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Effect of integrated nutrient management on yield and economics of potato (*Solanum tuberosum* L.)

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Abstract

A field experiment was conducted during the *rabi* season of the year 2017-18 on potato for testing the recommended dose of fertilizers (RDF) levels (0, 50, 75, 100, 125, 150%) with two organic manures (vermicompost 5 t/ha and mustard oil cake 2.5 t/ha) at research farm of Tirhut college of Agriculture Dholi, Muzaffarpur, Bihar. The experiment was carried out in randomized block design (RBD) with twelve treatments and replicated thrice. The soil of experimental plot was Entisols, sandy loam in texture under low available in N, P and K with pH 8.3. Among the yield, and tuber yield were recorded higher with the application of treatment T_{11} - 150% RDF + 5.0 t/ha vermicompost which was significantly superior over T_1 - absolute control, T_2 - 100% RDF, T3 - 50% RDF + 5.0 t/ha vermicompost, T4 - 50% RDF + 2.5 t/ha mustard oil cake, T_5 - 75% RDF + 5.0 t/ha vermicompost and T_6 - 75% RDF + 2.5 t/ha mustard oil cake but was statistically at par with treatments, T7 - 100% RDF + 5.0 t/ha vermicompost, T_8 - 100% RDF + 2.5 t/ha mustard oil cake, T_9 - 125% RDF + 5.0 t/ha vermicompost, T_{10} - 125% RDF + 2.5 t/ha mustard oil cake and T_{12} - 150% RDF + 2.5 t/ha mustard oil cake. But in the case of benefit: cost ratio the treatment T_2 - 100% RDF (2.11) fetched significantly higher benefit: cost ratio in comparison to treatment T_7 (1.62), T8 (1.31), T_9 (1.67), T_{10} (1.35), T_{11} (1.66) and T_{12} (1.35), whereas minimum benefit: cost ratio was obtained with treatment T_1- absolute control (0.69).

Keywords: RDF, vermicompost, mustard oil cake, cost of cultivation, B: C ratio

Introduction

Potato (*Solanum tuberosum* L.) is herbaceous annual plant and belongs to the family Solanaceae. The edible part of potato is modified underground stem. It is originated in South America and brought to India in 16th century by the Portuguese. Potato is the 4th major food crop after rice, wheat and maize of the world. Potato is rich source of energy and produces more food per unit area and time than all major food crops. Potato is one of the most efficient food crop which produce more dry matter, dietary fiber, quality protein, minerals and vitamin than wheat, maize and rice per unit area and time is considered as a balanced and nutritive food. India is the second largest potato producing country in the world after China. In India, during 2015-16, potato is grown over an area of 2.11 million hectare with an annual production of 43.41 million tonnes with an average yield of 20.5 t/ha. Almost 85% of total production comes from north India plain *viz*. Uttar Pradesh, West Bengal and Bihar. In world scenario, India has got second position after China with respect to production. Bihar is the third largest potato producer state of the country, occupying 5% area of total cultivated land *i.e*. 0.31 million hectare with a production of 6.34 million tonnes and productivity 19.88 t/ha (Horticultural statistics at a glance 2017). Potato is highly responsive to application of organic manures (Mondal *et al.*, 2005) [5]. Many physical, chemical and biological limitations of soil are often associated with low levels of organic matter content in the soil. In this context the concept of low-input sustainable agriculture (Grubinger, 1992) [6], which lays focus on reconsideration of agricultural practices such as green manuring, recycling crop residues and animal manures, and the inclusion of legumes in rotation, is important. However, such a practice cannot provide total nutrient needs of modern agriculture; integrated use of nutrients from fertilizers and organic sources seems to be more useful for sustaining yields. Integrated nutrient supply and management (INSM) is essential for sustaining crop productivity on long-term basis (Chettri *et al.*, 2004) [4], especially because higher use of agro-chemicals creates pollution problems.

Potato is highly responsive to application of organic manures (Mondal *et al.*, 2005) [16]. Among organic manures, mustard oil cake contains higher amount of nutrients such as 4.93% N, 0.53% P2O5 and 0.65% K2O (FAO, 1986).

Though mustard oil cake costs fairly higher than other organic manures, it supplies essential nutrients slowly and thus plants get nutrients for a longer period of time. It has been mentioned that mustard oil cake increases potato yield to a large extent in association with potassium (Hossain *et al.* 2003). Vermicompost has found to effectively enhance the root formation, elongation of stem and production of biomass in potato crop. Using of vermicompost is now a global movement for the second green revolution that emphasizes on composting. Ghosh *et al.* (1999). Observed that integration of vermicompost with inorganic fertilizers tends to increase the yield of potato crop. Vermicompost has higher level of nitrogen (1.6%), phosphorus (0.7%) and potassium (0.8%), Calcium (0.5%), magnesium (0.2%) (Buchanan *et al.*, 1988). The productivity of potato can be increased and sustained by adoption of integrated nutrient management. Keeping this point in view the present investigation has been carried out.

