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Productivity and Sustainable Soil Health Management of Potato (*Solanum tuberosum* L.) Field as Influenced by Bio-fertilizers

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A B S T R A C T

An On- farm trial were conducted during *Rabi* season of 2015-16 and 2016-17 at farmers field on pre-selected seven locations in Muzaffarpur district of Bihar considering farmers as replication to assess the efficacy of bio-fertilizers on yield and economics of potato. The results revealed that nutrient management of biofertilizer has statistically significant impact on tuber yield and economics as well as soil fertility status. The highest tuber yield (22.65 and 23.50t ha^{-1}) was obtained significant in the treatment N_{120}-P_{72}-K_{100} along with *Azotobacter* +PSB as compared to N_{150}-P_{90}-K_{100} (RDF) as well as farmers practice. The maximum net return (Rs. 65375.00 ha^{-1} and Rs.70250.00 ha^{-1}) and B: C ratio (2.31 and 2.49) was found in N_{120}-P_{72}-K_{100} along with *Azotobacter* +PSB over N_{150}-P_{90}-K_{100} (RDF) and farmers practice. However,the seed treated with *Azotobacter* and PSB registered net positive balance of available nitrogen and phosphorus soil status over initial.

Introduction

Potato (*Solanum tuberosum* L.) is very popular and important vegetable grown all over world. It is the fourth important crop after maize, wheat and rice (FAO, 2009).Potato is a high yielding, nutrient exhaustive short duration crop which needs higher quantities of fertilizers. A normal potato crop yielding 30 t/ ha removes about 100 kg N ha^{-1} from soil (Pandey *et al.*, 2006). Soil fertility depletion and productivity are the matter of nutrient imbalance, which limits crop yield.

Nitrogen, phosphorus and potassium are the supplements of nutrient influencing development, improvement and yield of potato. The phosphorus directly affects shoot development, root advancement and tuber

arrangement in potato while potassium is one of the vital constituent of cell and has impact on nature of tuber. Bio-fertilizers are biologically active products or microbial inoculants containing one or more beneficial bacteria orfungal strains in easy to use and economical carrier materials which conserve and mobilize crop nutrients in the soil.

Bio-fertilizer contains living microorganisms which when applied to seed, plant surfaces, or soil colonizes the *rhizospehere* or the interior of theplant and promotes growth by increasing theavailability of primary nutrients to the host plant (Mazid *et al.,* 2011a).At present the terrestrial input of nitrogen from biological N_2 fixation is held to be in the range of 139-170 X 106 t N per year as compared with 65 X 106 t N per year provided by fertilizer nitrogen.

However, on average the relative contribution of symbiotic, associative and free-living N-fixing systems is in the order of 70% symbiotic and 30% non-symbiotic. Maintaining the quality and sustainability of soil resources is a key issue, not only for optimizing the stability and productivity of natural ecosystems, but also to prevent erosion and minimize negative environmental stresses (Buscot, 2005). Integrated plant nutrient management has vital significance for the maintenance of soil productivity and boosting yield, reducing production cost and improving soil health are three inter-linked components of the sustainability triangle (Swarup,2010).

Keeping above mentioned facts and figures in point of view, the present investigation were taken up to study the effect of addition of *Azotobacter* and phosphorus-solublizing bacteria in supplementation of nutrient demand of potato (*Solanum tuberosum* L.) on yield and nutrient status of soil.

Materials and Methods

An On-farm trial was carried out during *Rabi* seasons of 2015-16 and 2016-17 under supervision of Krishi Vigyan Kendra, Sariya, Muzaffarpur (Bihar) on randomly pre-selected 07 farmers' fields as replication and each replication had the plot size of 300 m^2. The study area are confined in Muzaffarpur district that lies between $24^0$54' to 26^0 23' N latitudes, $84^0$53' to $85^0$45' E longitudes with altitude of 51.81m above mean sea level, which falls under the part of Indo- Gangetic North-West Alluvial plain Zone of Bihar. The area has categorized as tropical humid to sub-humid climate and having average rainfall 1234 mm with average temperature 25.3^{0}C and relative humidity 67 percent.

