

Contribution of nitrogen and phosphorus from combined application of *Azotobacter* and phosphobacteria in potato

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Abstract: Field experiments were conducted at AICRP centers viz Bhubaneswar, Chhindwara, Hisar, Kalyani, Kota, Modipuram, Ooty, and Pantnagar to investigate the role of biofertilizers (*Azotobacter* + Phosphobacteria) and *Bacillus* inoculation for nitrogen and phosphorus economy in potato crop. The treatment tuber soaking with 1% urea and sodium bicarbonate along with combined application of *Azotobacter* and PSB at both the fertility levels gave the highest yield at Ooty, Hisar, Chhindwara, Bhubaneswar, Faizabad, Kalyani and Pantnagar and was significantly better than the treatment receiving 100% recommended dose of fertilizers

of nitrogen and phosphorus and 75% recommended dose of fertilizers of nitrogen and phosphorus application (100% of RDF of NP & 75% of RDF of NP). At Faizabad, Hisar and Chhindwara, *Bacillus* tuber treatment was at par with tuber soaking with 1% urea and sodium bicarbonate along with biofertilizers application (*Azotobacter* and PSB) indicating possibility of saving 25% recommended dose of fertilizers of nitrogen and phosphorus at these places using seed soaking and bio-inoculants or *Bacillus* treatment. The yield trend was reflected in net returns also at the entire centre. At Kota centre the use of *B. subtilis* gave the highest yield and net return which was followed by *Bacillus cereus* and tuber soaking and biofertilizer.

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Introduction

Sustainable agriculture aims at long term maintenance of natural resources and agricultural productivity with minimal adverse impact on the environment. It emphasizes optimal crop production with minimal external inputs, reducing dependence on commercial inputs (fertilizers and pesticides) and substituting them with internal resources (Saravanane *et al.*, 2006). At present, there is a need for developing an efficient nutrient management system with the use of organic manures, inorganic fertilizers and biofertilizers to maintain soil fertility and for better crop production (Kamble *et al.*, 2006). The use of fertilizers had played an important role in bringing green revolution in India in late sixties. However, in the recent years, soil productivity and fertility are adversely affected by indiscriminate use of fertilizers resulting in decline in crop productivity. Moreover, the continuous mining of nutrients from soil reserves has led to depletion of essential plant nutrients. In addition, the increased dependence on fertilizers which are imported at a high international price necessitates the need to explore the possible alternative sources of plant nutrients. Microorganism's inoculations have emerged as an important component of integrated

plant nutrients supply (IPNS). They are cheaper as well as pollution free and are based on renewable energy source. Besides, they also improve soil physico-chemical properties, tillth and soil health in the long run (Singh 2001). Phosphate solubilizing Bacteria (PSB) are capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds and PSB produce phosphatase like phytase that hydrolyse organic forms of phosphate compounds efficiently (Zehra 2010).

Biofertilizers are living organisms used in the fertilization of soil and are useful in supplementing the usual application of chemical fertilizers and help in enriching the soil (Densilin *et al.*, 2010). The extent of benefit from these micro-organisms depends on their population and efficiency which, in turn is governed by a soil and environmental factors.

With this back ground, a field study was conducted in different agro-climatic regions of the country at different center of All India Coordinated Research Project on Potato to evaluate role of microorganism inoculation (*Azotobacter* + phosphorus solubilizing bacteria) and *Bacillus* treatment on nitrogen and phosphorus economy in potato.

