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Integrated nitrogen management through biofertilizers in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

A field experiment was conducted at Vegetable Research Farm, CSK HPKV, Palampur during rainy season of 2003 and 2004 to find out the most effective combination of bio- and chemical fertilizer in okra. The treatments consist of three nitrogen levels (80, 60 and 40% N), two biofertilizers (*Azotobacter* and *Azospirillum*) and two methods of biofertilizer application (soil and seed application). The control was recommended dose of chemical fertilizers (75, 50, 50 kg/ha of N, P_2O_5 and K_2O). Results indicated that the treatment 80% of the recommended nitrogen + *Azotobacter* as soil application was significantly superior in marketable yield (101.05 q/ha) as compared to control (74.65 q/ha). Among all the treatment combinations, the treatment 80% of the recommended nitrogen + *Azotobacter* performed better and was superior to control in both the years.

Keywords: Okra, *Azotobacter*, *Azospirillum*, nitrogen.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] popularly known as *Bhindi* is one of the important vegetable crops grown extensively in the mid hills of Himachal Pradesh during rainy season because of its tolerance to more rains and relatively lesser incidence of yellow vein mosaic disease in hilly tracts. It is valued for its tender and delicious fruits. Being a nutrient exhaustive crop, its requirement for macronutrients, especially nitrogen is more. Since nitrogen plays an important role in the synthesis of amino acids and proteins in the plant system, and thus, governs productivity and quality of okra fruits. During the last four decades, there is a spectacular breakthrough in the consumption of nitrogenous fertilizers leading to the imbalance of nutrients in soil thus affecting the soil health. Moreover, the use of expensive commercial fertilizers as per the requirement of the crop is not much affordable to the average farmer, being costly and at times not readily available. Therefore, the importance of integrated nutrients supply in sustaining productivity is emphasized to restore and sustain soil health and productivity in the long run which otherwise is likely to deteriorate due to continuous and intensive cultivation without adequate nutrients management. Biofertilizers have emerged as an important component of integrated nutrients supply system. It is also necessary to popularize the use of biofertilizers as they are cheap, handy and ecofriendly. They also enrich the soil with beneficial microorganisms, which may show a prolonged effect on the sequential crops. The microorganisms like *Azotobacter* and *Azospirillum* are considered important not only for their nitrogen fixing efficiency but also for their ability to produce antibacterial and antifungal compounds and growth hormones. The biofertilizers can partially substitute the chemical fertilizers thus reducing the cost of cultivation. Swain *et al.* (2003) reported that the biofertilizers, *Azotobacter* and *Azospirillum,* can be economical in saving nitrogenous fertilizers up to 15-20 per cent of recommended dose in *bhindi*. Therefore, there is a need to evolve integrated nutrients supply system by judicious combination of bio- and chemical fertilizers.

Material and Methods

The field studies were carried out at Vegetable Research Farm, CSK HPKV, Palampur, during rainy season of 2003 and 2004. The soil was acidic in reaction (pH 5.7), silty clay loam in texture, and the available N, P_2O_5 and K_2O were 292.93, 13.76 and 223.8 kg/ha, respectively. The total rains of 1829.5 and 1216.3 mm were received during the period June to September 2003 and 2004, respectively. The field experiment was conducted in randomized block design with four replications. The treatment combinations comprised of three nitrogen levels (80, 60 and 40% of the recommended dose), two biofertilizers

(*Azotobacter* and *Azospirillum*) and two methods of biofertilizer application (soil and seed application) including control (recommended dose of inorganic fertilizers, i.e., 75, 50, 50 kg/ha of N, P_2O_5 and K_2O and 10 t/ha of FYM). The variety P-8 was sown at a spacing of 45x22.5 cm in the plots of size 2.7x2.7 m. The entire recommended dose of P, K and FYM and one-third dose of nitrogen, treatment wise, were added before sowing. The remaining dose of nitrogen was top dressed in two equal splits at 30 and 45 days of sowing. *Azotobacter/Azospirillum* was applied as seed treatment (100 g/kg) and soil application (2.5 kg/ha). All cultural and management practices were followed whenever needed. The data on yield and different parameters were recorded, however, the data on plant height, internodal length and number of nodes per plant were recorded at the time of last picking of fruits. For plant analysis, the samples were taken from 10 plants at random from each plot at last harvest. The plant samples were washed with tap water then sterilized with HCl 0.1 N and again washed with distilled water. The samples were air dried and placed in oven at 60±5°C until constant weight was attained. Dried samples were ground and analyzed for nitrogen concentration. Total nitrogen in plant samples was estimated by Nessler's reagent method as described by Jackson (1973). The nitrogen uptake was calculated as the product of nitrogen concentration with respective dry weight of the plant sample.

