International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 1589-1593

Received: 15-05-2018
Accepted: 18-06-2018

Roop Singh Dangi
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

SP Singh
ICAR-Central Potato Research Institute- RS, Gwalior, Madhya Pradesh, India

Dharmendra Gaur
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

JP Dixit
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Sanjay Sharma
ICAR-Central Potato Research Institute- RS, Gwalior, Madhya Pradesh, India

Rahul Patidar
Department of Agronomy, RajmataVijayaraje Scindia Krishi VishwaVidyalaya, Gwalior, Madhya Pradesh, India

Correspondence
Roop Singh Dangi
Department of Agronomy, RajmataVijayaraje Scindia Krishi VishwaVidyalaya, Gwalior, Madhya Pradesh, India

Response of potato (*Solanum tuberosum* L.) to nitrogen levels under different cultural practices

Roop Singh Dangi, SP Singh, Dharmendra Gaur, JP Dixit, Sanjay Sharma and Rahul Patidar

Abstract
A field experiment, entitled "Response of potato (*Solanum tuberosum* L.) to nitrogen levels under different cultural practices" was conducted at the Research Farm of ICAR - Central Potato Research Institute, RS, Gwalior (M.P.) during *Rabi* season of 2016-17 on silty clay loam soil having 0.29% organic carbon, 160.25 kg available N, 24.35 kg available P, 270.01 kg available K/ha and pH 6.3. The experiment was laid out in split plot design with 8 treatment combinations replicated three times. The treatment combination consists of 2 cultural operations and 4 nitrogen levels. Heat tolerant potato variety "Kufri Surya" was planted using seed rate of 30 q ha^{-1}. The results revealed that application of 225 kg nitrogen ha^{-1} without hoeing produced higher plant height at harvest.There was no any significant effect of nitrogen levels and cultural practices on plant height. Application of 225 kg ha^{-1} in combination without hoeing exerted significant effect on plant height, similarly no. of stem $plant^{-1}$ and no. of compound leaves $plant^{-1}$ were statistically at par under different treatments except for no. of stem $plant^{-1}$ (2.79) at 50 DAP which was significantly higher for hoeing treatment. Cultural operations did not show any significant effect on tuber yield however increasing nitrogen levels significantly increased tuber yield. Highest tuber yield (24.81 t ha^{-1}) was recorded with 225 kg N ha^{-1}which was statistically superior over control and 75 kg N ha^{-1}. Cultural operation significantly increased tuber N uptake (63.98 kg ha^{-1}) over without cultural operation. Increasing levels of N application significantly reduced tuber K uptake. Non-significant effect of cultural operation was observed on harvest index. Increasing application of N significantly increased harvest index. Interaction effect of cultural operation with N rates was significant. Crop N demand reduced when cultural operation was followed. Under non- hoeing condition for getting optimum yield, there is need to enhance applied dose of N. However, application of 225 kg nitrogen ha^{-1} recorded significantly higher biological yield, harvest index and N uptake by crop. Whereas application of 225 kg nitrogen ha^{-1} without hoeing produced higher plant height at 30, 50 day after planting and at harvest. The maximum net return (Rs. 78, 419 ha^{-1}) and benefit: cost ratio (2.03) were recorded with hoeing with 225 kg nitrogen level. Whereas, lowest net return (Rs. 37, 427 ha^{-1}) and benefit: cost ratio (1.52) were found in without hoeing without nitrogen application, respectively.

Keywords: Cultural practices, economics, nitrogen levels, nutrient uptake potato and yield

Introduction
Potato (*Solanum tuberosum* L.) is starchy, tuberous and contributes substantially towards food and nutritional security in the world. The potato is a crop with a large number of wild relatives, a group of more than 100 tuber bearing *Solanum* species. It originated in the high Andean hills of South America. Potato is believed to have been introduced in India from Europe in early 17th century AD. The potato is ranked by FAO of United Nations as the world's 4th most important food crop after rice, wheat and maize (FAO, 2006) [10]. Potato is among one of the most diverse and nutritious crops on the earth.

