International Journal of Agricultural Sciences
Volume **15** | Issue 1 | January, 2019 | 32-36 ■ ISSN : 0973-130X
☞ **DOI:10.15740/HAS/IJAS/15.1/32-36**
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RESEARCH PAPER

Productivity and economics of potato grown with organics fertilization in comparison to inorganic fertilizers

Rajiv
Vegetable Research Station (C.S.A.U.A.T.) Kalyanpur, Kanpur (U.P.) India
(Email: rajiv.agro69@gmail.com)

Abstract : A field experiment was conducted on potato (*Solanum tuberosum* L.) at Vegetable Research Station Kalyanpur, Kanpur (U.P.) during 2010-11, 2011-12 and 2012-13 in sandy loam soil. Six different treatments of organic fertilization were tested against the control treatment of recommended inorganic NPK fertilizers. Organic treatments consisted crop residue incorporation, its management, biofertilizers (*Azotobacter* and phosphobacteria), vermicompost @ 5 t ha^{-1} or FYM @ 20 t ha^{-1} and recommended N based FYM application alone. Based on pooled data over years, treatment of recommended NPK fertilizers (180 kg N + 80 kg P_2O_5 + 100 kg K_2O ha^{-1}) produced highest potato tuber yield of 35.04 t ha^{-1} and earned maximum of Rs. 125177 ha^{-1} net return. It was followed by N based FYM application with 32.66 t ha^{-1} yield and Rs.109814 ha^{-1} net return. The treatment of crop residue management + biofertilizers + vermocompost @ 5 t ha^{-1} also produced considerable potato yield of 30.26 t ha^{-1} with Rs. 100543 ha^{-1} net return. Therefore, these two organics practices may serve as alternative of NPK inorganic fertilizers without much reduction in yield and net return and fear of pollution hazards.

Key Words : Potato, Organics, Biofertilizers, Inorganic fertilizers, Production, Economics

View Point Article : Rajiv (2019). Productivity and economics of potato grown with organics fertilization in comparison to inorganic fertilizers. *Internat. J. agric. Sci.*, **15** (1) : 32-36, **DOI:10.15740/HAS/IJAS/15.1/32-36.**

Article History : Received : 27.06.2018**; Revised :** 19.11.2018**; Accepted :** 24.11.2018

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the important crops of the world and is consumed by people across the globe both as food and as vegetable. It is contributing to world food basket just after rice, wheat and maize. India is one of the important countries producing about 25 million tones of potato from an area of 1.34 million ha with an average productivity of 18.6 t ha^{-1} (Tyagi *et al.*, 2012). Out of the total area under potato, 86 per cent area is in Indo-Gangetic plains, 6 per cent in the hills and remaining 8 per cent in South-eastern, Central and Peninsular India (Pandey *et al.*, 2012). The states of Uttar Pradesh, West Bengal and Bihar accounted for more than 70 per cent share in total production with the rank of 1^{st}, 2^{nd} and 3^{rd}, respectively in relation to potato production. The highest potato productivity of 30.8 MT is in Gujarat followed by West Bengal (30.0 MT). The state-wise area, production and productivity of potato during 2012-13 are furnished in Table A (Anonymous, 2014).

Potato being a heavy feeder of nutrients, requires high amounts of nitrogen, phosphorus and potassium. Compared with cereal crops, potato produces much more dry matter per unit area and time. This high rate of dry matter production results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply. A healthy crop of potato removes about 120-140 kg N, 25-30 kg P_2O_5 and 170-230 kg K_2O ha^{-1} (Dua, 2013). Chemical fertilizers are the main source of nutrient to potato crop. However, continuous use of chemical fertilizers has resulted in nutritional imbalance, depletion of soil organic matter, contamination of food and water, adverse effect on biodiversity as well as on human health. Considering these along with higher cost of chemical fertilizers, it is necessary to find out an alternative that besides sustaining the productivity with improving quality of potato should also be eco-friendly to the environment. Research evidences showed that potato crop responds well to organic manures application (Mondal *et al.*, 2005). Supplying of nutrients through organic sources can be opted for avoiding the hazardous effects of fertilizers and maintaining sustainability. Organic manures like FYM or vermicompost and biofertilizers like *Azotobacter* and phosphobacteria may play a major role in supplementing the crop nutrients through their direct addition, improvement in soil condition, nitrogen fixation and solubilisation of fixed forms of phosphorus in soil (Bhardwaj and Gaur, 1970). The demand for potato is expected to grow at 3.80 per cent annual compounded growth rate. At this rate, total consumption of potato by the year 2030 would be 67.23 million tonnes considering 2007 data of FAO, *i.e.*, 28.51 million tonnes as base. It indicates an excess production of 2.16 million tonnes by 2030 (Singh *et al.*, 2011). Keeping all these points in view, the present study was undertaken on organic fertilization of potato crop.