The experiment was laid out in randomized block design (RBD) with seven replications. There were experiment comprised 3 treatments *viz*.T0 -Farmers practice, T_1- N_{150}– P_{90} – K_{100} (RDF) and T_2– 20 % reduce RDF (N_{120}: P_{72}: K_{100}) + *Azotobacter*, +*phosphorus-solublizing bacteria* (PSB). The packets of *Azotobacter* and PSB containing 200gm inoculums were obtained from Department of Soil Science (Microbiology), TCA, Dholi, Muzaffarpur-Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. Before sowing, Seed tubers treated with half kg each of *Azotobacter* and PSB bio-fertilizers were dissolved in 40 liters of water. Slurry was prepared by boiling 2 kg jaggary in one liter of water. After cooling, it was added to solution of bio-fertilizers. Potato tubers were dipped in the biofertilizer solution for 30 minutes as per treatment and shade dried.

Tubers were planted with spacing of 20.0 cm plant to plant distance while 60.0 cm apart from row to row. Prior to lay out the plot under the trial, soil samples were collected from each farmers' field separately and

analyzed for available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus was extracted using the method of 0.5 M$NaHCO_3$ extractable colorimetric method (Olsen *et al*, 1954) and available potassium was measured by shaking the required amount of soil sample with 1 N NH_4OAc (pH 7.0) solution (1:5 soil: water solution ratio) for 5 minutes by Jackson (1973) method. All the selected experimental plots were received fertilizers as per treatment. Invariably, according to treatments, full dose of phosphorus and potassium applied as basal while nitrogen was applied in three splits *i.e.* 50 percent basal, 25 percent each at 40 and 55 DAS.

Results and Discussion

Tuber yield of potato

The effect of seed treatment with bio-fertilizer on tuber yield was studied after harvesting. Application of N_{120}-P_{72}-K_{100}+ *Azotobacter*+ *phosphorus- solublizing bacteria* significantly highest potato tuber yield were recorded (22.65 and 23.50t ha^{-1}) over the rest of the treatments, whereas minimum values of tuber yield was associated with farmers practice in both the years of experimentation (Table 1). The above results are in close conformity with the findings of Nag (2006) regarding crop residue incorporation with bio-fertilizers (*Azotobacter + PSB*) which produced the highest total tuber yield.

Similar results were also reported by Verma *et al.*, (2011) in potato crop. Though, the treatment T_1 showed its statistical superior in respect to tuber yield over farmers practice (T_0) in both the years. The effect of biological fertilizers containing nitrogen fixing bacteria and *phosphate-solubilizing bacteria* on the yield of agricultural crops has been investigated by Freitas (2000). Applying bio-fertilizers in potato crop significantly increased the tuber yield.

Economics

Net return (Rs.65375.00 ha^{-1} and Rs. 70250.00 ha^{-1}) and B:C ratio (2.31 and 2.49) under treatment T_2 was observed maximum among all the treatments but minimum Net return (Rs.60200.00ha^{-1} and Rs.55050.00 ha^{-1}) and Benefit : Cost ratio (2.27 and 2.22) was involved with treatment T_0 both the years of trial. It was attributed to reduction in cost of cultivation due to curtailing the chemical fertilizer dose as well as higher production under treatment N_{120}–P_{75}–K_{100} +*Azotobacter* + phosphorus - solublizing bacteria, where reduced chemical fertilizer was supplemented through *Azotobacter + phosphorus - solublizing bacteria* with other beneficial effect of aforesaid bio-fertilizers. These findings were also reported by Shivakumar and Ahlawat (2008).