Results and Discussion

Marketable Yield and Components

Okra significantly responded to nitrogen levels only in the second year. Higher marketable fruit yield was recorded with treatment 80% of recommended nitrogen (86.23 q/ha), which was significantly superior to 40 (72.53 q/ha) and 60% of recommended nitrogen (72.25 q/ha) (Table 1). The higher fruit yield in treatment 80% of recommended nitrogen was due to improved yield parameters namely number of nodes per plant and plant height. The nutrient nitrogen plays a vital role in enhancing the photosynthetic efficiency of plants through increase in chlorophyll content which ultimately results in the production of more carbohydrates that accelerate growth. The present findings are analogous to those reported by Bahadur and Manohar (2001), Swain *et al.* (2003) and Ray *et al.* (2005). The lower marketable yield of okra recorded in the first year (2003) was the consequence of more rains (226.9mm rain in 8 days) during the second fortnight of June 2003, which led to delay in sowing of crop on July 1st 2003 followed by relatively more rainfall even after sowing. The biofertilizers and methods of biofertilizers application were found to be non-significant from each other for marketable fruit yield during both the years of study.

Among interactions, the interaction nitrogen x biofertilizers x methods of biofertilizer application was significant during the second year (Table 1). The treatment combinations 80% of recommended nitrogen + *Azotobacter* as soil application (101.05 q/ha) and 80% of recommended nitrogen + *Azospirillum* as seed application (96.58 q/ha) were significantly superior to the control (74.65 q/ha). Higher marketable yield can be attributed to the favourable effect of 80% of recommended nitrogen on nodes per plant and plant height and *Azotobacter* on node number at which first flower appeared and inter nodal length. The *Azotobacter* excrete plant growth promoting substances (vitamins, gibberellins and kinetin) and antibacterial or/and antifungal compounds which improve vigour of the crop plants and thereby productivity (Pandey and Kumar, 1989). Besides, they help in the development and branching of roots which enhance the uptake of NO_3, NH_4, H_2PO_4, K and Fe, improve water status of the plants and increase nitrate reductase activity in the plant (Marwaha, 1995). These results are in line with those obtained by Wange and Kale (2003) and Swain *et al.* (2003).

Nitrogen Uptake

The maximum nitrogen uptake of 25.97 and 96.64 kg/ha was recorded with 80% of recommended nitrogen in the year 2003 and 2004, respectively (Table 2). In first year, it was statistically similar to 60% of recommended nitrogen, while the latter nitrogen uptake was significantly better over 60 and 40% of recommended nitrogen. The nitrogen uptake was significantly influenced by the biofertilizers. Among biofertilizers, *Azotobacter* proved better than *Azospirillum* during both the years (Table 2). Among interactions, the nitrogen x biofertilizers was significant only in the first year. The interaction between nitrogen x biofertilizers revealed that 80% of recommended nitrogen + *Azotobacter* (32.70 kg/ha) resulted in maximum uptake of nitrogen followed by 60% of recommended nitrogen + *Azotobacter*, which were at par but superior to all the remaining treatments (Table 1). The interaction nitrogen x biofertilizers x methods of biofertilizer application revealed that

Table 1. Marketable fruit yield (q/ha) and nitrogen uptake of okra as influenced by different nitrogen levels, biofertilizers and methods of biofertilizers application