MATERIAL AND METHODS

The field experiment was conducted during 2010-11, 2011-12 and 2012-13 at Vegetable Research Station Kalyanpur of C.S. Azad University of Agriculture and Technology, Kanpur under All India Co-ordinated Research Project on Potato. The soil was sandy loam

Table A : State-wise area, production and productivity of potato (2012-13) (Top 10 states)

State	Area (in ‘000 ha)	Production (in ‘000 MT)	Productivity (in MT ha^{-1})	Production share (%)
Uttar Pradesh	603.76	14,430.28	23.9	32
West Bengal	386.61	11,591.30	30.0	26
Bihar	322.46	6,640.55	20.6	15
Gujarat	81.27	2,499.73	30.8	5
Madhya Pradesh	108.87	2,299.00	21.1	5
Punjab	85.25	2,132.31	25.0	5
Assam	99.77	975.27	9.8	2
Karnataka	44.40	698.30	15.7	2
Haryana	29.47	676.02	22.9	1
Jharkhand	47.21	659.61	14.0	1
Others	183.10	2,741.20	15.0	6
Total	1,992.20	45,343.60	22.8	--

Table B : Details of treatments tested

Treatments No.	Details
T_1	Control (Recommended NPK fertilizers @ 180 kg N + 80 kg P_2O_5 + 100 kg K_2O ha^{-1})
T_2	Crop residue incorporation of all crops of potato based systems
T_3	T_2 + microbial culture to decompose crop residues
T_4	T_3 + biofertilizer *i.e. Azotobacter* or *Rhizobium* and phosphobacteria to all crops of system as per recommendation
T_5	T_4 + Vermicompost @ 5 t ha^{-1} in potato
T_6	T_4 + FYM @ 20 t ha^{-1} in potato
T_7	FYM on N basis as per the recommended for all crops in the rotation. It was applied in potato crop @ 40 t ha^{-1}

with organic carbon 0.40 per cent, available N 162.0 kg ha^{-1}, phosphorus 15.2 kg ha^{-1} and potassium 192 kg ha^{-1} at initiation of experiment. The experiment was conducted in fixed layout during all the three years. Soil pH was 7.8, which showed slightly alkaline reaction. There were seven treatments (Table B) tested in four times replicated Randomized Block Design (RBD).

The crop of potato was grown in rotations of bottle gourd – potato – green gram, cucumber – potato – green gram and black gram - potato – okra during 2010-11, 2011-12 and 2012-13, respectively. The available N, P and K contents in vermicompost were 1.52, 0.48 and 1.45 per cent and in FYM, these were 0.45, 0.25 and 0.52 per cent, respectively. Potato variety 'Kufri Bahar' was used in the experiment. Planting of potato was done in between 22 and 28 October while digging of tubers was done at full maturity between 20 and 25 February during different years. Haulms cutting of potato were done during first week of February in different years. Planting of seed tubers was done on ridges at 60 x 20 cm spacing. Potato seed tubers were taken out from the cold store 10-13 days before planting and were kept in plastic creates in the shade having diffused light to allow the emergence of sprouts. Crop was raised with recommended package of practices except treatments. The yield data were recorded on five randomly selected plants in each treatment and replication and recorded data were analyzed by using statistical techniques. On the basis of total variable cost and gross return, net return, return per rupee invested and per day return (PDR) were calculated as per methods suggested by Devasenapathy *et al*. (2008).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Crop productivity:

