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Integration effect of organic and inorganic nutrient sources on nutrient uptake of potato and soil properties in alluvial plains of Northern Bihar

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ABSTRACT

A field experiment was conductedto study the response of potato (*Solanum tuberosum* L.) to integrated nutrient managementwith variety *KufriAshoka.* Treatments consisted of five levels of RDF (0, 75, 100, 125, 150%) and two sources of organic manures (farmyard manure @ 20.0 t/ha and spent mushroom substrate @ 4.0 t/ha).The results revealed that there was a significant difference in various plant growth and yield parameters like growth, yield attributes and fresh yield of tubers, total nutrient uptake, the protein content of tuber and the fertility status of the post harvested soil. Application of 100 % RDF coupled with FYM 20 t/ha or SMS 4 t/ha had performed well, found statistically at par to treatments, 125% RDF and 150% RDF integrated with FYM 20 t/ha or SMS 4 t/ha respectively.

KEYWORDS

Spent Mushroom Substrate (SMS), Nutrient Use Efficiency, Sustainable agriculture

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INTRODUCTION

Potato (*Solanum tuberosum* L.) a short duration, high nutrient responsive crop, is cultivated in 150 countries covering an area of 19.25 million hectares with a production of 376.83 million tonnes and productivity of 19.25 tonnes per hectare. It ranks fourth in the world and third in India concerning production. In 2050 potato demand in India is estimated to be 122 million tons, compared to 48.60 million tons, almost 2.5 times the current production. Potato is an economical food as it provides a source of low-cost energy to the human diet. The potato tubers are the rich source of starch, vitamin C and B and minerals. It contains 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fiber and 0.9% ash (Khurana and Naik, 2003).At the present level of farm management practices, we can harvest only 42-45 per cent of the achievable yield. Growth, yield and quality of potato depend on nutrient availability in soil, which is directly related to the judicious application of manures and fertilizers. Nitrogen, phosphorus and potassium are considered the most important macronutrient for the potato crop in Indian soil. Potato relatively demands a higher level of soil nutrients due to poorly developed and shallow root system in relation to yield (Perrenoud, 1993). Low recovery of applied nitrogen, fixation of phosphorus and deficiency of potassium limiting the potato growth and production. Balanced fertilization is a prerequisite for getting optimum yield potential of potato (Kushwah *et al*., 2005). Sustainable production of crops cannot be maintained by using chemical fertilizers alone because of deterioration in soil physical and biological environments (Kumar *et al*., 2008 Singh and Bhatt, 2013). Great opportunities exist to increase potato yield and quality by improving nutrient management. Integrated nutrient management (INM) involving a combination of organic manure, fertilizersand management practices for balanced fertilization and sustainability of crop production on a long term basis (Singh *et al*., 2013; Hegde and Dwivedi, 1993). The basic objectives of integrated nutrient management (INM) are to reduce the inorganic fertilizer requirement, to restore organic matter in the soil, to enhance nutrient use efficiency and to maintain soil quality in terms of physical, chemical and biological properties. Keeping the above facts in view the present investigation was carried out tostudy the integration effect of organic & inorganic sources of nutrients on nutrient uptake & soil properties.

MATERIALS AND METHODS

A field experiment was conducted in the plot no. 13 during *rabi* season at Tirhut College of Agriculture Farm, Dholi (Muzaffarpur) which is located at an elevation of 52.18 meters above mean sea level and lies at 25º.98' N latitude and 85º.6' E longitude. The soil type of the experimental plot was calcareous alluvium in nature and slightly alkaline (pH 7.90, electrical conductivity 0.24dS/m) in reaction, due to the deposition of sediments transported by the river *Burhi Gandak* through the ages. Observations on various growth and yield attributing characters were recorded by randomly selecting five competitive plants of each treatment in a replication, which were tagged properly. The growth and yield parameters of the crop during the experimental duration were recorded at regular intervals, in order to assess the probable relationship between growth attributes and the final yield. Five representative plants were not dehaulmed, as the data of vine yield and dry matter yield is essential at the time of harvest for the purpose of research studies. The fertility status of the experimental soil was categorized as low concerning organic carbon (0.47%), available nitrogen (244.60 kg/ha), potassium (138.01kg/ha) and medium for available phosphorous (23.55 kg/ha). The spent mushroom substrate was purchased from

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AICRP on Mushroom Research, RPCAU Pusa. FYM was procured from dairy unit Pusa. FYM and SMS were applied and mixed into the soil at 10 days before planting accordingly to the respective treatments scheduled.