Materials and Methods

The experiments were conducted at eight centers located in different agro-climatic regions of the country *viz* Kalyani, Kota, Pantnagar, Ooty, Faizabad, Hisar, Chhindwara, and Bhubaneswar during 2003-04 and 2004-05 to investigate the role of biofertilizers (*Azotobacter* + Phosphobacteria) and *Bacillus* treatment of tubers before planting in potato. Popular potato cultivars of the regions namely Kufri Giriraj, Kufri Bahar, Kufri Badshah, Kufri Jawahar and Kufri Jyoti at Ooty, Hisar, Kota & Chhindwara, Pantnagar & Faizabad and Kalyani & Bhubaneswar were used in this study (Table 1). At all the centers the crop was grown during *rabi* (winter) season following recommended package of practices except at Ooty centers where the trial was

conducted in summer/kharif during 2004 and 2005. The four treatments consisting of different combinations of biofertilizers inoculation *viz.* no tuber treatment (T1), Soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes (T2), Soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes + biofertilizers (*Azotobacter* + Phosphobacteria) (T3) and *Bacillus* treatment of tubers before planting (T4) at two fertility levels (100% of RDF of NP & 75% of RDF of NP) were used in the study except at Kalyani, Kota and Pantnagar where *Bacillus cereus* (T4) and *Bacillus subtilis* (T5) were taken at two fertility levels. The experiment was planted in RBD with 4 replications at all centers except at Pantnagar, Faizabad and Kalyani where only three replications were used. Seed tubers were inoculated with biofertilizer culture and dried in shade before planting. The rest of seed tubers were treated in similar way but without bio-fertilizer. Nitrogen was applied in two splits i.e. half at planting and rest at earthing up about 30 days after planting. Basal application of P₂O₅ and K₂O as single super phosphate and muriate of potash, respectively, was made to all the plots as per treatments at the time of planting. At maturity, crop was harvested and tuber yield was recorded as per treatment. Data were analyzed separately for each centre using MSTATC statistical package. For working out net return, price of potato was taken as per respective region.

Results and Discussion

Yield

The tuber soaking and biofertilizer treatment had a positive effect at both fertility level and yield increase was observed during both the year at Kalyani and Pantnagar (Table 2, 3 and 4). At Kalyani, maximum yield 293.1 and 274.22 q/ha with average 283 q/ha was observed under tuber soaking and bio-fertilizer treatment at 100% NP application which was 20.50% and 20.31% higher as compare to 100% recommended dose of NP

Table 1. Experimental details of all centers

Centre	Rep	Plot size Net (m ²)	Variety	Date of Planting		Date of harvesting	
				2003-04	2004-05	2003-04	2004-05
Ooty	4	1.8 x 2.6	Kufri Giriraj	-	23.04.04	-	04.09.04
Hisar	4	3.6 x 3.6	Kufri Bahar	29.10.03	25.10.04	10.3.04	26.2.05
Kota	4	3.6 x 3.6	Kufri Badshah	12.11.03	9.10.04	05.3.04	4.3.05
Pantnagar	3	3.6 x 2.6	Kufri Jawahar	01.11.03	10.11.04	09.2.04	21.2.05
Faizabad	3	3.6 x 3.6	Kufri Jawahar	17.11.03	3.11.04	27.2.04	20.2.05
Chhindwara	4	3.6 x 3.6	Kufri Badshah	04.12.03	1.11.04	18.3.04	28.2.05
Kalyani	3	4.68	Kufri Jyoti	03.12.03	2.12.04	17.3.04	14.3.05
Bhubaneswar	4	3.6 x 3.6	Kufri Jyoti	24.11.03	23.11.04	23.2.04	22.02.05

during both the year. Whereas, at Pantnagar, tuber soaking and bio-fertilizer at 75% NP application gave maximum yield 272.44 and 258.90 q/ha during both the year with average 248.58 q/ha which was 13.91 and 31.94% higher as compare to control (recommended dose of NPK). However, at Kota tuber soaking and biofertilizers at 100% NP and 75% NP increased the yield but increase did not reach to the level of significance. The treatment with *Bacillus subtilis* was most effective and increased the yield significantly at both fertility levels (100% NPK and 75% NP & full K) during both years. Treating with *Bacillus subtilis* at 100% NP gave maximum mean yield (227.72 q/ha) followed by bacillus cereus (215.18 q/ha). Percent increase by the *Bacillus subtilis* was 39.75% and 39.70% followed by Bacillus cereus (34.93% and 29.38%) as compared to control.

