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Influence of microorganisms inoculation on nutrient economy in Potato-radish crop sequence in North Western Himalayas

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Abstract: Field experiments were conducted during 2007 and 2008 at Central Potato Research Institute on brown hill soils of Shimla to investigate the role of microorganism inoculation in fertilizer economy in potato-radish crop sequence. Different doses of inorganic fertilizers along with FYM and microorganisms inoculation showed significant effect on growth attributes, yield and nutrient uptake of potato as well as yield and nutrients uptake by radish. Application of FYM @ 5 t/ha along with microorganisms inoculation helped in early emergence. Combined application of 50% recommended dose of NPK through fertilizers along with tuber inoculation with microorganisms and 5 t/ha FYM proved to be more effective in terms of growth attributes, tuber yield, nutrients uptake and recoveries. Radish yield also showed similar trend with respect to different treatments and highest value was recorded under 50% recommended dose of NPK through fertilizers along with tuber inoculation with microorganisms and 5 t/ha FYM. This treatment was statistically at par with recommended doses of NPK. Therefore, use of microbial inoculants along with FYM can save half of fertilizer NPK in the north western hill region.

Introduction

The use of fertilizers played an important role in bringing green revolution in India in late sixties. However, in the recent years, soil productivity and fertility have been adversely affected by imbalanced and 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. Microorganisms inoculation have shown a good promise and 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 and soil health in the long run (Singh, 2001). The extent of benefit from these micro-organisms depends on their population and efficiency which, in turn is governed by a number of soil and environmental factors. Potato-radish is one of the important emerging cropping systems in north western hills (Singh *et al,* 2008). However, the information on microorganisms inoculation in potato and radish cropping system integrating it with other inorganic and organic sources of nutrients need to be generated. With this back ground field studies were conducted during 2007 and 2008 on slightly acidic soil in mid hills of Shimla to evaluate the role of microorganism inoculation (*Azotobacter* + phosphorus solubilizing bacteria) on nutrients economy in potato-radish crop sequence.

Materials and Methods

Field experiments were conducted during 2007 and 2008 at Central Potato Research Institute, Shimla. The soil was sandy loam having pH 6.18, organic carbon 1.76%, total N 0.36%, Brays P 125 kg/ha and NH_4OAc-K 475 kg/ha. During both the years potato planting was done in first week of April and radish was planted in first week of September after harvesting of potato and harvested after 70 days. Eight manurial treatments involving combinations of NPK through inorganic fertilizer and microorganisms inoculation *(Azotobacter+PSB) viz.*, Control (T1), 100% NPK

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through fertilizer (T2), 50% NPK through fertilizer (T3), 50% NPK through fertilizer along with 5t/ha FYM (T4), 50% NPK through fertilizer along with microorganisms inoculation (T5), 50% NPK along with 5t/ha FYM and microorganism inoculation (T6), 5t/ha FYM (T7) and only microorganisms inoculation (T8) were replicated three times using randomized block design. FYM as per the treatments was applied at the rate of 5 t/ha at the time of planting. Seed tubers were inoculated with microorganisms culture mixed in 5% sucrose solution for 10 minutes and dried in shade before planting. Likewise, the rest of seed tubers were treated in similar way but without bio-fertilizers. Nitrogen was applied @ 120 kg/ha in splits *i.e.* half at planting and rest at earthing up at 50 days after planting through calcium ammonium nitrate. Basal application of P and K through single super phosphate and muriate of potash respectively was done to all the plots as per treatments at the time of planting. Same treatments and similar microbial inoculation procedure were followed for succeeding radish crop. Recommended dose of fertilizer for potato and radish for N, P_2O_5 and K_2O was 120, 100, 100 and 100, 50 and 40 kg /ha, respectively, which was applied through calcium ammonium nitrate, single super phosphate and muriate of potash. Net plot size was 2.5 X 2.5 m with spacing of 50 X 25 cm for potato and 25 X 10 cm for radish. Both crops were raised following the recommended package of practices except the nutrient management.

Tubers, haulms and radish sample from each plot were washed with 0.1 N HCI solution to remove the dust and spray particles and then rinsed with distilled water. The samples were dried in hot air oven at 60 ºC and ground. N content in plant samples was determined by Kjeldahl method and for P and K estimation, samples were digested with nitric and perchloric acid (Jackson, 1967). Vanadate phosphomolybdate yellow colour method was followed for the determination of P in the extract and K was determined from same extract (Chapman, and Pratt, 1965) using flame photometer. Data were pooled over the years and analysed following standard statistical procedure. For working out net return from potato-radish crop sequence, price of potato and radish was taken as Rs. 700 and 400/q, respectively. Agronomic efficiency (AE), physiological efficiency (PE), apparent recovery (AR %) and percent yield response were computed using the tuber yield data, rates of fertilizer nutrients applied and total uptake by potato as follows.