Table 1 : Treatments details

Symbol	Description
T_1	Control
T_2	100% RDF
T_3	75% RDF + 20.0 t/ha Farm Yard Manure
T_4	75% RDF + 4.0 t/ha Spent Mushroom Substrate
T_5	100% RDF + 20.0 t/ha Farm Yard Manure
T_6	100% RDF + 4.0 t/ha Spent Mushroom Substrate
T_7	125% RDF + 20.0 t/ha Farm Yard Manure
T_8	125% RDF + 4.0 t/ha Spent Mushroom Substrate
T_9	150% RDF+ 20.0 t/ha Farm Yard Manure
T_{10}	150% RDF + 4.0 t/ha Spent Mushroom Substrate

The nutrient management was accomplished as per formulated treatments in the experiment under study (Table 1). The fertilizer recommendation for the crop potato was 150:90:100 kg NPK/ha. In treatment, T_2,100% recommended dose of NPK was applied. A full dose of recommended P and K and half of the N was applied as a basal application. The leftover quantity of recommended N was applied at 45 DAP, respectively. *Kufri Ashoka* variety was selected for the experimental studies. Five representative plants were selected from each plot for recording observations of growth, yield and quality attributing characters of potato. Haulms were sliced from the bottom leaving the underground portion unaffected, 10 days before harvesting. For estimation of available nutrients in the soil, samples from the soil up to 30 cm depth from the surface was collected from each plot, shade dried, powdered and sieved through 2 mm mesh. After sieving the sample was stored in a glass bottle for chemical analysis of the soil. Harvested five representative plants from each plot are shade dried, then oven dried for 48 hours at 65^0C, powdered. The powdered samples were stored in a container for nutrient content analysis. The analysis was performed as per the standard methodology and procedure (Table 2). Based on the nutrient content in haulms and tuber at harvest of the crop, the uptake of NPK of potato was worked. The fresh yield of tubers and vine in kg was multiplied with a value of 0.155 to get a dry yield of tubers and vines. The protein content of tuber was calculated by multiply the per cent nitrogen in tuber with a constant factor of 6.25.

Table 2 : Standard laboratory Methodology

Particulars	Methodology
pH (1:2.5)	Buckman pH meter (Jackson, 1967)
Electrical conductivity (dS/m at 25^0C)	Systronics electrical conductivity meter (Richards, 1954)
Organic carbon (%)	Walkley and Black method (Walkley and Black, 1934)
Available Nitrogen (kg N/ha)	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus (kg/ha)	Olsen's method (0.5 N $NaHCO_3$ extractable) (Olsen *et al.*,1954)
AvailablePotassium (kg /ha)	Flame photometric method (Jackson, 1967)

Data concerning multiple parameters were subjected to statistical study with the method of analysis of variance. The significance of the treatment impact was examined by the F test with critical differences value at a 5% level of significance were computed.

RESULTS AND DISCUSSION

Effect of of organic and inorganic nutrient sources on growth and yield attributes of potato