Potato yield was influenced significantly by different treatments during all the three years and also in pooled analysis (Table 1 and Fig. 1). Treatment T_1 of NPK fertilizer produced significantly highest tuber yield in all observations except during 2010-11 when treatments T_5, T_6 and T_7 of vermicompost or FYM remained at par with T_1 treatment. Based on 3-year pooled data, treatment T_1 produced significantly highest of 35.04 t ha^{-1} potato yield and was followed by treatment T_7 (32.66 t ha^{-1}) which gave higher tuber yield significantly than other treatments. Among remaining treatments, T_5 and T_6 being at par produced significantly higher yield than T_2, T_3 and T_4 treatments which were found at par with each other in tuber yield. As compared to treatment T_1 of NPK fertilizers, potato yield reduced in all organic treatments significantly but margin of reduction varied in different treatments. The margin was lowest of 2.38 t

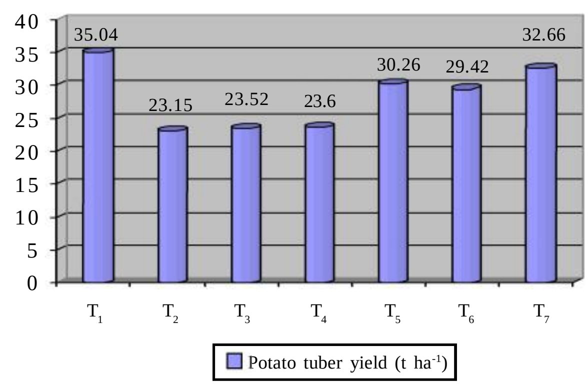

Fig. 1 : Treatment wise potato tuber yield (t ha^{-1})

Table 1: Effect of treatments on tuber yield of potato (t ha^{-1})

Treatments	Potato tuber yield (t ha^{-1})				Decrease in yield from control	
	2010-11	2011-12	2012-13	Pooled	t ha^{-1}	%
T_1	29.05	33.40	42.66	35.04	--	--
T_2	24.82	19.90	24.74	23.15	11.89	33.93
T_3	22.35	22.01	26.21	23.52	11.52	32.88
T_4	20.50	22.03	28.26	23.60	11.44	32.65
T_5	28.54	29.48	32.77	30.26	4.78	13.64
T_6	26.21	25.83	36.22	29.42	5.62	16.04
T_7	30.26	27.90	39.81	32.66	2.38	6.79
S.E.±	1.78	0.50	1.10	0.76	--	--
C.D.(P=0.05)	3.73	1.06	2.32	1.48	--	--

Details of treatments are given in Table B

ha^{-1} or 6.79 per cent in treatment T_7 and highest of 11.89 t ha^{-1} or 33.93 per cent in treatment T_2 of only crops residue incorporation. It might be attributed to the availability of nutrients for crop use. Crops residue incorporation alone or with biofertilizers could not meet the nutrition need of crop while vermicompost and FYM might have improved the availability of nutrients for crop use thus yielded nearer to NPK fertilizers treatment. These results corroborate with the findings of Meena *et al*. (2013) and Narayan *et al*. (2014). Organic manures are not only the good source of major and micro nutrients but also improve the physico-chemical properties of soil (Reust and Neyround, 2003).

Economics:

Cost of cultivation was involved significantly higher in treatment T_1 of NPK fertilizers during 2010-11 and 2011-12 but during last year of 2012-13, it was highest in treatment T_7 of N based FYM application. Thus, in pooled results, T_7 required highest cultivation cost followed by treatment T_1 and T_6 (Table 2). It might be attributed to higher cost of FYM and NPK fertilizers. Among other treatments, T_5 of vermicompost required higher cost perhaps because of vermicompost cost. Higher cost of potato cultivation with FYM or vermicompost application has also been estimated by Narayan *et al*. (2014).