(1) Agronomic efficiency (AE):

$$\frac{\text{Tuber yield in fertilized plot- Tuber yield in unfertilized plot}}{\text{Quantity of total nutrient applied}}$$

(2) Physiological efficiency (PE):

$$\frac{\text{Tuber yield in fertilized plot- Tuber yield in unfertilized plot}}{\text{Uptake in fertilized plot- Uptake in unfertilized plot}}$$

(3) Apparent recovery (AR %):

$$\frac{\text{Uptake in fertilized plot- Uptake in unfertilized plot}}{\text{Quantity of total nutrient applied}}$$

(4) Yield Response:

$$\frac{\text{Yield in fertilized plot - Yield in unfertilized plot}}{\text{Yield in unfertilized plot}}$$

Results and Discussion

Growth and yield of potato

Plant emergence at 30 days after planting showed significant effect of different treatments (Table 1). Maximum emergence was observed with application of FYM only (63%) which was at par only with those treatments where FYM was applied along with chemical and /or microorganism inoculation. However, after 40 days of planting there was no significant difference in the emergence. Application of NPK, FYM and microorganisms inoculation significantly increased plant growth attributes as compared to control and maximum increase in growth attributes *i.e.* plant height (24.23 cm), number of shoots/plant (2.27) and number of leaves/plant (12.61) were observed under combined application of 50% NPK through fertilizers along with tuber inoculation with microorganisms and 5 t/ha FYM,

Table 1. Effect of NPK and microorganism inoculation on plant emergence and yield attributes of potato

Treatments	Emergence at 30 DAP	Plant height (cm)	No. of Shoots/ plant	No. of Leaves/ plant
Control	57	15.21	1.30	8.00
100% NPK	45	23.40	2.07	12.47
50% NPK	50	20.57	1.73	9.80
50% NPK+ @ 5t FYM	59	20.57	1.93	9.27
50% NPK+ microorganisms	34	22.20	1.80	11.07
50% NPK+@ 5t FYM+ microorganisms	61	24.23	2.27	12.61
FYM @ 5t/ ha	63	21.53	2.13	10.73
Only microorganisms	58	20.71	1.93	10.09
CD at 5%	5.2	2.97	0.28	1.63
SE±	7.68	2.19	0.60	1.87

which was at par with 100% NPK , 50% NPK along with FYM and 50% NPK along with microorganism inoculation.

Total yield tuber increased significantly with the use of NPK, microorganisms and FYM as compared to control. The maximum yield (227 q/ha) was observed with 50% NPK and 5 t/ha FYM along with biofertilizers followed by 100% NPK (220 q/ha) and 50% NPK+ FYM (212 q/ ha). These treatments were at par and significantly better than other treatments including only FYM, only bio-fertilizers, application of 50% NPK and control. This showed that application of 5 t FYM/ha along with bio-inoculation can economize on inorganic N, P_2O_5 and K_2O by 60, 50 and 50kg /ha, respectively. Marked increase in yield of potato tubers under integrated use of organic, inorganic and biological sources of nutrients was possibly due to better growth attributes in these treatments. Beneficial effect in the north eastern hill region on yield and growth parameters (plant height, number of leaves and stems/plant) as a result of biofertilizer inoculation has also been reported earlier by Singh, (2002), Singh, (2002a) and Singh, (2002b). In the north western hills, increase in growth parameters by *Azotobacter* in combination with organic sources of plant nutrients has been reported by Sood and Sharma, (2001). The percent yield response followed similar trend as that of the tuber yield.

Nutrient uptake and apparent recovery

The uptake of N, P and K was significantly affected by different treatments (Table 2). Maximum uptake of N, P and K (63.4, 16.8 and 64.3 kg/ha) by tubers was obtained with 50% recommended dose of NPK + FYM + Bioinoculants which was statistically at par with 100% recommended dose of NPK followed by 50% NPK + FYM and 50% NPK + bio-fertilizers. Since the combined application of organic, inorganic sources of nutrients and biofertilizers resulted in increased yield and yield attributes of potato so the uptake values of above nutrients also registered a simultaneous increase. The increase in nutrient uptake was reflected in the enhanced recoveries of applied fertilizer N, P and K with the application of integrated use of organic nutrient sources including FYM and microorganisms (Fig. 1). Earlier studies at Shimla also found increased uptake and recovery of P in the presence of PSB (Sud and Jatav, 2007). This may be due to beneficial effect of PSB in the acidic soils by the release of native P present in the soil which in turn makes sufficient P in soil solution around root zone (Anonymous, 2008).