The data presented in Table 2 indicate that potato crop raised under various treatments had a significant response on growth and yield attributes. Among different treatments, treatmentplot receiving150% RDF+ 20 t/ha FYM, registered higher plant height (48.80 cm), number of shoots (5.87/plant) and dry matter production (70.16 g/plant),fresh yield of tuber per plant,(359.63 g/plant), total tuber yield (265.29 q/ha), and biomass yield(379.11 q/ha),was found statistically at par with with treatments 100%, 125% and 150% RDF integrated with FYM 20 t/ha and SMS 4 t/ha respectively and significantly superior over rest of the treatments. The increment in plant height, number of shoots and leaves per plant with an increase in fertilizers dosage coupled with organic manures could clearly indicate that application of organic manures to the soil in concurrence with mineral fertilizers, which could have significantly enhanced the nutrient availability, leading to beneficial impact on growth parameters as indicated by (Youtrchi *et al.*, 2013).The higher yield achieved by applying a higher fertilizer dose (NPK) may be due to the positive reaction of potato crop to nutrients such as nitrogen, phosphorus and potash. In general N, P and K had a profound effect on the size of tuber. N and P influenced tuber formation in potato by influencing the activity and phytohormone balance of the plant especially, on gibberellin, abscisic acid and cytokin in levels. Potassium application promotes the activation of a number of enzymes involved in photosynthesis, carbohydrate, protein metabolism and helps to translocation carbohydrates from leaves to tubers. Organic manure in the soil improves nitrogen mineralization, plant absorption of phosphorus, by promoting carbonic acid production the acid that increases the solubility of phosphate compounds. Organic manures also supply micro nutrients and enhance the soil physico-chemical characteristics resulting in enhanced nutrient uptake that would have increased the yield of large sized tubers. The FYM has been found to be superior than SMS because it is bulky in nature and provides more quantities of available macro and micro nutrients. The FYM nutrient release was faster than SMS since the rate of mineralization of SMS was slow. These experimental results are in close agreement with the findings of Alam *et al.* (2007), Sarkar *et al.* (2011), Baishya *et al.* (2013), Sharma and Kumar (2014) and Kumar *et al*. (2017).

Table 3: Effect of organic and inorganic nutrient sources on growth and yield attributes of potato

Treatments	Plant height	Number of shoots per plant	Dry matter accumulation (g/plant)	Tuber yield (g/plant)	Fresh Yield of Tubers (q/ha)	Biomass Yield (q/ha)
T_1 – Control	31.48	3.33	41.20	151.34	110.48	182.89
T_2 - 100% RDF	39.57	4.87	57.50	279.19	225.95	329.34
T_3 -75 % RDF + 20.0 t/ha FYM	38.83	4.80	56.12	276.27	229.56	332.31
T_4 -75 % RDF + 4.0 t/ha SMS	38.52	4.67	54.81	265.43	228.21	330.48
T_5 -100 % RDF + 20.0 t/ha FYM	44.26	5.33	65.45	340.92	252.11	361.01
T_6 -100% RDF + 4.0 t/ha SMS	44.49	5.30	64.80	336.35	248.15	356.78
T_7 -125 % RDF + 20.0 t/ha FYM	47.59	5.73	68.24	350.88	260.29	372.32
T_8 -125% RDF + 4.0 t/ha SMS	46.37	5.67	67.35	345.43	258.11	369.90
T_9 -150% RDF+ 20.0 t/ha FYM	48.80	5.87	70.16	359.63	265.29	379.11
T_{10} -150%RDF + 4.0 t/ha SMS	47.75	5.80	69.73	351.96	261.72	374.52
SEm(±)	2.01	0.18	1.76	7.41	5.54	10.12
CD (*p=0.05*)	6.44	0.58	5.63	23.70	17.72	32.38

Effect of of organic and inorganic nutrient sources on nutrient content, uptake by potato

A close scrutiny of mean data concerning nutrient content, uptake by potato tubers, vine and protein content in tuber revealed that graded level of NPK with integration of organic manures (FYM and SMS) exerted significant difference.The data represented in Table 4 regarding nitrogen content, uptake by potato tubers, vinesand protein content in tuber was increased significantly in response to increasing the rate of fertilizer level along with organic manure (FYM and SMS) from null up to the highest rate of the recommended fertilizer. The per cent nitrogen content, and nitrogen uptake by tubers (2.08 %, 81.54 kg/ha), vines (1.46 %, 25.06 kg/ha), protein content (13.00 %) and total N-uptake (106.60 kg/ha) was found maximum in the plot receiving150% RDF+ 20 t/ha FYM,which was found statistically at par with treatments 100%, 125% and 150% RDF integrated with FYM 20 t/ha and SMS 4 t/ha respectively and significantly superior over rest of the treatments.