At Ooty centre, both the years, soaking of seed tubers in 1% urea + 1% sodium bicarbonate for 5 minutes and biofertilizers (*Azotobacter* + Phosphobacteria) gave higher mean yield 237.54 q/ha (206.62 and 268.5 q/ha during both years) at 100% NP application, which was significantly better as compare to other treatment and which was 20.27% and 18.28% higher than control (recommended dose of NPK) during both the year. Tuber soaking with 1% urea and sodium bicarbonate along with biofertilizer was able to improve yield even at 100% NP. This tuber treatment was also saving 25% NP fertilizers as it gave statistically at par yield at 75% recommended NP with 100% NP.

At Faizabad, maximum yield (272.72 and 266.65 q/ha) was observed with bacillus treatment at both 100% and 75 % NP levels as compared to 100% NPK (250.13 q/ha). Yield with tuber soaking and biofertilizer at 100 % NP levels was at par with Bacillus treatment at 100% NP application but at 75% NP application bacillus treatment was significantly superior to tuber soaking and biofertilizer.

At Hisar, Soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes + Biofertilizers (*Azotobacter* + Phosphobacteria) gave better yield at both the fertility levels as compared to bacillus treatment at both fertility levels. This treatment gave maximum average yield 416.28 and 394.77q/ha at both the fertility levels followed by bacillus treatment as compared to 100% NPK application.

At Chhindwara, Soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes + Biofertilizers (*Azotobacter* + Phosphobacteria) and bacillus treatment of tubers before planting gave better yield at both the fertility levels as compared to 100% NPK. At 100% NP level seed soaking and biofertilizers treatment gave maximum average yield (244.84 t/ha) closely followed by bacillus treatments at 100% NP (244.12 q/ha). These treatments were at par to each other. Yield with tuber soaking and bio-fertilizers at 100% NP application was 16.73 and 17.27% higher compared to 100% NPK application during both the years.

At Bhubaneswar, significantly maximum yield (163.58 and 158.95 q/ha) was observed with tuber soaking and bio-fertilizer at both the fertilizer levels as compared to recommended dose of NPK (136.57 q/ha). Therefore, it was possible to save 25% of NP fertilizers with the use of biofertilizer and seed soaking at this center also.

Similar results were obtained by Subba Rao (1993), Singh *et al.*, (2006) and Densilin *et al.*, (2010) that Biofertilizers are the formulation of living microorganisms, which are able to fix atmospheric nitrogen in the available form for plants either by living freely in the soil or being associated symbiotically with plants. Biofertilizers are inputs containing microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes (Tien *et al.*, 1979).

Table 2. Effect of two fertility level and biofertilizer (*Azotobacter* + Phosphobacteria) on mean total tuber yield (t/ha) at different centers.

Treatments	Kalyani	Kota	Pantnagar	Ooty	Hisar	Chhindwara
F1 T1	235.59	162.86	217.42	199.40	399.40	209.25
F1 T2	260.34	179.11	232.74	202.21	399.98	224.33
F1 T3	283.66	192.90	248.58	237.56	416.28	244.84
F1 T4	272.98	215.18	232.20	209.31	407.21	244.12
F1T5	274.94	227.72	237.01	-	-	-
F2 T1	230.60	152.11	237.90	161.15	381.85	196.30
F2 T2	253.92	155.67	236.83	160.49	382.23	214.27
F2 T3	268.53	158.28	265.67	205.56	394.77	229.42
F2 T4	258.55	171.69	249.30	168.07	385.13	227.53
F2T5	259.98	194.93	254.01	-	-	-

Table 3. Effect of two fertility level and biofertilizer (*Azotobacter* + Phosphobacteria) on total tuber yield (t/ha) at different centers

