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Response of N, P & K Uptake Pattern under the Different Integrated Nutrient Management Practices on Potato, *Solanum tuberosum* L., Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out in a Randomized Block Design treatments 8 viz. T1 Control,T2 FYM @ 30 t/ha) + biofertilizer (PSB), T3 poultry manure @ 5 t/ha + biofertilizer (PSB),T4 vermicompost @ 7.5 t/ha + biofertilizer (PSB), T5 FYM @ 10 t/ha + poultry manure @ 1.7 t/ha

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+vermicompost 2.7 t/ha + biofertilizer (PSB), T6 67% RDF through inorganic sources + 33% RDF through organic sources i.e. FYM + biofertilizer (PSB), T7 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer (PSB) and T8 Farmer practices (through organic). All the treatment combinations were replicated three times. The soil of the experiment field was silty loam in texture and medium in fertility status with the pH values 8.1, organic carbon 0.31%. The available nitrogen, phosphorus and potassium were 140.0, 15.2, and 240 kg ha-1 respectively.

Keywords: INM; FYM; PSB; vermicompost; RDF.

1. INTRODUCTION

"Potato (*Solanum tuberosum* L.) popularly known as "The King of Vegetables" is a native of South America (Peru) and occupies the largest area under any single vegetable crop in the world. Presently, developing countries of Asia accounts for more than 46% of global output under potato. It is an excellent source of carbohydrates with low fat percentage which makes it a balance food. Due to high protein: calorie ratio (17g protein: 1000 kcal) and short vegetative cycle, potatoes yield substantially more edible energy, protein and dry matter per unit area per unit time" [1].

"The trend of organic farming is getting momentum because people prefer to consume vegetable free from chemical residues. On the other hand, the ecological concerns regarding residual toxicity due to indiscriminate and excessive use of chemicals by means of fertilizers and pesticides and their harmful effects on soil health as well as on biodiversity indicates an urgent need for a shift to available organic resources as manure along with fertilizers". Shubha et al. [2] "Use of sub-optimum dose in imbalance form is one of the most potent factor for low productivity of potato. Thus, use of optimum dose in imbalance form is essential for higher production. Presently, FYM is a major source of organic matter and nutrients, besides poultry manure and vermicompost. These organic sources generally contain low level of nutrients and are required in higher amounts to fulfill the needs of crop, therefore, it is essential to supply the nutrient in integrated manner. On the other hand the dependence on inorganic fertilizer can be reduced in the days with the integrated use of organic and inorganic in proper combination. Application of FYM to soil have practiced for many centuries and its application to soil have increase crop yield, improved soil properties, increased soil fertility, increased soil organic matter, increased microbial activities and improved soil structure for sustainable agriculture" [3]. "FYM is good source of major plant nutrients like 0.5% nitrogen, 0.2% phosphorus and 0.5% potash. Poultry manure used as an organic fertilizer, especially for soil low in nitrogen. Poultry manure contains significant amounts of N, P, K, S and other plant nutrients" [4]. "Poultry manure rich in major and minor plant nutrients like 3% nitrogen, 2.63% phosphorus and 1.4% potash. Vermicompost is a rich mixture of major and minor plant nutrients. On an average vermicompost contains 2% nitrogen, 1% phosphorus, 1.5% potash. Besides, vermicompost is a rich source of nutrients, vitamins, enzymes, antibiotics, plant growth hormones and a number of beneficial microorganisms" [5]. Biofertilizer is an organic product containing a specific group of micro organism which has an ability to convert unavailable nutrient to available form by biological process. Biofertilizers play an important role in improving nutrient availability to the crop plant.

Modern nutrient management strategy has shifted its focus towards the concept of sustainability and eco-friendliness. Continuous application of heavy doses of chemical fertilizers without organic manures or biofertilizers has led to a deterioration of soil health in terms of physical and chemical properties of soil, declining of soil microbial activities, reduction in soil humus, increased pollution of soil, water and air.

2. MATERIALS AND METHODS

The experiment was conducted at the Agriculture Research Farm, Shri Durga Ji Post Graduate College, Chandeshwar, Azamgarh, (U.P.) during Rabi season of 2019-20. The farm is situated at the Azamgarh – Ghazipur road at the distance of 07 km from Azamgarh district head quarter.