Table 4 : Effect of different treatments on N- content, protein content and uptake in potato

Treatment	N-content in tuber (%)	N-content in vine (%)	Protein content (%)	N-uptake by tuber (kg/ha)	N-uptake by vine (kg/ha)	Total uptake (kg/ha)
T_1 – Control	1.66	1.04	10.38	28.46	11.68	40.14
T_2 - 100% RDF	1.88	1.29	11.75	65.81	20.66	86.46
T_3 -75 % RDF + 20.0 t/ha FYM	1.83	1.24	11.44	65.14	19.78	84.92
T_4 -75 % RDF + 4.0 t/ha SMS	1.80	1.21	11.25	63.60	19.17	82.76
T_5 -100 % RDF + 20.0 t/ha FYM	1.97	1.38	12.31	76.46	23.33	99.78
T_6 -100% RDF + 4.0 t/ha SMS	1.94	1.35	12.13	75.37	22.72	98.10
T_7 -125 % RDF + 20.0 t/ha FYM	2.04	1.43	12.75	79.50	24.46	103.96
T_8 -125% RDF + 4.0 t/ha SMS	1.99	1.39	12.44	77.58	23.77	101.34
T_9 -150% RDF+ 20.0 t/ha FYM	2.08	1.46	13.00	81.54	25.06	106.60
T_{10} -150%RDF + 4.0 t/ha SMS	2.05	1.44	12.81	80.17	24.99	105.16
SEm(±)	0.06	0.04	0.35	2.02	0.83	2.69
CD (*p=0.05*)	0.18	0.12	1.12	6.47	2.65	8.59

Citation of the average data concerning on phosphorus and potassium content in tuber, vines, uptake by tuber, vine at harvest stage on dry weight basis as influenced through graded levels of NPK integrated with organic manures (FYM and SMS) are explained and presented in Table 5 and 6. Application of 150% RDF + 20.0 t/ha FYM registered the maximum content and uptakes of phosphorousin tubers (0.60 % 24.01 kg/ha), vines (0.58 %, .97 kg/ha), and potassium in tubers (2.56 %, 100.97 kg/ha) in vines (1.38 %, 24.02 kg/ha), total P -uptake (33.98 kg/ha) and K-uptake (124.99 kg/ha)which was found statistically at par with treatments 100%, 125% and 150% RDF integrated with FYM 20 t/ha and SMS 4 t/ha respectively and significantly superior over rest of the treatments.

The increase in nutrient content and uptake in potato tuber and vines was due to increased nutrient supply by inorganic and organic sources primarily N, P and K, organic manures supply plant nutrients throughout the growing period because of their slow mineralization rate. Addition of organic manures improve soil physical properties promoting better root growth and absorption of nutrients from the soil and also enhances the activity of beneficial microorganisms in the rhizosphere of the plant. However, further increases in nutrients dosage, total nutrient content and uptake in plants obey the law of diminishing returns. The protein level in the tuber was directly related to the amount of nitrogen content in the tuber, as nitrogen is an essential component for amino acid synthesis, which is necessary for the synthesis of proteins.