Treatments	Kalyani		Kota		Pantnagar	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
F1 T1	243.24	227.93	161.26	164.45	238.61	196.23
F1 T2	272.09	248.58	177.66	180.55	256.42	209.05
F1 T3	293.10	274.22	195.79	190.01	265.68	231.48
F1 T4	274.58	271.37	217.59	212.77	252.85	211.54
F1T5	284.91	264.96	225.69	229.74	243.95	230.06
F2 T1	239.68	221.52	149.50	154.71	242.17	233.62
F2 T2	264.96	242.88	151.43	159.91	259.98	213.68
F2 T3	275.65	261.40	155.48	161.07	272.44	258.90
F2 T4	270.66	246.44	178.05	165.32	254.64	243.95
F2T5	275.65	244.31	205.44	184.41	251.07	256.95
CD (P=0.005)	NS	NS	42.13	28.32	NS	NS

Table 4. Effect of two fertility level and biofertilizer (*Azotobacter* + Phosphobacteria) on total tuber yield (t/ha) at different centers

Treatments	Ooty		Faizabad		Hisar		Chhindwara	Bhubaneswar
	2004	2005	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04
F1 T1	171.80	227.00	250.13	419.56	379.24	203.07	215.43	136.57
F1 T2	172.22	232.20	258.83	414.93	385.03	217.90	230.75	157.41
F1 T3	206.62	268.50	271.00	435.57	396.98	237.04	252.64	163.58
F1 T4	178.42	240.20	272.72	418.01	396.41	236.48	251.76	150.46
F2 T1	136.59	185.70	244.05	413.58	350.11	192.44	200.15	136.19
F2 T2	137.18	183.80	261.42	406.63	357.83	209.03	219.50	140.24
F2 T3	176.71	234.40	222.36	422.07	367.47	228.45	230.38	158.95
F2 T4	143.64	192.50	266.65	403.55	366.70	226.85	228.20	148.92
CD (P=0.005)	16.1	22.65	28.91	6.06	16.38	13.99	17.43	9.2

Table 5. Effect of two fertility level and biofertilizer (*Azotobacter* + Phosphobacteria) on mean net return (Rs/ha) at different centers except at Faizabad and Bhubaneswar

Treatments	Kota	Pantnagar	Ooty	Faizabad	Hisar (Over control)	Chhindwara	Bhubaneswar
F1T1	53628	3997	23489	48000	0	52733	16000
F1T2	59206	3369	23393	50136	-491	57730	18760
F1T3	63976	6815	38016	52999	2776	63601	20760
F1T4	71963	2866	27149	54373	956	63355	17420
F1T5	76350	4669	-	-	-	-	-
F2T1	50551	7899	9436	46940	0	48962	17190
F2T2	52001	8299	8701	52148	-527	54951	16160
F2T3	52532	15192	26657	39956	1988	58859	21560
F2T4	57397	11507	12114	53053	50	58194	20350
F2T5	65541	12829	-	-	-	-	-

Net return

The mean net returns followed similar trend as yield at different centers (Table 5). At Kota, maximum mean net return (Rs 76350/ha) was obtained by the application of 100% NP + *Bacillus subtilis* closely followed by 100% NP + *Bacillus cereus* with Rs 71936 net return/ha during the year of experimentation. Therefore, it can conclude that both the species bacillus were superior

over bio-fertilize (Rs 63976/ha) at Kota. Whereas, At Pantnagar, application of 75% NP + soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes and biofertilizers (*Azotobacter* + Phosphobacteria) gave maximum mean net return (Rs 15192/ha) during the years of experimentation followed by 75% NP + *Bacillus subtilis* (Rs 12829/ha), whereas, minimum mean net return (Rs 3997/ha) was observed when 100% NPK was applied.

