil organic carbon content when the crop was raised with chemical fertilizers only.

Available N and K status of soil were also markedly increased wherever FYM or FYM + *azotobacter* or FYM + *azotobacter* + chemical fertilizers were applied. Maximum increase was observed when the soil was provided with bioinoculant along with FYM and full-recommended doses of NPK fertilizers. A considerable depletion of soil available N and K was found in treatment provided with chemical fertilizers or chemical fertilizers + *azotobacter* inoculation. On the other hand, available P in soil was variably increased in all the treatments provided. Maximum increase was registered in the integrated use of FYM + *azotobacter* + full recommended NPK fertilizers. Build up of available N and P in soil with the combined use of organic, inorganic and biofertilizers are in line with the findings of Prasad and Rokima (1992).

The present study thus indicated that application of *azospirillum* or *azotobacter* supplemented with 15 t FYM ha^{-1} and 25-12.5-12.5 kg NPK ha^{-1} to lady's finger appeared to be much beneficial for sustaining higher growth, fruit yield and N-saving up to 25 kg ha^{-1} to crop and augmenting fertility status of soil in respect of available N, P and K in medium land of Dankuni basin in West Bengal.

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Table 1 : Growth and yield of lady's finger as influenced by FYM, chemical fertilizers, a*zospirillum* and their combinations

Treatments	Plant height (cm)			Number of fruits/ plant	Fruit yield (q / ha)	Per cent increase in yield over control
	Days after sowing					
	30	45	60			
15 t FYM ha^{-1} (control)	36.3	46.3	52.6	5.8	51.8	-
50% RDF	36.6	53.4	61.3	6.9	61.3	18.4
100% RDF	37.1	53.8	62.7	7.0	63.3	22.1
15 t FYM ha^{-1} + 50% RDF	37.5	54.4	63.3	7.1	63.7	23.0
15 t FYM ha^{-1} + 100% RDF	38.4	55.8	64.5	7.2	64.5	24.5
15 t FYM ha^{-1} + *Azospirillum*	37.2	53.4	60.9	6.3	56.3	8.7
50% RDF + *Azospirillum*	38.6	54.4	63.2	7.1	64.2	23.8
100% RDF + *Azospirillum*	39.5	54.9	63.9	7.2	64.7	24.8
15 t FYM ha^{-1} + 50% RDF + *Azospirillum*	41.3	56.3	65.6	7.3	67.2	29.7
15 t FYM ha^{-1} +100% RDF + *Azospirillum*	42.4	57.0	66.2	7.4	67.5	30.2
CD at 5%	NS	2.0	2.3	0.4	0.6	-

Recommended dose of fertilizer: 50–25–25 kg N, P_2O_5, K_2O/ ha, NS: not significant

Table 2 : Growth and yield of lady's finger as influenced by FYM, chemical fertilizers, *azotobacter* and their combinations

Treatments	Plant height, cm			Number of fruits/ plant	Fruit yield (q / ha)	Per cent increase in yield over control
	Days after sowing					
	30	45	60			
15 t FYM ha^{-1} (control)	38.6	48.5	53.7	5.9	52.7	-
50% RDF	39.6	51.2	62.9	6.9	62.3	18.1
100% RDF	40.8	52.9	63.3	7.1	63.5	20.5
15 t FYM ha^{-1} + 50% RDF	41.4	53.5	64.5	7.2	65.2	23.6
15 t FYM ha^{-1} +100% RDF	41.6	54.6	65.5	7.3	65.6	24.5
15 t FYM ha^{-1} + *Azotobacter*	38.5	52.4	60.3	6.8	58.2	10.3
50% RDF + *Azotobacter*	38.6	52.9	63.9	7.2	64.8	24.9
100% RDF + *Azotobacter*	42.6	54.5	64.2	7.2	66.3	25.7
15 t FYM ha^{-1} + 50% RDF + *Azotobacter*	43.1	55.9	65.2	7.4	68.5	30.0
15 t FYM ha^{-1} +100% RDF + *Azotobacter*	43.5	56.1	65.3	7.4	68.9	30.8
CD at 5%	1.2	1.1	0.9	0.2	0.5	-

Recommended fertilizer dose: 50–25–25 kg N, P_2O_5, K_2O/ ha

Table 3 : Transformation of pH, organic C, available N, P and K in soil as influenced by FYM, chemical fertilizers, *azospirillum* / a*zotobacter* and their combinations

Treatments	Soil pH	Organic carbon (%)	Av.N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	Treatments	Soil pH	Organic carbon (%)	Av.N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})
15 t FYM ha^{-1} (control)	7.63	0.78	276.93	33.00	186.60	15 t FYM ha^{-1} (control)	7.60	0.80	274.13	35.90	188.43
50% RDF	7.53	0.73	238.53	25.33	121.90	50% RDF	7.53	0.71	231.73	24.83	122.90
100% RDF	7.51	0.71	246.80	30.00	132.97	100% RDF	7.50	0.69	243.40	31.67	136.10
15 t FYM ha^{-1} + 50% RDF	7.60	0.77	293.20	37.50	195.53	15 t FYM ha^{-1} + 50% RDF	7.58	0.78	287.93	39.00	197.63
15 t FYM ha^{-1} + 100% RDF	7.58	0.76	309.87	40.83	201.73	15 t FYM ha^{-1} +100% RDF	7.57	0.77	316.03	42.17	203.30
15 t FYM ha^{-1} + Azospirillum	7.63	0.78	285.20	35.67	184.10	15 t FYM ha^{-1} + *Azotobacter*	7.61	0.80	290.10	35.83	186.55
50% RDF + *Azospirillum*	7.60	0.78	241.47	36.87	122.03	50% RDF + *Azotobacter*	7.59	0.78	239.90	35.67	125.03
100% RDF + *Azospirillum*	7.58	0.77	252.27	40.50	131.03	100% RDF + *Azotobacter*	7.57	0.79	275.80	37.05	135.63
15 t FYM ha^{-1} + 50% RDF + *Azospirillum*	7.63	0.80	303.07	42.33	193.67	15 t FYM ha^{-1} + 50% RDF + *Azotobacter*	7.61	0.82	308.73	41.17	197.43
15 t FYM ha^{-1} +100% RDF + *Azospirillum*	7.61	0.79	323.60	46.30	208.20	15 t FYM ha^{-1} +100% RDF + *Azotobacter*	7.60	0.81	330.33	43.50	210.38

Recommended fertilizer dose: 50–25–25 kg N, P_2O_5, K_2O/ ha

Initial soil pH 7.55, Organic carbon 0.75%, Available N 268.75 Kg ha^{-1}, Available P 21.80 Kg ha^{-1} and Available K 182.15 kg ha^{-1}