Table 5: Effect of different treatments on P- content and uptake in potato

Treatment	P-content in tuber (%)	P-content in vine (%)	P-uptake by tuber (kg/ha)	P-uptake by vine (kg/ha)	Total uptake (kg/ha)
T_1 – Control	0.38	0.33	6.48	3.74	10.22
T_2 - 100% RDF	0.54	0.52	18.98	8.33	27.31
T_3 -75 % RDF + 20.0 t/ha FYM	0.52	0.50	18.58	7.92	26.51
T_4 -75 % RDF + 4.0 t/ha SMS	0.51	0.49	18.18	7.69	25. 87
T_5 -100 % RDF + 20.0 t/ha FYM	0.57	0.56	22.12	9.39	31.51
T_6 -100% RDF + 4.0 t/ha SMS	0.56	0.55	21.90	9.32	31.22
T7-125 % RDF + 20.0 t/ha FYM	0.59	0.57	23.56	9.86	33.43
T_8 -125% RDF + 4.0 t/ha SMS	0.58	0.56	23.38	9.79	33.16
T_9 -150% RDF+ 20.0 t/ ha FYM	0.60	0.58	24.01	9.97	33.98
T_{10} -150% RDF + 4.0 t/ha SMS	0.59	0.56	23.89	9.90	33.79
SEm(±)	**0.02**	**0.01**	**0.67**	**0.29**	**0.88**
CD (*p=0.05*)	**0.05**	**0.04**	**2.13**	**0.93**	**2.83**

Table : Effect of different treatments on K- content and uptake in potato

Treatment	K-content in tuber (%)	K-content in vine (%)	K-uptake by tuber (kg/ha)	K-uptake by vine (kg/ha)	Total uptake (kg/ha)
T_1 – Control	2.00	0.94	34.23	10.60	44.83
T_2 - 100% RDF	2.13	1.18	82.07	19.24	101.30
T_3 -75 % RDF + 20.0 t/ha FYM	2.17	1.19	80.63	19.05	99.6 9
T_4 -75 % RDF + 4.0 t/ha SMS	2.12	1.17	79.71	18.56	98.28
T_5 -100 % RDF + 20.0 t/ha FYM	2.39	1.30	94.07	21.96	116.03
T_6 -100% RDF + 4.0 t/ha SMS	2.40	1.28	93.79	21.59	115.39
T_7 -125 % RDF + 20.0 t/ha FYM	2.51	1.35	98.73	23.14	121.86
T_8 -125% RDF + 4 .0 t/ha SMS	2.46	1.31	97.94	22.89	120.83
T_9 -150% RDF+ 20.0 t/ha FYM	2.56	1.38	100.97	24.02	124.99
T_{10} -150% RDF + 4.0 t/ha SMS	2.52	1.36	99.61	23.90	123.51
SEm(±)	**0.07**	**0.04**	**2.68**	**0.77**	**3.11**
CD (*p=0.05*)	**0.22**	**0.12**	**8.58**	**2.46**	**9.95**

Similar results are also observed in Kumar *et al.*(2011), Lakshmi *et al.* (2012), Islam *et al*. (2013).

Effect of organic and inorganic nutrient sources on pH, electrical conductivity, organic matter, available N, P_2O_5 and K_2O of post-harvest soil

Post harvest analysis of soil pH and electrical conductivity (dS/m) revealed that there were no significant differences in pH and electrical conductivity among all the treatments in the field experimentation. However the maximum pH (8.26) and electrical conductivity (0.25dS/m) was observed in the treatment 75% RDF + 4.0 t/ha SMS. The pH and electrical conductivity were found minimum in the treatment 150% RDF+ 20.0 t/ha FYM (7.78, 0.22dS/m) respectively. The release of organic acids like humic and carbonic acids during the mineralization of organic manures enhances the H^+ ion activity results in a slight decrease in pH was observed.. Similar findings also reported by Kumar *et al*. (2017). Integration of organic and inorganic sources of nutrients exerted a significant effect on organic carbon, organic matter content and available N, P, and K in post-harvest soil. The mean data presented in Table 7 revealed that maximum content of organic matter (0.90%) was observed in the treatments 125 % RDF + 20.0 t/ha FYM, 150 % RDF + 20.0 t/ha FYMand 150 % RDF + 4.0 t/ha SMS, were found significantly superior over control (0.67%) and 100 per cent recommended dose of fertilizer (0.76%) and remained statistically at par with other treatments. In this study increase in nutrient dosage, a slight increase in the percentage of organic matter was observed due to the external application of organic manures like FYM and SMS which enhanced the soil organic matter. Similarly, the availability of nitrogen, phosphorous and potassium was found maximum in the treatment 150 % RDF + 20.0 t/ha FYM (272.88, 32.06 and 157.81 NPK kg/ha) which was found statistically at par with treatments 100%, 125% and 150% RDF integrated with FYM 20 t/ha and SMS 4 t/ha and significantly superior over rest of the treatments.

