Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP1: 113-117

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

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

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

Neha Singh Kirar
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Rahul Patidar
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

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

(Special Issue- 1)
2nd International Conference
"Food Security, Nutrition and Sustainable Agriculture - Emerging Technologies"
(February 14-16, 2019)

Effect of nitrogen levels, cultural practices and their interactions on growth and yield attributes and yield of potato (*Solanum tuberosum* L.)

Roop Singh Dangi, SP Singh, Dharmendra Gaur, JP Dixit, SK Sharma, Neelam Singh, Neha Singh Kirar and Rahul Patidar

Abstract
A field experiment, entitled "Effect of nitrogen levels, cultural practices and their interactions on growth and yield attributes and yield of potato (*Solanum tuberosum* L.)" 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 3000 kg/ha. Planting was done at an inter row spacing of 60 cm apart and intra row spacing was kept at 20 cm apart. Basal dose was applied as per treatment through Urea, SSP and MOP in each treatment. The crop was planted on 24th October 2016 and harvested on 4th February 2017. The results revealed that application of 225 kg nitrogen/ha recorded significantly higher haulm fresh weight (377 g/5 plant), haulm dry weight (34.33 g/5 plant), number of green tubers {(< 25 g- 34/plot and total-103/plot)}, number of total tubers (< 25g - 91.5/plot, 50-75 g-51.8/plot). Similarly normal tuber yield (>75 g-11.11 kg/plot), green tuber yield-7.07 kg/plot as well as total tuber yield (>75 g-16.03 kg/plot) in addition to fresh tuber, available P in soil. However, chlorophyll content, AGR (g/day), RGR (g/g/day) were recorded non-significant in all treatments. On the other hand interaction of N_2H_1, N_0H_0, N_1H_0 and N_1H_1 recorded significantly higher value under available nutrient P (60.08 kg/ha), available nutrient N (178 kg/ha) and K (386.77 kg/ha), tuber dry production at 30 DAS (16.69 g) and haulm fresh weight (1183.33g/ 5 plant) at harvest, respectively. Hence, under non- hoeing condition application of 225 kg N/ha and under hoeing situation 150kg N/ha are desirable doses.

Keywords: Cultural practices, available nutrient, nitrogen levels, AGR, RGR and chlorophyll

Introduction
Potato (*Solanum tuberosum* L.) is starchy, tuberous and contributes substantially towards food and nutritional security in the world.

The current global production of potato is around 453.43 million tonnes and China being the biggest 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) [7]. 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 condition 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) [1]. In Madhya Pradesh, area under the crop during 2014-15 was 111.06 thousand hectares, with production and productivity of 2425 thousand tones and 21116 kg ha^{-1}, respectively and Madhya Pradesh was at 6th position with 21116 kg ha^{-1} (Agricultural Statistics at a Glance, 2015).

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 people 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) [2] 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) [5] and Chongtham *et al*. (2015) [4] 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.

Farmers of Madhya Pradesh grow potato in *rabi* season. The productivity of potato in this region is low compared to some states. Nutrients have major influence on yield and quality of crop in different ways among which nitrogen is the key nutrient which influences the early crop development, tuber initiation, tuber size, tuber specific gravity and protein content. Patidar *et al.* (2017) found that the number of tubers, and dry matter accumulation both in haulm and tuber were significantly increased by application of recommended dose of fertilizers (RDF).

In view of the above facts, the present investigation was conducted to evaluate the effect of Potato (*Solanum tuberosum* L.) on agronomic parameter, physiological parameter, grading and available nutrients under various nitrogen levels and cultural practices.

Materials and Methods

A field experiment, entitled "Effect of nitrogen levels, cultural practices and their interactions on growth and yield attributes and yield of potato (*Solanum tuberosum* L.)" 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 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 *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). Heat tolerant Potato variety "Kufri Surya" was planted using a seed rate of 3000 kg/ha inter row spacing was kept at 60 cm apart. Basal dose of NPK was applied as per treatment through Urea, SSP and MOP. The crop was planted on 24th October 2016 and harvested on 4th Feb. 2017.

The recommended dose of N, P and K were 180, 34.9 and 100 kg/ha 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. On the next day of potato planting, herbicide Metribuzin was applied @ 500 g a.i./ha was applied uniformly in each treatment. The hoeing was done at 24 days after planting.

NPK contents (kg/ha) were determined before start of the experiment and after completion of experiment. Five potato plants were randomly sampled from the inner rows of the each plot leaving the border rows. The sampled plants were carefully dunged out, the roots thoroughly washed under running water, put in labeled envelop bags and taken to the laboratory where the growth and yield parameters were recorded. The plant samples were partitioned into various plant fractions and after sun drying sample were subjected to oven-drying at 62 °C until a constant weight was attained. Completely dried samples were weighed and the dry matter (DM) content of different plant parts was measured and expressed in g/5 plant. Growth parameter and yield attributes were recorded at 30, 50 DAP, harvest stage.