Materials and Methods

The field experiment was conducted during Rabi season in year 2017-18 at the farm of Tirhut College of Agriculture, Dholi (Muzaffarpur) which is situated on the southern bank of the river Burhi Gandak at an altitude of 52.18 meter above mean sea level and lies at 25º.98' N latitude and 85º.6' E longitude. Field experimental was laid out in Randomized Block Design with twelve treatments *viz.*, T1 - absolute control, T2 - 100% RDF, T3 - 50% RDF + 5.0 t/ha vermicompost, T4 - 50% RDF + 2.5 t/ha mustard oil cake, T5 - 75% RDF + 5.0 t/ha vermicompost, T6 - 75% RDF + 2.5 t/ha mustard oil cake, T7 - 100% RDF + 5.0 t/ha vermicompost, T8 -100% RDF + 2.5 t/ha mustard oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake, T11 - 150% RDF + 5.0 t/ha vermicompost and T12 - 150% RDF + 2.5 t/ha mustard oil cake and replicated thrice.

The cost of cultivation was worked out by taking into consideration all the expenses incurred. Gross return was worked out by multiplying per ha tuber yield obtained under various treatments with the prevailing market selling rate. Net return was calculated by deducting the cost of cultivation from the gross return of the individual treatment. Benefit: cost ratio was calculated by dividing net income by the cost of cultivation of individual treatment.

$$\text{B: C ratio} = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Results and Discussion

Grade wise yield of tubers (q/ha) of potato crop

Results in (table 1) showed that the application of 150% recommended dose of fertilizer along with combination of organic manures recorded higher tuber yield of all grades (25-50, 50-75 and >75 g) whereas minimum under T_1 - absolute control. The maximum grade wise (<25g) yield of tuber obtained in treatment T_1 - absolute control (50.07 q/ha) and the minimum was found in T_{11} (34.04 q/ha). Higher yield of better grade (50-75 and >75g) tubers obtained in this investigation with the increasing level of RDF with organic manures may also be due to the response of fertilizers to bulking of potato tuber. The increase in tuber size in response to the increased supply of fertilizer nutrient could be due to more luxuriant growth, more foliage and leaf area and higher supply photosynthesis which might have induced formation of bigger tubers thereby resulting in higher yields (Patricinia and Bansal, 1999) [18]. Similar results had been reported by Patel (2013) [17] Banjare (2012) [2], Kumar *et al.* (2008 and 2011) [11, 13] and Das *et al.*, (2009) [5].

Tuber and vine yield

Mean data given in (Table 2.) revealed that different treatments had significant effect on yield and vine yields. The highest tuber (276.15 q/ha) and vine yield (118.45 q/ha) was recorded with 150% recommended dose of fertilizer along with vermicompost which was significantly higher than other treatments but was at par with treatments T7 T8 T9 T10 T11 and T12. Higher yield obtained with application of higher dose of fertilizers (NPK) might be due to positive response of potato crop to the nutrients like nitrogen, phosphorus and potash. The beneficial response of organic manure to increase the crop yield might also be attributed to the availability of sufficient amounts of plant nutrients throughout the growth period and especially at critical growth periods of crops resulting its better uptake, plant vigour and superior yield attributes. These results are in conformity with the finding of Sarkar *et al.* (2011) [20], Banjare (2012) [2], Patel (2013) [17] and Kumar *et al.* (2017) [14].

Biomass yield (q/ha) of potato crop

Mean data revealed that the Maximum biomass yield was obtained under treatment T_{11} - 150% RDF+5.0 t/ha vermicompost which was statistically at par with treatments, T_7 -100% RDF + 5.0 t/ha vermicompost, T_8 - 100% RDF + 2.5 t/ha mustard oil cake, T_9 -125% RDF + 5.0 t/ha vermicompost, T_{10} - 125% RDF +2.5 t/ha mustard oil cake and T_{12} - 150% RDF +2.5 t/ha mustard oil cake and significantly superior over rest of the treatments. Omission of nutrients may induce a specific nutrient deficiency, stress and retard the biomass production. The increase in the yield of vines was due to the increase in the levels of N, P and K at each successive level. The increase in biomass ascribed to higher number of stolons, higher plant height, dry matter production, shoot per plant, leaves per plant, LAI per plant, dry matter accumulation per plant, bulking rate of tuber per plant, vine yield and the better assimilation of carbohydrate and their translocation to tubers which ultimately helped in the enlargement of tuber weight thus increase biomass production of potato. This is in conformity with result of Gupta and Pal (1989) [7], Bhaumik and Dandapat (1991) [3] and Singh and Sharma (1997) [21]. Similar results had also been reported by Roy and Sharma (2001) [19].

Economics

Cost of cultivation

Mean data given in (Table 3.) revealed that the highest cost of cultivation (116386`/ha) was obtained in treatment $T_{12}$ -150% RDF + 2.5 t/ha mustard oil cake and lowest cost of cultivation (65917 `/ha) was obtained with treatment T_1 - absolute control.