Table 1. Edaphic condition of soil

S. No.	Soil properties	Method employed	Values obtained
A. Chemical Properties			
1.	pH (1:2.5)	Glass electrode pH Meter Jackson (1973)	8.1
2.	Organic carbon (%)	Walkely and Blacks (1934) Method	0.31%
3.	Available nitrogen (kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asija, 1956)	140.00
4.	Available phosphorus (kg ha^{-1})	Olsen method (Olsen 1954) *et al*.	15.2
5.	Available potassium (kg ha^{-1})	Flame photometer (Jackson, 1973)	240.0
B. Physical properties			
1.	Soil texture	Hydrometer (Bouyoucos, 1936) Method	
	Sand (%)		29.10
	Silt (%)		57.40
	Clay (%)		13.50
2.	Textural class	Triangular method (Lyon et al. 1952)	Silty loam

Table 2. Composition of inorganic & organic sources

Name of manure	Nitrogen %	Phosphorus %	Potash %
N:P:K	150	100	120
FYM	0.5	0.25	0.5
Vermicompost	2.0	0.3	0.7
Poultry Manure	3.0	0.2	0.6

2.1 Details of Treatments

T_1: Control, T_2: FYM @ 30 t/ha + biofertilizer (PSB), T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB), T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB), T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB), T_6: 67% RDF through inorganic sources + 33% RDF through organic sources i.e. FYM + biofertilizer(PSB) , T_7: 33% RDF through inorganic sources + 67% RDN through organic sources i.e. FYM + biofertilizer(PSB), T_8: Farmer practices (through organic). The treatments were allocated to respective plots randomly in all three replication by using the random number. The layout of present investigation is given below. Randomized Block Design (RBD), replication 03, 08 treatments combination, used variety Kufri Ashoka.

2.2 Fertilizers & Manure

Recommended doses of fertilizers (RDF) like N:P:K is given @ 150:100:120 kg/ha. The organic nutrients were applied through FYM, vermicompost and poultry manure. Organic sources were applied three week before planting. Detailed composition of N:P:K, FYM, vermicompost and poultry manure.

2.3 Yield Studies

Number of 0-25g, 25-50g, 50-75g & >75g tuber (grade wise) hill^{-1}: The plants selected for number of haulm hill^{-1} were also used for this purpose each grade of tubers were separated and counted the number of tubers hill^{-1}.

Weight of 0-25g, 25-50g, 50-75g & >75g tubers grade (g hill^{-1}): The same tuber grades for number of tubers g hill^{-1} was used for this purpose. Average weight of each grade of tubers was calculated on the basis of tubers weighted of five hills.

Weight of 0-25g, 25-50g, 50-75g & >75g tubers grades (kg plot^{-1}): Each plot was harvested separately and tuber weight of 0-25g, 25-50g, 50-75g & >75g grade recorded in kg plot^{-1}.

Tuber yield (q ha^{-1}): After harvesting, the yield of total tubers plot^{-1} were recorded in kilograms separately and converted into q ha^{-1}.

2.4 Soil Analysis

Moisture percent of soil:

$$\text{Moisture (\%)} = \frac{Fresh\ weight\ of\ soil\ (g) - Dry\ weight\ of\ soil(g)}{\text{Dry weight of soil (g)}} \times 100$$

pH: pH was determined with the help of glass electrode pH meter 1: 2.5 soil water uspension as described by Jackson (1973).

Organic carbon: Organic carbon in soil was determined by Walkley and Black's rapid titration method as advocated by Jackson(1973).

Available nitrogen: The available nitrogen content in soil samples was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

Available phosphorus: The available phosphorus in soil was determined by Olsen's method as per procedure described by Olsen et al (1954).

Available potassium: The available potassium in soil was determined by Morgan's method as advocated by Jackson (1973).