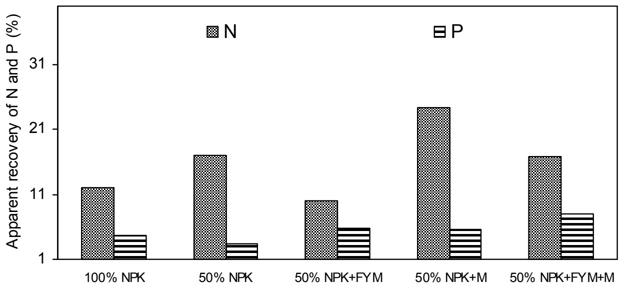

Fig: 1 Effect of microorganism inoculation on apparent nitrogen and phosphorus recovery

Physiological and agronomic efficiency

Physiological efficiency is the increase in tuber production obtained per unit increase in nutrient absorbed over control, whereas, agronomic efficiency is the increase in economic yield per unit increase in nutrient applied. Physiological and agronomic efficiencies of potato crop were significantly influenced by the various combinations of NPK, FYM and bio-fertilizers. Maximum physiological efficiency for N and P (5.45 and 13.14 q/kg, respectively) was obtained when 50% NPK was applied through fertilizers along with FYM (Table 3). This was followed by 50% NPK + FYM + biofertilizers and 100% NPK through fertilizers.

Table 2. Effect of NPK and microorganism inoculation on yield, yield response and nutrients uptake by potato

Treatments	Yield (q/ha)	Yield response (%)	Nutrient uptake by tuber (kg/ha)		
			N	P	K
Control	165	---	42.9	11.7	46.4
100% NPK	220	33.08	57.3	16.6	59.5
50% NPK	182	9.81	53.1	13.4	55.3
50% NPK+ @ 5t FYM	212	28.21	51.4	15.3	58.1
50% NPK+ microorganisms	196	18.49	57.1	16.8	64.3
50% NPK+@ 5t FYM+ microorganisms	227	37.56	63.4	15.2	59.0
FYM @ 5t/ha	186	12.48	51.7	16.0	61.4
Only microorganisms	180	8.93	48.7	15.1	57.0
CD at 5%	37	----	61.6	2.3	10.5
SE±	7.68	----	2.19	0.60	1.87

Table 3. Effect of NPK and microorganism inoculation on physiological efficiency (q/kg) and net return from potato

Treatments	Physiological efficiency		
	N	P	K
Control	-	-	-
100% NPK	3.79	11.61	4.15
50% NPK	1.58	9.54	1.82
50% NPK+ @ 5t FYM	5.45	13.14	3.97
50% NPK+ microorganisms	1.49	8.94	2.42
50% NPK+@ 5t FYM+ microorganisms	4.36	12.75	3.46
FYM @ 5t/ha	2.33	4.79	1.38
Only microorganisms	2.52	4.38	1.38

Whereas, for K 100% NPK application through fertilizers gave highest physiological efficiency (4.15 q/kg) followed by 50% NPK through fertilizer + FYM and application of 50% NPK + FYM + microorganisms inoculation. This clearly indicates that in the treatments where organic sources partly replaced the inorganic fertilizer, crop was able to convert the absorbed nutrients particularly N and P in economic yield in a better way. Lowest physiological efficiency of N was observed in treatment where only 50% NPK was applied indicating that due to stress of P and K the absorbed N could not be converted into yield. However, in the absence of chemical fertilizers, there was stress of N in the plant and the absorbed P and K could not be converted in to the yield therefore, their physiological efficiency was the lowest when no chemical fertilizer was applied. The apparent agronomic efficiency of fertilizer N and P increased with the application of FYM (Fig. 2). The maximum efficiency was observed when both FYM and microorganisms inoculation were used with 50% NPK. This was also due to increased availability of these nutrients from bio-fertilizers and FYM.