At Ooty, maximum mean net return (Rs 38016/ha) was obtained with 100% NP along with soaking of seed tubers and use of biofertilizers (*Azotobacter* + Phosphobacteria) which was 63% more net return as compare to only recommended dose of NPK application (Rs 23489/ha). At Faizabad, maximum net return (Rs 54,373/ha) was under 100% NP + *Bacillus* treatment as compared to control (Rs 48000/ha). This was followed by 75% NP application along *Bacillus* treatment (Rs 53053/ha). At Hisar, soaking of seed tubers and biofertilizers (*Azotobacter* + Phosphobacteria) inoculation gave higher mean net return at both the fertility levels during both years as compared to control. But maximum was under 100% NP application.

At Chhindwara, soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes + biofertilizers (*Azotobacter* + Phosphobacteria) inoculation and *bacillus* treatment gave highest mean net return (Rs 63601 and 63355/ha) at 100% NP application followed by 75% NP application which was higher over 100% recommended dose of NPK application (Rs 52733/ha). Whereas, at Bhubaneswar, soaking of seed tubers and biofertilizers inoculation gave maximum net return at 75% NP application followed by 100% NP application.

At Ooty, Faizabad, Hisar, Chhindwara and Bhubaneswar soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes and biofertilizers (*Azotobacter* + Phosphobacteria) gave maximum net return at both the levels of fertilizers *i.e.* 100% NP and 75% NP but at Chhindwara, *Bacillus* treatment gave nearly same net return at 100 and 75% NP application. At Kota, *Bacillus subtilis* gave higher net return at 100 and 75% NP compare to tuber soaking and biofertilizer. At Pantnagar, soaking of seed tubers in solution of 1% urea + 1% sodium bicarbonate for 5 minutes and biofertilizers (*Azotobacter* + Phosphobacteria) gave higher net return at 75% NP application. Therefore, it can be concluded that soaking of tuber + application of bio-fertilizer and *Bacillus* treatment alongwith inorganic fertilizer increased yield and net return at all centers as compared to alone application the fertilizers. .

Appropriate combination of biofertilizer, would be favourable for greater nutrient uptake by the crop and also would improve the soil health and soil fertility status. Soaking in a solution containing 1% each of urea and sodium bicarbonate along with seed treatment with *Azotobacter* + Phosphobacteria at both the fertility levels of NP improved potato yield as compared to alone application of the fertilizer and also economized N & P

fertilizer. Potato seed tuber treatment with *Bacillus cereus* or *Bacillus subtilis* along with recommended dose of NPK was also recommended to get higher yield. Seed soaking + biofertilizer treatment (*Azotobacter* + Phosphobacteria) and *Bacillus* treatment along with recommended dose of NPK gave more yields even by recommended dose of fertilizer.

सारांश

एक प्रयोग एआईसीआरपी केन्द्र भुवनेश्वर, छिन्दवाड़ा हिसार, कलपानी, कोटा, गोदीपुरम, ऊटी और पंतनगर में जैव खाद (एजोटोवैक्टर+ फोस्फोवैक्टरिया) और बैसिलस के रोल को N₂ और फास्फोरस के लिए किया गया। ट्यूबर को 1% यूरिया सोडियम बाइकार्बोनेट के साथ सोक करके (एजोटोवैक्टर और पीएसबी के साथ लगाया गया। अधिकतम उपज ऊटी, हिसार, छिन्दवाड़ा, भवनेश्वर फैजाबाद और पन्तनगर में पाया गया। यह उपज नाइट्रोजन (75%) खाद से ज्यादा था। फैजाबाद, हिसार और छिन्दवाड़ा में बैसिलस के ट्यूबर को 1% यूरिया और सोडियम बाइकार्बोनेट के साथ सोक करके लगाया गया। यह उपज दूसरे केन्द्र में उपज से अलग था। कोटा केन्द्र पर बै. सब्सटिलिस की उपज दूसरे बै. सिरस से अधिक था।

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