Potato is an ingredient in many dishes and salads. It is a non-fattening, nutritious and wholesome food that supplies many important nutrients to the diet. It contains approximately 78% water, 22% dry matter (specific gravity) and less than 1% fat. About 82% of dry matter is carbohydrate, mainly starch with some dietary fiber and have better nutritional quality than cereals. Potato contains at least 12 essential amino-acid, minerals and is also source of vitamin C, thiamine (B_6), iron and folic acid.

It is used for variety of purposes and typically as a vegetable, hence regarded as "King of vegetables". But in fact, it is likely that less than 50 per cent of potato grown worldwide is consumed fresh in the form of vegetable. The rest are processed into potato food product (potato flour, chips, French fries etc.) and food ingredients, feed to cattle, pigs and chickens and processed into starch for industry.

The current global production of potato is around 453.43 million tonnes and China being the largest producer globally. India ranks 2nd in area and production of potato in the world after China which contribute 11 per cent of world potato production (FAO STAT, 2014) [11]. In India, potato production is mainly confined to Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, Gujarat, Punjab, Assam and Haryana. More than 90% potato crop is grown in winter season under assured irrigation facility from October to March. In India, it is grown on an area of 2 million hectares with the production of 44.3 million tonnes and the productivity is 21967 kg ha^{-1} (Anonymous, 2015) [2].

Potato is very sensitive crop to nitrogen fertilization. Excess nitrogen may prolong the vegetative phase and thus, interfere with the initiation of tuberization, decreasing yield and dry matter accumulation in the tubers. Hand hoeing is common with small farm holders while mechanization is preferred by large farmers. Because of decreasing availability of labour and/or family members at cheaper rate until recent past hiring labourer for hoeing is getting more and more difficult and expensive. Hoeing has been still an important practice for not only weed control but also other management requirements. Bartova *et al.* (2012) [4] reported that 100 kg N ha^{-1} is sufficient for production of potato tubers with high content of both crude protein and starch, especially in production areas with higher altitude Fandika *et al.* (2016) [9] and also Chongtham *et al*. (2015) [6] reported that application of more than 80 kg N ha^{-1} decreased yield in potato. Application of 150 kg N ha^{-1} improved tuber yield and crop productivity with higher remuneration and efficient use of phosphorus, potassium and water. However agronomic use efficiency of nitrogen decreased with subsequent increase in nitrogen levels.

Nutrients have major influence on yield and quality of crop in different ways among which nitrogen is one of the key nutrient and influences the early crop development and tuber initiation, tuber size, tuber specific gravity and protein content. Patidar *et al.* (2017) [16] found that the plant height, number of tubers, dry matter accumulation both in haulm and tuber was significantly increased by application of recommended dose of fertilizers (RDF). In view of the above facts, the present investigation was conducted to evaluate response of potato to nitrogen levels under different cultural practices.

Materials and Methods

A field experiment, entitled "Response of potato (*Solanum tuberosum* L.) to nitrogen levels under different cultural practices" was conducted at the Research Farm of ICAR, Central Potato Research Station, Gwalior (M.P.) during *Rabi* season of 2016-17 on silty clay soil having 0.29% organic carbon, 160.25 kg available N, 24.35 kg available P, 270.01 kg available K ha^{-1} and pH 6.3. The experiment was laid out in split plot design with 8 treatment combinations replicated three times. The treatment combination consists of 2 cultural operations viz. Hoeing (H_1) and without hoeing (H_0) and 4 nitrogen levels *viz.* 0 (N_0), 75 (N_1), 150 (N_2) and 225 (N_3) kg N ha^{-1}). Heat tolerant potato variety "Kufri Surya" was planted using a seed rate of 30 q ha^{-1}. Inter row spacing was kept at 60 cm apart. Basal dose of NPK was applied as per treatment. The crop was planted on 24th October 2016 and harvested on 4th Feb. 2017.

The recommended dose of N, P_2O_5 and K_2O were 180, 80 and 120 kg ha^{-1} for the crop. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Cultural practices were followed as per standard recommendation to potato crop. Prior to planting, the field was prepared as per the standard procedure and laid out properly. On the next day of potato planting, application of herbicide Metribuzin @ 500 g a.i./ha was applied in each treatment to control weeds. The hoeing was done at 24 days after planting as per treatment. Economics was worked out taking both variable and fixed costs into account. Data were analyzed as per standard procedure with 5% probability level.