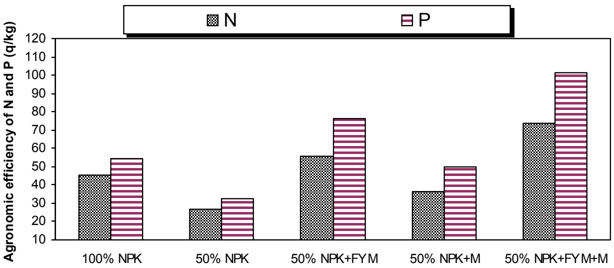

Fig. 2. Effect of microorganism inoculation on agronomic efficiency of N and P

Radish yield

The yield of radish under different dose of NPK through inorganic fertilizer alone and along with microorganisms followed similar trend as that of potato tuber yield (Table 4). Radish and radish top yield (127.78 and 85.26 q/ha) was also higher in the treatment where 100% NPK was applied through inorganic fertilizers and it was at par with 50% NPK + FYM and microorganisms (125.87 and 85.69 q/ha radish and radish top yield). In other treatments, where inorganic fertilizers, FYM and microbial inoculation were not combined, radish yield decreased significantly. This was possibly due to the fact that at this proportion, availability of N from microbial inoculum and P from native sources to radish was increased. Microbial inoculation, FYM and inorganic fertilizer maintained the availability of nutrients at a rate at which crop did not suffer from nutrient deficiency. It was clear that inoculation of microorganism along with FYM and 50% of recommended dose of NPK resulted into more uptake of NPK through radish, radish top and total by whole plant and was at par with 100% of recommended dose of NPK (100, 50 and 40 kg/ha N, P_2O_5 and K_2O). This may be due to balance availability of nutrient and favourable microbial activity in root zone for proper root and shoot growth.

Net return and benefit cost ratio of the system

Net return from potato-radish crop sequence also followed similar trend (Table 5) as that of tuber yield with highest values of Rs 108077/ha observed in 50% inorganic NPK + FYM and bio-fertilizer treatment. This was closely followed by 100% NPK (Rs 107792/ha) and 50% inorganic NPK along with FYM (Rs 94677/ha). FYM application and microorganism inoculation along with 50% NPK and 100% NPK gave higher net return of Rs 35605/ha and Rs 34920/ha respectively, followed by half recommended dose of NPK along with FYM (Rs 22205/ha) as compared to only 50% NPK application through fertilizer. Singh (2000) reported that the combined use of *Azotobacter*+ phosphobacteria gave

Table 4. Effect of NPK and microorganism inoculation on yield, and nutrients uptake by succeeding crop radish

Treatments	Radish yield (q/ha)	Radish top yield (q/ha)	Nutrients uptake by radish (kg/ha)			Nutrients uptake radish top (kg/ha)			Total nutrients uptake radish (kg/ha)		
			N	P	K	N	P	K	N	P	K
Control	78.56	41.00	10.20	1.78	20.17	15.47	1.65	16.10	25.67	3.42	36.26
100% NPK	127.78	85.26	20.28	4.08	41.83	44.25	4.34	46.29	64.53	8.42	88.11
50% NPK	98.65	62.56	14.05	2.62	18.89	27.74	3.11	31.29	41.79	5.73	50.18
50% NPK+FYM	114.20	84.36	16.93	3.48	34.15	39.68	4.01	42.03	56.61	7.49	76.18
50% NPK+ microorganisms	113.45	81.56	17.43	3.51	25.30	41.42	3.73	41.29	58.85	7.24	66.59
50% NPK+FYM+ microorganisms	125.87	85.69	19.65	3.84	39.55	43.46	4.08	44.83	63.11	7.92	84.38
FYM @ 5t/ha	91.56	65.35	13.97	2.85	25.99	31.12	3.30	31.89	45.09	6.15	57.87
Only microorganisms	93.48	66.23	13.90	2.78	25.69	29.68	3.16	33.05	43.59	5.94	58.74
CD at 5%	13.65	8.25	2.78	0.58	4.78	3.15	0.61	6.01	8.87	1.16	11.50

Table 5. Effect of NPK and microorganism inoculation on net return from potato-radish crop sequence (Rs/ha)

Treatments	Cost of cultivation	Net return	B:C ratio
Control	95000	56368	1.59
100% NPK	110520	107392	1.97
50% NPK	103291	72472	1.70
50% NPK+ @ 5t FYM	113291	94677	1.84
50% NPK+ microorganisms	104291	91412	1.88
50% NPK+@ 5t FYM+ microorganisms	114291	108077	1.95
FYM @ 5t/ha	105000	72273	1.69
Only microorganisms	96000	77913	1.81

higher tuber yield and net return as compared to separate use of microorganisms and control in the north eastern hill region. The benefit: cost ratio was highest in the treatment receiving 100% NPK through fertilizer (1.97) closely followed by 50% inorganic NPK along with FYM and treatments (1.95) and 50% NPK along with microorganism inoculation (1.88). Whereas, control gave the lowest B: C ratio (1.59) B: C ratio.

