

Response of potato (*Solanum tuberosum*) to bio-fertilizer and nitrogen under North-Eastern hill conditions

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ABSTRACT

A field experiment was conducted during summer season of 1996–98 (March–July) at Upper Shillong, to evaluate the N efficiency with bio-fertilizers inoculation. Combined inoculation of *Azotobacter* and phospho-inoculant culture together significantly increased the tuber yield. When these bio-fertilizers inoculated separately *Azotobacter* gave 7.9% and phospho-inoculant gave 8.6% higher tuber yield significantly up to maximum level (150 kg N/ha). *Azotobacter* increased the tuber yield by 24, 10, 2 and 4% at 0, 50, 100 and 150 kg N/ha respectively. In case of phospho-inoculant the corresponding increase was 22, 13, 2 and 4% and with combined inoculation the increase was 29, 19, 10 and 11% respectively. Combined inoculation of both fertilizers along with 150 kg N/ha was the highest yielder and gave the tuber production in the ratio 22 : 62 : 16 of large, medium and small size tubers, respectively, corresponding to that control had a ratio of 9 : 66 : 25. The highest net return was also obtained from this treatment.

Key words : Bio-fertilizer, *Azotobacter*, Phospho-inoculant culture, Tuber yield, Tuber size

Among major nutrients, as nitrogen plays an important role in improving the growth and yield of potato, a large quantity of nitrogenous fertilizers is applied to the crop. Evidence is growing of favourable effect of *Azotobacter* and phosphate-solubilizing bacteria in providing plant nutrients to several crops and in supplementing the expensive inorganic fertilizers. As no specific information is available on the response of potato crop to nitrogen with bio-fertilizers, a study was undertaken on

this aspect in north-eastern hills region.

MATERIALS AND METHODS

A field experiment was conducted during summer seasons (March–July) of 1996–98 at Upper Shillong to evaluate the efficiency of bio-fertilizers in increasing the efficacy of nitrogen applied to potato crop at varying levels on a typic hapludalf sandy-loam soil. The soil was rich in organic carbon (1.7%) with pH 5.4, medium in available N and K and low in available P.

Four treatments of bio-fertilizers (*Azotobacter* and phospho-inoculant culture strain *Pseudomonas striata* alone and in combination and the control) were allotted in main plots and 4 levels of nitrogen (0, 50, 100 and 150 kg N/ha) were allotted in subplots arranged in split-plot design with 4 replicates. The crop received a basal dose of 52 kg P, 50 kg K and 15 tonnes FYM/ha at planting. The bio-fertilizers were applied in furrows opened for potato planting with farmyard manure. Well-sprouted, healthy tubers of 'Kufri Jyoti' were planted at 60 cm × 20 cm spacing in the last week of March during 1996 and 1997 and first week of April during 1998. Half dose of N was applied at planting and half at earthing time through urea. Plant emergence was recorded just before earthing up. Proper plant-protection measures were adopted to protect the crop from late blight and insect pests. The tubers were lifted from the field in the last week of July when the haulms were fully dried. The produce of each plot graded in 3 sizes, viz. large (>100 g), medium (20–100 g) and small (<20 g). The number of tubers and their weight were recorded separately. For nutrients uptake study samples of tubers and haulm were cut into pieces and dried in hot-air oven at 65–70°C and ground. The N, P and K contents in samples were determined by usual procedure.

RESULTS AND DISCUSSION

Tuber yield

There were no remarkable differences in plant stand due to varying treatments and it was more than 94% during all the 3 years. Combined inoculation of *Azotobacter* and

phospho-inoculant culture significantly increased the plant height, compound leaves, tuber number and tuber weight/hill, which finally increased the tuber yield the significantly (Table 2). When these bio-fertilizers were applied separately, *Azotobacter* gave 7.9% and phospho-inoculant culture 8.6% higher tuber yield over the control. It indicates that when both cultures applied together had synergistic effect on each other and gave more tuber yield and higher recovery of applied nutrients (Table 1). Saxena and Tilak (1994) also reported similar results. Increase in N levels also increased the tuber yield significantly during all the years. This significant increase was up to 100 kg N/ha in 1996 and 1998, and up to 150 kg N/ha during 1997 and pooled yield. The potato yield had quadratic relationship with N levels. Similar response was observed with all the bio-fertilizer treatments. The tuber yield was highly correlated with N as R^2 value was 0.965, 0.951, 0.931 and 0.959 and the optimum N at different bio-fertilizer treatments obtained from quadratic response equation was 116.3, 104.0, 101.0 and 99.8 kg N/ha for the control, *Azotobacter*, phospho-inoculant culture and combined inoculation of both bio-fertilizers respectively. Singh and Sharma (1994) and Daka and Dutta (1997) also reported significant response of potato to N levels in acidic soils. Interaction between bio-fertilizer treatments and nitrogen levels were not significant. *Azotobacter* increased the tuber yield by 24, 10, 2 and 4% at 0, 50, 100 and 150 kg N/ha respectively. In case of phospho-inoculant culture the corresponding increase was 22, 13, 2 and

Table 1. Effect of bio-fertilizer and nitrogen levels on the bio-metric characteristics and nutrients uptake in potato