Results and Discussion

Effect of cultural operations and nitrogen levels on growth attributes

Plant population remained statistically unchanged (non-significant) under the various treatments without giving any definite trend at 30 DAP. It obviously reflects the fact from these data that the planting of seed tuber was done properly, uniformly in each treatment using healthy and viable sprouted tuber to maintain the better emergence and crop stand. Thus the crop stand remained almost uniform, sufficient in all the treatments.

In general, the plant height increased with the advancement in crop age irrespective of the treatment and reached maximum at maturity. The rate of increase in plant height was more during 30 to 50 DAP as compared to 50 DAP to maturity. The height of plants was almost ceased or slightly declined at maturity because of senescence. The plant height, in general, enhanced considerably in all the treatments with the advancement of plant growth from initial up to harvest. The plant height varied significantly among the different nitrogen doses and cultural practices at all growth stages due to their positive effect. At the early (30 DAP) stage, the height ranged from 23.77 to 25.13 cm, whereas at 50 DAP, it ranged from 46.98 to 47.90 cm at harvest the height went up to the range of 52.17 to 54.07 cm. Plant height of potato recorded at 30, 50 days after planting and at harvest was non-significantly affected due to cultural operation and nitrogen levels. Response of the potato crop to the cultural operation and nitrogen interaction was not found to be significant at 30 and 50 DAP however it caused significant effect at harvest. Among the cultural operation and N level interactions cultural operation with 150 kg nitrogen level application recorded maximum plant height (57.33 cm) at harvest. Combination of no-cultural operation with 225 kg nitrogen level was followed by no-cultural operation with 75 kg nitrogen levels. Corroboratory findings were also reported by Kumar *et al.* (2007) [14], Prativa and Bhattarai (2011) [17] and Kumar *et al.* (2013) [13].

At the early (30 DAP) stage, number of stem/plant ranged from 2.33 to 3.13, whereas at 50 DAP, it ranged from 2.35 to 2.88 at harvest, the number of stem/plant went up to the range of 2.37 to 2.80. Number of stem $plant^{-1}$ was significantly affected by cultural operation at 50 days after planting, However, Cultural operations were effective and increased number of stem $plant^{-1}$ at all stages of crop. Number of stem $plant^{-1}$ at 30, 50 DAP and at harvest interaction effect of cultural operation and nitrogen level was found to be non-significant. These finding are in close vicinity Kumar *et al.* (2007) [14], Prativa and Bhattarai (2011) [17] and Kumar *et al.* (2013) [13].

At 30 DAP the number of compound leaves ranged from 15.27 to 18.93, whereas at 50 DAP, it ranged from 29.37 to 33.23, at harvest, number of compound leaves $plant^{-1}$ went up to the range from 30.73 to 35.28. Numbers of compound

leaves plant^{-1} was significantly affected by cultural operation at 50 days after planting. However, Cultural operation was effective and enhanced numbers of compound leaves/plants at all stages of crop. Numbers of compound leaves plant^{-1} vary significantly due to nitrogen level at 30 day after planting and at harvest stage. However, at 30 days after planting application of 75 kg nitrogen significantly produced more number of compound leaves plant^{-1}, which remain at par with control, 150 and 225 kg/ha N levels. While nitrogen levels significantly produced more number of compound leaves/plant, which remain at par with no fertilizer. Response of the cultural operation and nitrogen interaction on the number of compound leaves/plant at 30, 50 DAP and at harvest was found to be non-significant. The results are also in line with findings of Baishya *et al.* (2012).

Effect of cultural operations and nitrogen levels on uptake of N, P and K crop

Total uptake of N, P and K by tuber and haulm ranged from 87.11 to 111.48, 24.84 to 26.90 and 106.84 to 120.61 kg ha^{-1}, respectively. Total uptake of N was significantly affected due to nitrogen levels and cultural operations. Total uptake of P and K was non-significantly affected with the application of nitrogen levels and cultural operations. However, response of the potato crop to the cultural operation and nitrogen interaction was found to be significant for N uptake, but non-significant effect for P & K uptakes. Maximum total uptake of N by crop was recorded with treatment combinations of hoeing in combination with 75 kg N ha^{-1} (120.93 kg N ha^{-1}) followed by hoeing in combination with 225 kg N/ha.