Nitrogen and phosphorus status of soil

The pooled data (Table 2) of two years of trial, found that treatment (T_2) has net positive gain of available nitrogen and phosphorus as compared with rest treatments *i.e.* T_1 and T_0 and on the other hand, net loss of available nitrogen and phosphorus were observed in treatment T_0. It indicates that uses of *Azotobacter* and *phosphorus-solubilizing bacteria* (PSB) together in the present experiment were cumulatively translated into net gain of available nitrogen and phosphorus.

They have the capacity to produce natural resistance in plants against pests and soil borne diseases, because antibodies are produced and beneficial micro-organisms participate in the soil to increase fertility (Board, 2004). There are two kinds of bio-fertilizers *i.e.* nitrogen bio- fertilizers and phosphatic bio-fertilizers.

Table.1 Effect of Bio-fertilizer (*Azotobacter and PSB*) on tuber yield and economics of potato

Treatments	Tuber yield (t ha^{-1})			Economics (Rs. ha^{-1})							
	2015-16	2016-17	Pooled	2015-16				2016-17			
				Cost of cultivation	Gross return	Net return	B:C ratio	Cost of cultivation	Gross return	Net return	B:C ratio
T_0: Farmers Practice	21.54	20.01	20.78	47500.00	107700.00	60200.00	2.27	45000.00	100050.00	55050.00	2.22
T_1: RDF (N_{150}-P_{90}-K_{100})	22.44	22.50	22.47	49000.00	112215.00	63215.00	2.29	47000.00	112500.00	65500.00	2.39
T_2: N_{120}-P_{72}-K_{100} +*Azot.*+PSB	22.65	23.50	23.08	50000.00	115375.00	65375.00	2.31	47250.00	117500.00	70250.00	2.49
SEm±	1.17	0.72	0.46	442.08	328.62	477.42	-	278.52	352.43	251.93	-
C. D. (P=0.05)	3.59	2.23	1.40	1361.98	1012.43	1470.86	-	858.09	1085.79	776.15	-

Table.2 Effect of Bio-fertilizer (*Azotobacter and PSB*) on soil fertility

Treatments	Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Net change (net gain/loss)	
	Initial	Post-harvest	Initial	Post-harvest	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})
T_0: Farmers Practice	213.29	212.73	28.50	28.05	-0.56	-0.45
T_1: RDF (N_{150}-P_{90}-K_{100})	224.95	224.81	30.00	29.96	-0.14	-0.04
T_2: N_{120}-P_{72}-K_{100} +*Azot.*+PSB	240.91	243.37	32.15	34.83	2.46	2.68
SEm±	2.81	2.00	0.38	0.30	-	-
C. D. (P=0.05)	8.65	6.15	1.16	0.92	-	-

Nitrogen bio-fertilizers add nitrogen to the dirt by diminishing environmental nitrogen and phosphatic bio-fertilizers can solubilize the phosphates bound in soil and builds its accessibility in plant. To build the creation and nature of potato, sensible blend of natural wellsprings of supplement alongside inorganic and bio-fertilizers (*azotobacter, phosphobacteria*) get great reaction Nag (2006).

It is free living and non-symbiotic N-fixing organism that also produces certain substances good for the growth of plants and antibodies that suppress many root pathogens.They improve seed germination and plant growth by producing vitamins, NAA, GA and other chemicals (plant hormones) that are inhibitory to certain root pathogens (Mazid *et al.*, 2011b).

Application of bio-fertilizers, especially biological nitrogen fixation through integrated use by chemical fertilizers is most important strategy for integrated plant nutrient in sustainable management.It can be concluded that combined inoculation of potato tuber with *Azotobactor* and PSB showed significantly higher tuber yield, as compare to other treatments.

So, these two bio fertilizers (*Azotobactor* and PSB) along with normal doses of major other fertilizers like N,P and K may be recommended to the potato growers to get higher yields and to prevent losses and to increase the overall production of potato. In this way, *Azotobactor* plays healthful stimulatory and remedial part for the advantage of yield, which makes it a potential bio-manure for potato. Similarly, PSB solubilizes phosphorus from soil source and makes it available to plant.

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