The results showed that in rainfed areas of north western Himalayas where soil organic matter is high, microorganism inoculation (phosphate solubilizing bacteria (PSB) + *Azotobacter)* are of great importance in reducing fertilizer doses and practicing integrated plant nutrients supply. It may be concluded that combined application of 50% recommended dose of NPK along with tuber inoculation with microorganisms and 5 t/ha FYM for potato and radish can be effective in reducing the inorganic NPK dose by 50%. Besides saving 50% inorganic fertilizer, this treatment also showed increased efficiency, net return and B: C ratio.

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सारांश

वर्ष 2007 और 2008 के फील्ड प्रयोगों के दौरान भूरे रंग के शिमला के पहाड़ी मिट्टी पर केन्द्रीय आलू अनुसंधान संस्थान में आयोजित किए गये आलू–मूली फसल अनुक्रम में उर्वरक अर्थव्यवस्था में सूक्ष्मजीव की भूमिका की जांच की गयी। एफवाईएम और सूक्ष्मजीवों के साथ अकार्बनिक उर्वरकों के विभिन्न खुराक से आलू की उपज और पोषक तत्व तेज द्वारा मूली की उपज पर महत्वपूर्ण प्रभाव दिखा। एफवाईएम के अनुप्रयोग/5 टन प्रति हेक्टेयर/सूक्ष्मजीवों के साथ जल्दी उद्‌भव में मदद मिलती है। एफवाईएम विकास विशेषताओ, कंद उपज, पोषक तत्वों के मामले में 50% की संयुक्त सुक्ष्मजीवों और 5 टन/हेक्टेयर एनपीके की खुराक और अधिक प्रभावी साबित हुई है। मूली उपज भी सूक्ष्मजीवों और 5 टन/हेक्टेयर 50% उर्वरक की खुराक के माध्यम से और अधिक प्रभावी साबित हुई है। इसलिए, एफवाईएम के साथ सूक्ष्म जीवों का उपयोग से उर्वरक एनपीके से उत्तर पश्चिमी पहाड़ी क्षेत्र में बचा सकता है।

References

Anonymous (2008) Annual Scientific Report, Central Potato Research Institute, Shimla, pp. 144.

Chapman HD and Pratt PF (1965) Method of Analysis for Soil, Plants and Water. Div. Agril. Sci. Univ. Calif., USA.

Jackson ML (1967) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Singh K (2000) Effect of inoculation with *Azotobacter* and Phosphobacteria on potato (*Solanum tuberosum*) in north-eastern hills. Indian Journal of Agricultural Sciences 70(6): 385-386.

Singh K (2001) Response of potato *(Solanum tuberosum*) to bio-fertilizer and nitrogen under north-eastern hill conditions. Indian Journal of Agronomy 46(2): 375-379.

Singh K (2002) Role of biofertilizers in increasing the efficiency of nitrogen to potato crop under north eastern hill conditions. In: Potato, Global Research and Development Vol. 2 (SM Paul Khurana *et al*., Eds). Indian Potato Association, CPRI, Shimla pp. 904-07.

Singh SK (2002a) Effect of phosphobacteria, nitrogen and phosphorus on the tuber yield of potato *(Solanum tuberosum)* under East Khasi hill conditions of Meghalaya. Indian Journal of Agronomy 47(2): 273-277.

Singh SK (2002b) Efficacy of phosphate solubilizing biofertilizer with phosphorus on potato yield. In: *Potato, Global Research and Development* Vol. 2 (SM Paul Khurana *et al*., Eds). Indian Potato Association, Central Potato Research Institute, Shimla pp. 908-11.

Sood MC and RC Sharma (2001) Value of growth promoting bacteria, vermicompost and *Azotobacter* on potato production in Shimla hills. Journal of Indian Potato Association 28(1): 52-53.

Sud KC and MK Jatav (2007) Response of potato to phosphorus and phosphorus solubilizing bacteria in brown hill soils of Shimla. Potato Journal 34:109-11.

Singh JP, Dua VK, Kumar Manoj, Govindakrishnan, PM and Lal, SS (2008) Cultural management of crops in potato based cropping systems in India, CPRI, Extension Bulletine No. 39, Central Potato Research Institute, Himachal Pradesh, India, 48 pp.