Effect of cultural operations and nitrogen levels on tuber yield, haulm yield, biological yield and harvest index

Tuber yield was significantly affected due to nitrogen levels however there was no any significant effect of cultural operations. Tuber yield ranged from 18.66 to 24.81 t ha-^{1}. Dubey *et al* (2013) [8] also reported highest tuber yield with the application of 150 kg N ha-^{1}. Significant effect due to nitrogen levels and non-significant effect due to cultural operations was observed on biological yield at harvest. The biological yield ranged from 30.97 to 35.72 t ha^{-1}. Haulm yield was non-significantly affected by nitrogen level and cultural operations which ranged from 11.96 to 13.48 t ha^{-1} However, nitrogen applications were effective and enhanced the vegetative growth at all stages of potato crop. In case of interaction effect of nitrogen level and cultural operation on biological yield, haulm yield and harvest index were significant. Maximum haulm yield was recorded in without hoeing in combination with 75 kg N ha^{-1} (15.67 t ha^{-1}) followed by Hoeing in combination without N application (12.52 t ha^{-1}). Biological yield and harvest index depend on haulm and tuber yields. Harvest index did not deviate due to nitrogen levels and cultural operations. These finding are in accordance with Mondal *et al.* (2005) [15], Sidhu *et al*. (2005) [18], Brar *et al.* (2006) [5], Kumar *et al.* (2007) [14], Baishaya *et al.* (2012) [3], Ali *et al*. (2012) [1], Dua *et al.* (2015) [7] and Kelling *et al.* (2016) [12].

Effect of cultural operations and nitrogen levels on economics of potato cultivation

Higher cost of cultivation was recorded with hoeing with 225 kg N ha^{-1} (Rs. 76270 ha^{-1}) and lowest cost of cultivation (Rs.70840 ha^{-1}) with no- hoeing in combination without N. Higher gross return (Rs.154689 ha^{-1}) was recorded with hoeing in combination with 225 kg N ha^{-1}. The lowest gross return (Rs.108267/ha) was recorded with no cultural operation in combination without N. Highest net return (Rs. 78419 ha^{-1}) was recorded with hoeing in combination with 225 kg nitrogen level and lowest net return (Rs.37470 ha^{-1} with no-hoeing without Napplication. Highest benefit: cost ratio was recorded with hoeing in combination with 225 kg N ha^{-1} (2.03) and lowest with no-hoeing without N application (1.52).

Conclusions

Based on the above findings, it is concluded that potato responds well under the higher application of nitrogen (225 kg ha^{-1}) when grown without hoeing *i.e.* without intercultural operation. Higher application of N enhanced crop growth, yield attributes and yield. Higher economic yield can be achieved with nitrogen application @ 225 kg N ha^{-1} without hoeing. However under the situation wherein hoeing is possible application of lower dose of 150 kg N ha^{-1} was found equally effective.

Table 1: Effect of nitrogen levels and cultural practices on plant height, number of stems and number of compound leaves.

Treatments	Plant population (No./m^2)	Plant height (cm)			No. of stem/plant			No. of leaves/plant		
		30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest
Cultural Operation										
Hoeing	6.88	23.97	47.90	53.07	2.80	2.79	2.75	18.37	32.78	35.28
Without Hoeing	6.95	24.55	46.98	52.73	2.78	2.59	2.45	17.00	29.55	30.73
S.Em.±	0.13	0.68	1.39	2.26	0.08	0.03	0.06	0.90	1.36	3.38
C.D. at 5%	NS	NS	NS	NS	NS	0.16	NS	NS	NS	NS
Nitrogen Levels										
0kg N/ha	6.45	23.77	47.07	52.17	2.80	2.73	2.77	18.77	29.87	35.10
75kg N/ha	6.88	25.13	47.23	52.70	3.13	2.88	2.47	18.93	32.20	32.03
150kg N/ha	7.05	24.07	47.70	54.07	2.90	2.80	2.80	17.77	33.23	33.20
225kg N/ha	7.28	24.07	47.77	52.67	2.33	2.35	2.37	15.27	29.37	31.70
S.Em.±	0.09	1.20	1.35	1.61	0.23	0.21	0.22	1.00	1.43	2.15
C.D. at 5%	0.28	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of nitrogen levels and cultural practices on yield and uptake of nutrients.