3. RESULTS AND DISCUSSION

3.1 Yield and Yield Attributes

Undoubtedly adequate supply of nutrients in available form determines the number of tuber (grade wise) hill^{-1} and weight of tuber gram hill^{-1} as the present study, application of the T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer(PSB) has recorded the highest number of tuber grade wise hill^{-1} (0-25g, 25-50g, 50-75g and >75g) *i.e*., 3.26, 2.24, 2.05 and 2.04, respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 3.20, 2.17, 2.01 and 1.98 the least T_1 control *i.e*., 3.04, 2.09, 1.90 and 1.89. Application of T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) recorded the highest number of tuber grade g hill^{-1} (0-25g, 25-50g, 50-75g and >75g) *i.e*., 23.17, 115.66, 138.93 and 184.88 respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer PSB) *i.e*., 19.47, 97.35, 116.92 and 115.62 the least T_1 control 9.35,46.77,56.19 and 76.80. The highest grade wise number of tuber plot^{-1} was found in (10 t FYM ha^{-1} with 100% RDF NPK) reported by Raghav et al. [6]. The improvement in growth (plant height, dry matter accumulation, no. of leaves) and yield attributes (tuber weight/plant, no. of tubers/plant) under integrated nutrient management practices in the present experiment due to continuous supply of plant nutrients was mainly responsible for higher potato tuber yield(q/ha) under this experiment. Barman et al. [7] observed that "possibility of improving, growth and tuber yield of potato by the use of integrated nutrient management. Results obtained after statistical analysis of data revealed that the height of plant, number of compound leaves/hill, number of haulms/hill, yield attributes and yield. Further number of A, B, C and D grade tubers/plot, percent of A, B, C and D grade tubers/plot, yield of A, B, C and D grade tubers/plot (kg), total number of tubers plot, total weight of tubers per plot (kg) and tuber yield (t/ha) showed the beneficial response by the use of integrated levels of N, FYM and vermicompost. However, on the basis of pooled data it was also further observed that the application of 150 kg N, 20 t FYM and 5 ton vermicompost /ha of improvement in growth and tuber yield of potato".

Organic nutrient sources are known to restore organic matter in soil and enhance nutrient use efficiency by a crop which results in improved growth and yield of a crop. In the present investigation, the potato crop has got higher T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer PSB) recorded the highest number of tuber grade kg plot^{-1} (0-25g, 25-50g, 50-75g and >75g) *i.e*., 2.50, 14.98, 18.99 and 13.48 respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 2.16, 12.68, 16.03 and 11.29 the least T_1 control *i.e*., 1.16, 6.07, 7.34 and 5.63. The yield q ha^{-1} highly influenced by T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 386.60 q ha^{-1} and followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 324.53 q ha^{-1} the least T_1control *i.e*., 150 q ha^{-1}.

Table 3. Number of tuber grade wise at harvest and weight of tubers grade (g hill^{-1}) as affected by integrated nutrient management practices in potato

Treatments	Number of tuber (grade wise) hill^{-1}				Weight of tubers grade (g hill^{-1})			
	0-25g	25-50g	50-75g	>75g	0-25g	25-50g	50-75g	>75g
T_1: Control	3.04	2.09	1.90	1.89	9.35	46.77	56.19	76.80
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	3.10	2.11	1.95	1.92	15.75	78.74	94.52	125.90
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	3.11	2.12	1.96	1.96	16.37	81.81	98.28	130.81
T_4: Vermicompost @ 7.5 t/ha + biofertilizer(PSB)	3.11	2.12	1.97	1.96	17.55	87.76	105.42	140.32
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	3.11	2.15	1.98	1.97	17.92	89.58	107.58	143.26
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e* FYM + biofertilizer (PSB)	3.26	2.24	2.05	2.04	23.17	115.66	138.93	184.88
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources *i.e.* FYM + biofertilizer (PSB)	3.20	2.17	2.01	1.98	19.47	97.35	116.92	155.62
T_8: Farmer practices (through organic)	3.12	2.16	1.99	1.98	18.49	92.45	111.06	147.83
SEm±	0.01	0.01	0.01	0.01	0.53	2.68	3.22	4.57
CD 5%	0.04	0.04	0.03	0.03	1.60	8.12	9.76	13.85

Table 4. Weight of potato tuber grade wise (kg plot-1), tuber yield (q ha-1) and Nutrient (N, P&K) Uptake by tuber (kg/h-1) as affected by integrated nutrient management practices