SPAD meter is used for judging the chlorophyll content in plant. Physiological parameters were recorded as:

Relative growth rate (RGR)

The relative growth rate was calculated by the formula of Blackman (1919) [3] and expressed as g/g/day

$$RGR = \frac{Log_e w_2 - Log_e w_1}{t_2 - t_1}$$

Where

w1 = dry weight (g)/plant at t1,
w2 = dry weight (g)/Plant at t2
t1 = time of first observation
t_2 = time of second observation

Absolute Growth Rate (AGR)

Absolute growth rate (AGR) is the dry matter production per unit time (g/day), which was calculated by using the formula as given by Radford (1967) [10].

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where

W_1 = Dry weight of the plant (g) at time t_1
W_2 = Dry weight of the plant (g) at time t_2
t1 = time of first observation
t_2 = time of second observation

Available N, P, K contents (kg/ha) were determined through Alkaline permanganate method (Subbiah and Asija, 1956) [11], Olsen's method (Olsen *et al*., 1954) [9], Flame photometer (Muhur *et al*., 1965) [8] methods, respectively.

Data were analyzed as per standard procedure with 5% probability level.

Results and Discussion

Agronomic Parameter

Haulm fresh weight/5 plant

Haulm fresh weight/5 plant increased considerably in all the treatments with the progression of crop growth from initial to harvest. At the early (30 DAP) stage, the haulm fresh weight ranged from 243.67 to 377.00 g with different N levels; at 50 DAP, it ranged from 548.33 to 693.67 g; at harvest it ranged from 814.50 to 1024 g. Haulm fresh weight/5 plant was significantly influenced by cultural operation at 30 days after planting though it was, statistically at par with 150 kg and 225 kg. However, cultural operations are effective and enhanced haulm fresh weight/5 plants of all stages of potato crop. Haulm fresh weight/5 plant did not vary significantly due to nitrogen level at 50 day after planting and at harvest stage. Response of the potato crop of the cultural operation as well as nitrogen levels interaction effect was found to be non-significant at 30 DAP and 50 DAP. H_1N_1 showed maximum fresh haulm weight/5 plant 1183.33g at harvest which was significantly higher over H_1N_0 and H_1N_3.

Application of nitrogen recorded significant effect on haulm fresh weight/5 plant at 30 DAP. Haulm fresh weight/5 plant increased from 0 kg N to 225 kg N/ha. It may be due to higher vegetative growth. Application of 225 kg N/ha recorded higher Haulm fresh weight/5 plant at 30 DAP as compared to other treatments.

Haulm dry weight/5 plant

The haulm dry weight/5 plant, in general, increased considerably in all the treatments with the progression of crop growth from initial to harvest. At the early (30 DAP) stage, the weight ranged from 23.33 to 34.33 g, whereas at 50 DAP, it ranged from 59.67 to 76.33 g, at harvest, haulm dry weight/5 plants went up to the range of 73.59 to 94.25g. Haulm dry weight/5 plant was significantly affected by nitrogen level at 30 days after planting, which remained statistically at par with 150 kg and 225 kg. However, cultural operation Response of the cultural operation as well as nitrogen levels interaction was found non-significant for haulm dry weight/5 plant at 30, 50 and at harvest.

Fresh weight of tubers/5 plant

Perusal of data for fresh weight of tubers/5 plant at 30, 50 DAP and at harvest. in general, showed considerable increase in all the treatments with the progression of crop growth from initial to harvest. At the early (30 DAP) stage, the weight ranged from 233.79 to 245.17g, at 50 DAP, it ranged from 261.67 to 357.67g, and at harvest, range was from 1498.50 to 1855.00 g. Cultural operation as well as nitrogen levels interaction was found to be non-significant at 30, 50 DAP and at harvest.

Dry weight of tubers/5 plant

Dry weight of tubers/5 plant at 30, 50 DAP and at harvest were increased considerably in all the treatments with the progression of crop growth from initial to harvest. At the early (30 DAP) stage, the dry weight of tubers/5 plant ranged from 32.00 to 33.83 g, whereas at 50 DAP, it ranged from 42.67 to 56.33 g, at harvest, the range was from 338.63 to 422.03 g. Dry weight of tubers/5 plant was not affected significantly by nitrogen levels and cultural operations. However, a cultural operation was effective and enhanced dry weight of tubers/5 plant of all stages of potato crop. Dry weight of tubers/5 plant did not vary significantly due to cultural operation and nitrogen level at 30, 50 day after planting and at harvest stage. Response of the potato crop to the cultural operation as well as nitrogen levels interaction effect was not found to be significant at 30, 50 day after planting and at harvest.