Treatment	Plant height (cm)	Stems/ m ²	Compound leaves/ m ²	Tubers/ m ²	Tuber weight/ hill (g)	Total nutrients (kg/ha)		
						N	P	K
Control (without bio-fertilizer)	36.7	31.3	340.5	52.8	195.5	73.2	6.53	75.6
<i>Azotobacter</i>	42.5	32.1	389.6	55.8	208.2	82.7	7.48	84.1
Phospho-inoculant culture	45.8	33.7	402.8	56.5	208.9	81.9	8.96	83.2
<i>Azotobacter</i> + phospho-inoculant culture	47.3	34.2	429.3	59.8	225.3	89.6	9.78	91.7
CD (P = 0.05)	7.2	NS	31.2	NS	21.6	9.2	1.4	8.9
<i>Nitrogen (kg/ha)</i>								
0	32.3	28.7	287.3	50.3	153.7	53.8	4.87	55.3
50	39.5	32.3	372.2	54.5	215.5	76.2	7.12	75.9
100	44.7	33.8	412.7	58.3	228.4	84.7	8.47	86.5
150	49.2	35.2	448.5	61.5	236.2	90.5	9.21	88.7
CD (P = 0.05)	8.7	NS	25.7	6.8	25.3	8.7	2.3	10.5

4% and with combined inoculation of both culture was 29, 19, 10 and 11% respectively. It indicates that the bio-fertilizers increased the efficiency of applied nitrogen and its efficiency decreased with increasing N levels. Upadhyay *et al.* (1994), Mahendran and Chandramani (1998) also observed similar results.

Nutrients uptake

The uptake of all the major nutrients increased significantly with combined inoculation of both the bio-fertilizers. The N uptake was higher by 13, 11 and 23.4% with *Azotobacter*, phospho-inoculant culture and combined inoculation of both the bio-fertilizer respectively over the control. Corresponding to that P uptake was higher by 14.5, 37.1 and 49.8 and K was 11.2, 10.1 and 21.3 respectively. Higher

recovery of P was recorded because applied P fixed in the soil due to acidic nature of soil and due to inoculation of phosphorus-solubilizing bacterial culture released the fixed P from the soil and made available to plants. Similar observation was also recorded by Mahendran and Chandramani (1998).

Tuber number and size

The tuber number and large- and medium-size tubers were significantly increased with the increasing levels of N but bio-fertilizer treatments had significant effect only on the production of large-size tuber (Table 1). Bio-fertilizers or N levels did not affect production of small-size tubers significantly. Combined inoculation of *Azotobacter* + phospho-inoculant culture along with 150 kg N/ha was the best

Table 2. Effect of bio-fertilizer treatments and nitrogen levels on the production and economics of potato

Treatment	Tuber yield (tonnes/ha)				Graded tuber yield (tonnes/ha)			Net return (Rs/ha)
	1996	1997	1998	Mean	Large	Medium	Small	
Control (without bio-fertilizer)	15.2	14.2	16.1	15.2	2.4	9.9	2.8	19,948
<i>Azotobacter</i>	16.8	14.9	17.3	16.4	3.2	10.0	3.2	24,548
Phospho-inoculant culture	17.2	15.0	17.2	16.5	3.1	10.5	2.9	25,048
<i>Azotobacter</i> + phospho-inoculant culture	17.7	16.7	18.6	17.7	3.5	11.1	3.1	29,748
CD (P=0.05)	NS	NS	1.5	1.3	0.7	NS	NS	
<i>Nitrogen (kg/ha)</i>								
0	11.4	11.1	14.3	12.3	1.6	7.9	2.8	8,825
50	17.4	15.0	17.3	16.9	3.3	10.3	3.0	25,690
100	19.0	16.2	18.7	18.0	3.5	11.4	3.2	30,755
150	19.1	18.6	18.8	18.9	3.7	12.2	3.0	34,020
CD (P=0.05)	1.5	1.1	1.1	0.7	0.4	0.6	NS	

Cost of cultivation (excluding N and bio-fertilizer cost), Rs 40,000/ha; N/kg, Rs 8.70; Bio-fertilizer, Rs 100/ha + Rs 100 labour cost

Sale price of potato, Rs 4,000/tonne

treatment, which gave the tuber production in ratio 22 : 62 : 16 of large, medium and small-size tubers, respectively, corresponding to that control gave 9 : 66 : 25 ratio respectively. The grade-wise distribution revealed that the increase in yield was due to the cumulative effect of both increase in number and size of tuber. The results confirm the findings of Upadhyay *et al.* (1994) and Sharma *et al.* (1996).

Economic feasibility

Higher net return was obtained with the combined inoculation of both bio-fertilizers, being 49.1, 21.2 and 18.8% higher over the control, *Azotobacter* and phospho-inoculant respectively. Increasing

levels of N over without N gave 191.1, 248.5 and 285.5% higher net return at 50, 100 and 150 kg N/ha respectively. The highest net return was obtained with combined application of both fertilizer along with 150 kg N/ha, followed by 100 kg N/ha at the same bio-fertilizer combination, but it was 7.3% lower than best one.

It could be concluded that the bio-fertilizer as cheaper source may be used in acid soils for sustainable agriculture specially in heavy feeder crops like potato.

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