Treatments	Wt. tuber grade kg plot^{-1}				Tuber yield (q/ha^{-1})	Uptake (Kg/ha)		
	0-25g	25-50g	50-75g	>75g		N	P	K
T_1: Control	1.16	6.07	7.34	5.63	150.00	57.05	10.85	59.75
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	1.78	10.22	12.93	8.98	262.53	125.18	25.25	127.25
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	1.86	10.93	13.80	9.75	280.50	130.75	26.95	137.75
T_4: Vermicompost @ 7.5 t/ha + biofertilizer(PSB)	1.99	11.36	14.36	10.17	292.60	136.55	26.25	132.05
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	2.02	11.64	14.71	10.43	298.66	139.58	26.75	140.01
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e* FYM + biofertilizer (PSB)	2.50	14.98	18.99	13.48	386.60	184.64	34.85	185.51
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources *i.e.* FYM + biofertilizer (PSB)	2.16	12.68	16.03	11.29	324.53	155.25	28.25	150.55
T_8: Farmer practices (through organic)	2.05	12.00	15.18	11.70	308.26	140.95	27.75	142.25
SEm±	0.07	0.31	0.37	0.29	2.70	3.83	0.63	3.39
CD 5%	0.22	0.93	1.11	0.86	8.20	11.61	1.90	10.26

Table 5. Soil fertility status of after harvest of tuber

Treatments	Soil fertility status of after harvest of tuber					
	Soil texture	OC g kg^{-1}	p^H	Av N kg ha^{-1}	Av PKg ha^{-1}	Av Kg ha^{-1}
T_1: Control	Silt loam	0.30	8.1	135	14.7	237
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	Silt loam	0.32	8.05	143	15.3	242
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	Silt loam	0.32	8.05	143	15.3	242
T_4: Vermicompost @ 7.5 t/ha + biofertilizer(PSB)	Silt loam	0.32	8.05	143	15.3	242
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	Silt loam	0.33	8.0	143	15.3	242
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e* FYM + biofertilizer (PSB)	Silt loam	0.33	8.05	145	15.3	244
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources *i.e.* FYM + biofertilizer (PSB)	Silt loam	0.32	8.05	144	15.3	243
T_8: Farmer practices (through organic)	Silt loam	0.32	8.05	143	15.3	242
Initial status		0.31	8.10	140.0	15.2	240

The desirable effect obtained in potato crop with the T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) could be due to the availability of balanced trace elements along with the major elements, which favor the uptake of nutrients. The data obtained from the present study indicated that the uptake of N, P, and K were significantly higher in these treatments. Apart from the improvement in uptake of nutrients the manures applied in these treatments have also a positive effect with respect to soil physical properties *viz.,* water holding capacity and structural stability of a soil and improve the soil microbial population which are responsible for N-fixation and phosphorus solubilization. Verma et al. [8] who also found that "the highest grade wise yield of tubers per plot in treatment receiving crop residues + Azotobacter + phosphobacteria + biodynamic approach + microbial culture in potato. Patel (2013) also recorded the maximum grade wise (0-25, 25-50 g, 50-75 g and >75g) yield of tubers plot^{-1} in potato with 150% RDF at harvesting stage". "Assessed the effect of different doses of NPK on yield of potato crop and revealed that the fertilizer application increased the potato yield significantly" Nizamuddin et al*.* [9].

3.2 Available Nutrient in Soil after Harvest as Influenced by Nutrient Sources

In the present investigation available soil texture, organic carbon, pH, nitrogen, phosphorus, potassium and content were influenced by integrated nutrient management practices. As it was observed in Table 3, The highest organic carbon found T_5 FYM @ 10 t/ha + poultry manure @ 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB) *i.e*., 3.30 g kg^{-1} and nitrogen and phosphorus content after harvest was recorded the T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer(PSB) *i.e*., 145 kg/ha, respectively). The improvement in organic carbon(%), available N, P and K under all integrated nutrient management practices as compared to control was mainly because of the addition of nutrients through different organic sources like FYM, poultry manure vermicompost and biofertilizers which resulted in higher availability of nutrients. On the other hand reduction in pH of soil after harvest of crop as compared to initial soil pH was become of the fact that distant organic manures bacteria released various organic acids which helps to reduce the pH of soil which happened in this experiment as pH was reduced under all integrated nutrient management practices as compared to control. These results are in conformation with Arun et al*.* [10] who observed "significantly improved post harvest soil fertility with the application of 100 per cent N through farmyard manure which was however comparable with 100 per cent N through sheep manure or poultry manure in baby corn".

4. CONCLUSION

Significantly higher uptake of major nutrients viz., Nitrogen (184.64 kg/ha), phosphorus (34.85 kg/ha) and potassium (185.51 kg/ha) by tuber, was recorded with the application of 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*, FYM + biofertilizer (PSB) T_6 followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) and lowest being with T_1 (control). Application of integrated nutrient management (INM) in the ratio of 2:1 (67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) was found to be effective for growth, and yield of potato and nutrient uptake.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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