Nitrogen levels	Biofertilizers	Marketable fruit yield (q/ha)						Nitrogen Uptake					
		Methods of biofertilizers application						Methods of biofertilizers application					
		M_1		M_2		Mean (NxB)		M_1		M_2		Mean (NxB)	
		2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
N_1	B_1	30.81	101.05	24.65	80.50	27.73	90.78	31.48	121.88	33.89	117.8	32.70	119.84
	B_2	24.30	66.80	19.53	96.58	21.91	81.69	19.07	56.73	19.37	90.15	19.24	73.44
N_2	B_1	21.60	62.68	25.35	85.28	23.48	73.98	29.41	75.73	27.72	99.40	28.56	87.56
	B_2	21.22	69.50	19.17	71.55	20.20	70.53	24.55	88.45	19.58	58.65	22.06	73.55
N_3	B_1	17:83	75.35	21.93	67.48	19.88	71.41	18.88	78.18	22.22	60.60	20.56	69.39
	B_2	22.60	71.23	21.55	76.05	21.59	73.64	22.40	87.45	22.33	82.53	22.36	84.99
N x M	N_1	27.55	83.93	22.09	88.54	24.83	86.23	25.30	85.30	26.64	103.98	25.97	96.64
	N_2	21.41	66.09	22.26	78.41	21.84	72.25	26.99	82.09	23.65	79.03	25.32	80.56
	N_3	20.21	73.29	21.25	71.76	20.73	72.53	20.66	82.81	22.26	71.56	21.46	77.19
B x M	B_1	23.41	79.69	23.98	77.75	23.69	78.72	26.61	91.93	27.95	92.60	27.28	92.26
	B_2	22.71	69.18	19.76	81.39	21.23	75.28	22.03	77.54	20.42	77.11	21.22	77.33
Mean		23.06	74.43	21.87	79.57			24.32	84.73	24.18	84.85		
Control mean		21.58	74.65					22.00	90.38				
Others mean		22.46	77.00					24.25	84.79				
For comparing means of													
Nitrogen (N)		NS	9.18					3.51	12.12				
Biofertilizers (B)		NS	NS					2.87	9.90				
Methods of biofertilizers application (M)		NS	NS					NS	NS				
Interaction													
NxB		NS	NS					4.97	17.14				
NxM		NS	NS					NS	NS				
BxM		NS	NS					NS	NS				
NxBxM		NS	18.37					NS	24.24				
Control vs. others		NS	NS					NS	NS				

Note: N_1: 80%N; N_2: 60%N and N_3: 40% N; B_1: *Azotobacter* and B_2: *Azospirillum*; M_1: Soil application and M_2: Seed application

the treatment combination 80% of recommended nitrogen + *Azotobacter* as soil application (121.88 kg/ha) resulted in the highest uptake of nitrogen in the second year (Table 1). It was closely followed by 80% of recommended nitrogen + *Azotobacter* as seed application (117.80 kg/ha) and 60% of recommended nitrogen + *Azotobacter* as seed application (99.40 kg/ha). The results revealed that the treatment combination 80% of recommended nitrogen + *Azotobacter* irrespective of the method of application recorded significantly higher nitrogen uptake by the plants during both the years. This treatment combination had also resulted in significantly higher marketable fruit yield during the second year. Increased uptake of nitrogen with *Azotobacter* is due to increased root surface area and production of enzymatic complexes in the rhizosphere which increases the availability of nutrients (Singh *et al.*, 1997). Swain *et al.* (2003) also reported significantly higher nitrogen uptake by okra plants when biofertilizers (*Azotobacter* and *Azospirillum*) were applied in the soil along with 100% of recommended nitrogen.

Table 2. Yield components, marketable fruit yield and nitrogen uptake of okra as influenced by nitrogen, biofertilizers and methods of biofertilizers application

Treatments	No of nodes per plant		Internodal length (cm)		No. of fruits per plant		Plant height (cm)		Node number at which first flower appear		Marketable yield (q/ha)		Nitrogen uptake (kg/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
N_1 (80% N)	10.00	16.11	6.06	8.31	2.73	6.96	24.82	86.23	3.69	4.31	24.82	86.23	25.97	96.64
N_2 (60% N)	9.03	14.97	5.61	8.16	2.51	6.61	21.84	72.25	3.94	4.19	21.84	72.25	25.32	80.56
N_3 (40% N)	8.95	15.16	5.64	8.34	2.83	6.91	20.73	72.53	3.69	4.19	20.73	72.53	21.46	77.19
CD (P=0.05)	0.85	0.90	NS	NS	NS	NS	NS	9.18	NS	NS	NS	9.18	3.51	12.12
B_1 (*Azotobacter*)	9.22	15.16	6.15	8.55	2.62	7.08	23.69	78.72	3.63	4.00	23.69	78.72	27.28	92.26
B_2 (*Azospirillum*)	9.43	15.66	5.39	7.98	2.75	6.58	21.23	75.28	3.92	4.46	21.23	75.28	21.22	77.33
CD (P=0.05)	NS	NS	0.37	0.39	NS	NS	NS	NS	NS	0.26	NS	NS	2.87	9.90
M_1 (Soil application)	9.23	15.24	6.11	8.19	2.58	6.62	23.06	74.43	3.63	4.21	23.06	74.43	24.32	84.73
M_2 (Seed application)	9.42	15.59	5.43	8.35	2.79	7.03	21.87	79.57	3.92	4.25	21.87	79.57	24.18	84.85
CD (P= 0.05)	NS	NS	0.37	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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