Gross income was worked out significantly highest of Rs. 191097 ha^{-1} in treatment T_1 followed by treatment T_7 with Rs. 177169 ha^{-1} income. Treatment T_5 of vermicompost gave significantly higher income than T_6 of FYM application. Other treatments recorded almost similar gross income being lowest under T_2 of only residues incorporation. Application of microbial culture alone for residue decomposition (T_3) and additional use of biofertilizers (T_4) also increased gross income significantly. These gross income values are attributed to potato yield of tubers, as it is the only source of income from potato cultivation.

Net return was obtained significantly highest of Rs. 125177 ha^{-1} under treatment T_1 of NPK fertilizers

Table 2: Effect of treatments on economic parameters of potato (Rs. ha^{-1})

Treatments	Cost of cultivation (Rs. ha^{-1})				Gross income (Rs. ha^{-1})				Net return (Rs. ha^{-1})			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	62280	62280	69560	65920	133630	183700	255960	191097	71350	121420	186400	125177
T_2	59280	59280	59280	59280	114172	109450	148440	124021	54892	50170	89160	64741
T_3	59480	59480	59480	59480	102810	121055	157260	127042	43330	61575	97780	67562
T_4	60130	60130	60130	60130	94300	121165	169560	128342	34170	61035	109430	68212
T_5	62180	62180	63430	62805	131284	162140	196620	163348	69104	99960	133190	100543
T_6	61932	61932	68932	65432	120566	142065	217320	159984	58634	80133	148388	94552
T_7	60430	60430	74280	67355	139196	153450	238860	177169	78766	93020	164580	109814
S.E.±	161	162	162	281	649	337	1235	488	551	464	682	617
C.D.(P=0.05)	339	341	340	550	1364	708	2595	956	1158	974	1432	1210

Details of treatments are given in Table B

Table 3 : Effect of treatments on return per rupee invested and per day returns of potato

Treatments	Return per rupee invested (Rs.)				Per day return (Rs. ha^{-1})			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	2.14	2.95	3.68	2.90	604.66	1028.98	1579.66	1071.10
T_2	1.92	1.85	2.50	2.09	465.19	425.17	755.59	548.65
T_3	1.73	2.03	2.64	2.13	367.20	521.82	828.64	572.55
T_4	1.57	2.01	2.82	2.13	289.58	517.24	927.37	578.06
T_5	2.11	2.61	3.10	2.61	585.63	847.12	1128.73	853.83
T_6	1.95	2.29	3.15	2.46	496.90	679.09	1257.52	811.17
T_7	2.30	2.54	3.22	2.69	667.51	788.30	1394.74	950.18
S.E.±	0.12	0.11	0.15	0.13	23.18	33.26	53.72	42.15
C.D.(P=0.05)	0.25	0.24	0.32	0.30	51.12	70.24	113.46	79.88

Details of treatments are given in Table B followed by T_7 of N based FYM application with Rs. 109814 ha^{-1} and by T_5 of vermicompost with Rs. 100543 ha^{-1} (Table 2). Treatment T_6 of FYM @ 20 t ha^{-1} gave significantly lower return that T_5 of vermicompost @5t ha^{-1} application. It showed the superiority of vermicompost over FYM among organics. Treatment T_2 of only residue incorporation earned lowest net return of only Rs. 64741 ha^{-1}, while T_3 of microbial culture increased net return significantly and T_4 of biofertilizers over T_3 further increased the net return significantly. Net return is the resultant of gross income and cost of cultivation where gross income dominated over cultivation cost in present study. Return per rupee invested and per day return (PDR) followed the same pattern of net return under different treatments (Table 3). It might be due to higher increase in gross income in comparison to increase in cultivation cost under respective treatments. These results are in close agreement to the findings of Sarkar *et al*. (2011) and Narayan *et al*. (2014).

Conclusion:

The results of the experiment may be concluded that for getting highest yield and net return of potato, application of recommended NPK fertilizers is essential. However, N based FYM application or crop residue management with biofertilizers (*Azotobacter* and Phosphobacteria) and vermicompost @ 5 t ha^{-1} are proper alternative of inorganic fertilizers without much reduction in yield and net returns. It will ensure the sustainability in production and soil health along with pollution free environment.

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