Treatments	Tuber yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Uptake by tuber (kg/ha)		
				N	P	K
Cultural operation						
Hoewing	21.54	33.71	0.64	63.98	17.43	65.34
Without Hoeing	22.45	35.29	0.63	48.84	17.12	72.98
S.Em.±	2.02	2.44	0.01	1.15	0.66	1.36
C.D. at 5%	NS	NS	NS	7.01	NS	NS
Nitrogen levels						
0 kg N/ha	18.66	30.97	0.60	54.03	18.97	74.64
75 kg N/ha	21.07	34.55	0.61	58.85	16.76	74.09
150 kg N/ha	23.46	35.72	0.66	54.92	16.03	57.93
225 kg N/ha	24.81	36.76	0.67	57.84	17.35	69.97
S.Em.±	0.49	0.45	0.01	1.66	0.96	1.39
C.D. at 5%	1.51	1.38	0.04	NS	NS	4.28

Table 3: Effect of nitrogen levels and cultural practices on economics of different treatments

Treatment combination	Expenditure (Rs ha^{-1})		Total	Gross return	Net return	B:C ratio
	Common	Variable				
H0N0	65300	5540	70840	108267	37427	1.52
H0N1	65300	6515	71815	126853	55038	1.77
H0N2	65300	7490	72790	138938	66148	1.90
H0N3	65300	8470	73770	142978	69208	1.94
H1N0	65300	8040	73340	115669	42329	1.58
H1N1	65300	9015	74315	125987	51672	1.70
H1N2	65300	9990	75290	142564	67274	1.89
H1N3	65300	10970	76270	154689	78419	2.03

Table 4: Interaction effect of nitrogen and cultural practice on haulm yield and biological yield, harvest index, nutrient uptake

Nitrogen Levels	Cultural operations		Cultural operations		Cultural operations		Cultural operations		Cultural operations	
	H1	H0	H1	H0	H1	H0	H1	H0	H1	H0
	Biological yield (t ha^{-1})		Haulm yield (t ha^{-1})		Harvest index (%)		K uptake by haulm (kg ha^{-1})		Total N uptake (kg ha^{-1})	
N0	30.57	31.37	12.52	12.09	0.59	0.62	42.52	52.67	104.67	69.55
N1	32.44	36.66	11.30	15.67	0.65	0.57	43.22	45.55	120.93	87.93
N2	35.55	35.89	12.39	12.13	0.65	0.66	48.33	42.01	105.44	95.15
N3	36.27	37.25	12.44	11.47	0.66	0.69	47.86	51.33	114.89	98.04
S.Em.±	0.68		0.73		0.02		0.84		2.91	
C.D. at 5%	1.96		2.24		0.06		2.60		8.96	

Table 5: Effect of nitrogen levels and cultural practices on NPK uptake of tuber and crop uptake (kg)

Treatments	Uptake by haulm (kg/ha)			Total Uptake of crop (kg/ha)		
	N	P	K	N	P	K
Cultural Operation						
Hoewing	47.50	8.69	45.49	111.48	26.12	113.24
Without hoeing	38.83	9.01	47.89	87.66	26.13	119.81
S.Em.±	1.30	0.34	0.78	1.61	0.36	6.32
C.D. at 5%	7.91	NS	NS	9.82	NS	NS
Nitrogen Levels						
0kg N/ha	33.08	7.93	47.60	87.11	26.90	120.61
75kg N/ha	45.58	9.79	44.38	104.43	26.55	118.38
150kg N/ha	45.38	8.81	45.17	100.29	24.84	106.84
225kg N/ha	48.62	8.87	49.60	106.46	26.21	120.26
S.Em.±	1.90	0.49	0.60	2.06	0.78	6.42
C.D. at 5%	5.86	NS	1.84	6.34	NS	NS