Applying organic manures along with increased levels of fertilizers to the soil will enhance the labile pool concentration of major nutrients and organic carbon content. Organic matter in the soil triggers the microbial activity and releases nitrogen through mineralization of applied organic matter. Phosphorus fertilizers and manure in the soil increase the available P status of soil which might be attributed to the build-up of available P owing to the production of carbonic acid, the acid that increases the solubility of phosphate

Table 7: Effect of different treatments on pH, electrical conductivity, organic matter, available N, P_2O_5 and K_2O of post-harvest soil

Treatment	pH	EC (dS/m)	Organic matter (%)	Nitrogen (kg/ha)	Phosphorous (kg/ha)	Potassium (kg/ha)
T_1 – Control	7.97	0.24	0.67	166.52	21.36	98.86
T_2 - 100% RDF	7.97	0.23	0.76	202.06	25.19	138.21
T_3 -75 % RDF + 20.0 t/ha FYM	8.10	0.24	0.84	233.42	27.38	139.31
T_4 -75 % RDF + 4.0 t/ha SMS	8.26	0.25	0.83	227.88	26.84	137.02
T_5 -100 % RDF + 20.0 t/ha FYM	7.83	0.23	0.86	256.60	30.57	148.34
T_6 -100% RDF + 4.0 t/ha SMS	8.05	0.24	0.86	248.56	29.48	147.39
T_7 -125 % RDF + 20.0 t/ha FYM	8.08	0.24	0.90	265.78	31.22	155.34
T_8 -125% RDF + 4.0 t/ha SMS	7.85	0.22	0.88	259.05	30.82	153.91
T_9 -150% RDF+ 20.0 t/ha FYM	7.78	0.22	0.90	272.88	32.06	157.81
T_{10} -150%RDF + 4.0 t/ha SMS	7.87	0.23	0.90	266.60	31.77	156.69
SEm(±)	0.23	0.01	0.03	8.00	0.85	4.23
CD (*p=0.05*)	NS	NS	0.09	25.59	2.71	13.53

compounds and other chelating agents which form soluble complexes with native P in soils. The increase in available K may be due to the higher application of K along with organic manures which was advantageous as they improve soil physical and chemical properties. Organic manures also supply micronutrients, maintain healthy positive nutrient balance due to an increase in soil cation exchange capacity, water holding capacity and finally soil fertility levels by improving the activity of beneficial soil microbial population which helps in mineralization and mobilization of nutrients. The experimental results observed in the present research work on nutrient status were supported by the findings of Patel (2013) and Kumar *et al.*(2017)in potato.

CONCLUSION

Based on results obtained in the present investigation,the highest tuber yield was observed in 150% RDF + 20.0 t/ha FYM treatment, it was found statistically at par with treatments T_5-100% RDF + 20.0 t/ha FYM and T_6-100% RDF + 4.0 t/ha SMS.The total N, P and K content and uptake by potato was significantly influenced by various treatments. The total N, P and K uptake by the potato crop was found maximum in treatment 150% RDF+ 20.0 t/ha FYM. The minimum uptake of nutrient by potato crop was observed in Control treatment. Addition of 150% RDF coupled with 20 t/ha FYM to the soil registered higher, per cent organic carbon, available N, P_2O_5 and K_2O content of the soil, was being statistically at par with treatments 125 % RDF + 20.0 t/ha FYM, 150 % RDF + 20.0 t/ha FYM and 150 % RDF + 4.0 t/ha SMS, For sustainable potato crop production as well as enhancing the soil nutrient status, application of 100% RDF + 20 t/ha farm yard manure or 100% RDF + 4.0 t/ha spent mushroom substrate are recommended under calcareous soil of northern Bihar.

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