Gross return

Result in (table 3) showed that the significantly higher gross return (276147 `/ha) was obtained by treatment T_{11} - 150% RDF + 5.0 t/ha vermicompost over rest of the treatments. This result indicated that increasing levels of RDF with combination of vermicompost and mustard oil cake played important positive role in increasing the gross return by producing increased yield. This finding is in favour of the finding of Kushwah (1999) [15], Verma *et al.* (1997) [23] and Kumar *et al.* (2012) [12].

Net return

Perusal of mean data (table 3) revealed that. The treatment T_{11} - 150% RDF + 5.0 t/ha vermicompost recorded significantly higher net return (172261 `/ha) in comparison to the rest of the treatments. This might be due to the higher yield of potato induced by the increasing nutrient supply in T_{11} in comparison to control. This finding is in favour of kushwah (1999) [15], Krishnamurthy *et al.* (2001) [10] and Surin and Jha (2002) [22].

Benefit: Cost ratio

Mean data given in (table 3) revealed that increasing level of recommended dose of fertilizer with combination of vermicompost and mustard oil cake significantly affected the benefit: cost ratio. But the treatment T_2- 100% RDF (2.11) fetched significantly higher benefit: cost ratio in comparison to treatment T_7 -100% RDF + 5.0 t/ha vermicompost (1.62), T_8 -100% RDF + 2.5 t/ha mustard oil cake (1.31), T_9 -125% RDF + 5.0 t/ha vermicompost (1.67), T_{10} -125% RDF +2.5 t/ha mustard oil cake (1.35), T_{11} - 150% RDF + 5.0 t/ha vermicompost (1.66) and T_{12} -150% RDF + 2.5 t/ha mustard oil cake (1.35), whereas minimum benefit: cost ratio was obtained with treatment T_1- absolute control (0.69). This might be due to vermicompost and mustard oil cake was found less economic due to it's high price which reduced the returned per rupee invested. The results are in conformity with the finding of Kumar *et al.* (2008) [11], Baishya (2009) [1] and Kumar *et al.* (2012) [12].

Table 1: Effect of different treatments on grade-wise tuber yield (q/ha) of potato

Treatment	Tuber yield (q/ha)				
	<25 g	25-50 g	50-75 g	>75 g	total
T_1	50.07	23.73	20.16	17.33	111.28
T_2	35.55	63.78	67.98	65.98	233.30
T_3	49.30	63.37	52.81	44.76	210.24
T_4	49.93	60.29	54.07	42.73	207.02
T_5	47.78	67.49	59.64	62.32	237.23
T_6	48.18	68.65	58.82	59.93	235.58
T_7	39.93	63.25	77.66	81.17	262.00
T_8	40.64	64.12	76.99	77.91	259.67
T_9	40.89	65.61	82.06	83.89	272.45
T_{10}	39.37	68.91	79.48	81.47	269.23
T_{11}	34.04	69.30	85.51	87.30	276.15
T_{12}	35.67	67.39	83.85	86.97	273.87
S Em (±)	1.61	2.20	3.18	3.40	7.65
CD(*p=0.05*)	4.72	6.47	9.33	9.98	22.43

Table 2: Effect of different treatments on fresh tuber yield (q/ha) and yield attributes of potato

Treatments	Fresh tuber yield (q/ha)	Yield of vine (q/ha)	Yield of biomass (q/ha)	Tuber: vine ratio	Harvest index (%)
T_1	111.28	72.20	183.47	1.54	60.65
T_2	233.30	106.69	339.98	2.19	68.62
T_3	210.24	100.68	310.92	2.09	67.62
T_4	207.02	99.45	306.47	2.08	67.55
T_5	237.23	106.48	343.72	2.23	69.02
T_6	235.58	105.59	341.18	2.23	69.05
T_7	262.00	115.96	377.96	2.26	69.32
T_8	259.67	116.72	376.39	2.22	68.99
T_9	272.45	117.26	389.71	2.32	69.91
T_{10}	269.23	117.15	386.38	2.30	69.68
T_{11}	276.15	118.45	394.66	2.33	69.97
T_{12}	273.87	118.21	392.09	2.32	69.85
S Em (±)	8.24	3.48	12.37	0.07	1.70
CD(*p*=0.05)	24.16	10.19	36.28	0.20	4.97

Table 3: Effect of different treatments on economics of potato cultivation

Treatments	Cost of cultivation (`/ha)	Gross returns (`/ha)	Net returns (`/ha)	B:C ratio
T_1	65917	111277	45360	0.69
T_2	75077	233297	158220	2.11
T_3	96273	210243	113970	1.18
T_4	108773	207023	98250	0.90
T_5	98189	237233	139044	1.42
T_6	110689	235583	124894	1.13
T_7	100077	262003	161926	1.62
T_8	112577	259670	147093	1.31
T_9	101970	272447	170477	1.67
T_{10}	114470	269233	154763	1.35
T_{11}	103886	276147	172261	1.66
T_{12}	116386	273873	157487	1.35
S Em (±)	-	7647.45	7647.45	0.08
CD(p=0.05)	-	22429.19	22429.19	0.22

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