References

1. Ali J, Singh SP. Response of potato to nitrogen and potassium in alluvial soil of South-Western plain zone of Uttar Pradesh. Annals of Agricultural Research. 2012; 33(1&2):40-44
2. Anonymous. Food and Agriculture, Statistics, 2015. Http//www.fao.org.in/potato.
3. Baishaya LK, Kumar M, Ghosh M, Ghosh DC. Effect of integrated nutrient management on growth, productivity and economics of rain fed potato in Meghalaya hills. International Journal of Agricultural, Environment and Biotechnology. 2012; 6(1):69-77.
4. Bartova V, Berta J, Svajner J, Divis J. Soil nitrogen variability in relation to seasonal nitrogen cycling and accumulation of nitrogenous components in starch processing potatoes. Soil and Plant Science. 2012; 62:70-78.
5. Brar MS, Kaur N. Effect of soil and foliar applied potassium and nitrogen on yield of potato (*Solanum tuberosum*) in alluvial soils of Punjab, India. Indian Journal of Agricultural Sciences. 2006; 76(12):740-743.

6. Chongtham SK, Patel RNJ, Patel CK, Patel D, Patel CR, Zapadiya DM. Yield, nutrient and water use efficiency and economics of potato variety kufrisurya as influenced by different nitrogen levels. International Journal of Agriculture Science. 2015; 7:785-787.
7. Dua VK, Kumar S, Jatav MK, Lal SS. Nitrogen requirement of component crops in potato+maize intercropping in north-western hills of India, Potato Journal. 2015; 42(1):36-43.
8. Dubey RK, Singh V, Devi K, Kartek K. Effect of nitrogen levels and cultivars on growth and yield components on potato in foot hills Arunachal Pradesh. Indian Journal of Horticulture. 2013; 69(4):545-549.
9. Fandika I, Kemp P, Millner J, David H, Roskruge N. Irrigation and nitrogen effects on tuber yield and water use efficiency of heritage and modern potato cultivars. Agricultural Water Management. 2016; 170:148-157.
10. FAO Food and Agriculture, Statistics, 2006. Http//www.fao.org.in/potato.
11. FAO Food and Agriculture, Statistics, 2014. Http//www.fao.org.in/potato.
12. Kelling K, Stevenson W, Speth P, Vaughan J. Interactive effects of fumigation and fungicides on potato response to nitrogen rate or timing. American Journal Potato Research. 2016; 93:533-542.
13. Kumar CVR, Prakash SS, Prashant GMHA, Chikkaramappa T. Growth and Yield of Potato as Influenced by Sources and Time of Fertilizer Application under Rainfed Condition. Trends in Biosciences, 2013; 6(4):377-381.
14. Kumar P, Pandey SK, Singh BP, Singh SV, Kumar D. Effect of nitrogen rate on growth, yield, economics and crisps quality of Indian potato processing cultivars. Potato Research. 2007; 50:143-155.
15. Mondal SS, Acharya D, Ghosh A, Bug A. Integrated nutrient management on the growth, productivity and quality of potato in Indo-gangetic plains of West Bengal. Potato Journal. 2005; 32(1&2):75-78.
16. Patidar R, Dharmendra Gaur, Singh SP, Kalpana Sharma, SK Sharma, Hemlata Dhakad *et al*. Evaluation of different fertilizer coating material to increase Nitrogen use efficiency in potato (*Solanum tuberosum* L.) International Journal of Chemical Studies. 2017; 5(6):147-151.
17. Prativa KC, Bhattarai BP. Effect of Integrated Nutrient Management on the Growth, Yield and Soil Nutrient Status in Tomato. Nepal, Journal of Science and Technology. 2011; 12:23-28.
18. Sidhu AS, Thind SS, Sekhan NK, Singh CB, Hira GS. Planting method, irrigation and nitrogen effects in potato. Journal of the Indian Society of Soil Science. 2005; 53:399-400.