Tuber dry matter production/5 plant

The dry matter production increased considerably in all the treatments with the progression of crop growth up to harvest. At the early (30 DAP) stage, the tuber dry matter production ranged from 13.72 to 14.76g, at 50 DAP, it ranged from 42.67 to 56.33g, at harvest, it went up to 338.63 to 422.03g.

Dry matter production was significantly affected by nitrogen level and cultural operations at 30 DAP. However, non-significant effect at 50 DAP and at harvest.

Responses of the cultural operation as well as nitrogen interaction was found to be significant at 30 DAP. Higher tubers dry matter production was recorded at 30 DAP with H_0N_1 (16.60).

Physiological Parameter

SPAD value

SPAD 502 value was non-significant due to cultural operation and nitrogen level. SPAD value ranged from 51.43 to 55.32. Response of chlorophyll content of the potato crop of the cultural operation as well as nitrogen interaction was not found to be significant. However value of chlorophyll content was increased from 0 kg N to 225 kg N. Nitrogen is essential nutrient for increasing the greenness of leaf of the plant and greenness of plant is directly related to the chlorophyll content therefore, application of nitrogen from 0 to 225 kg/ha recorded incremental pattern in SPAD reading.

AGR (Absolute growth rate)

The AGR g/day was non-significant due to cultural operation and nitrogen levels. AGR g/day at 30-50 days after planting ranged from 98.50 to 116.81 and 50 days after planting to harvest from 58.28 to 88.15. Response of AGR g/day at 30-50 days after planting and 50 days after planting to harvest for potato crop due to cultural operation as well as nitrogen levels interaction was not found to be significant.

Table 1: Effect of nitrogen levels and cultural practices on haulm fresh and weight/5 plant and tuber dry matter production

Treatments	Haulm fresh weight/5 plant(g)			Haulm dry weight/5 plant(g)			Fresh weight of tubers/5 plant(g)			Dry weight of tubers/5 plant (g)			Tuber dry matter production (g)		
	30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest	30 DAP	50 DAP	At harvest
Cultural operation															
Hoeing	32.33	67.83	94.25	32.33	67.83	94.25	243.76	348.33	1855.00	33.42	55.67	422.03	13.72	55.67	422.03
Without hoeing	29.00	68.00	73.59	29.00	68.00	73.59	233.79	300.17	1498.50	32.08	47.00	338.63	14.76	47.00	338.63
S.Em.±	3.07	6.46	5.20	3.07	6.46	5.20	3.88	38.64	103.65	0.36	5.10	27.55	0.15	5.10	27.55
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.92	NS	NS
Nitrogen levels															
0 kg N/ha	243.67	693.67	822.33	23.33	59.67	75.54	238.93	337.00	1629.67	33.17	42.67	377.18	14.68	53.67	377.18
75 kg N/ha	339.67	548.33	952.33	33.33	76.33	88.39	235.31	261.67	1724.33	33.83	53.67	386.01	14.37	42.67	386.01
150 kg N/ha	337.33	637.67	943.67	31.67	67.67	91.59	245.17	357.67	1670.67	32.02	56.33	379.45	13.81	56.33	379.45
225 kg N/ha	377.00	613.00	958.67	34.33	68.00	80.16	235.70	340.67	1682.33	32.00	52.67	378.67	14.10	52.67	378.67
S.Em.±	27.84	37.24	46.94	2.58	3.90	4.33	6.32	42.17	115.21	0.94	6.32	35.80	0.19	6.32	35.80
C.D. at 5%	85.79	NS	NS	7.94	NS	NS	NS	NS	NS	NS	NS	NS	0.58	NS	NS

Table 2: Effect of nitrogen levels and cultural practices on SPAD, AGR, RGR

Treatments	SPAD value	AGR (30-50 DAP)	AGR (50DAP-harvest)	RGR (30-50 DAP)	RGR (50 DAP-harvest)
Cultural operation					
Hoeing	53.23	108.49	86.50	1.99	1.84
Without hoeing	53.43	102.88	61.27	1.89	1.68
S.Em. ±	0.59	27.95	21.70	0.19	0.12
C.D. at 5%	NS	NS	NS	NS	NS
Nitrogen levels					
0 kg N/ha	52.68	107.74	70.55	2.00	1.73
75 kg N/ha	51.43	99.70	88.15	1.95	1.86
150 kg N/ha	53.87	98.50	78.56	1.87	1.79
225 kg N/ha	55.32	116.81	58.28	1.94	1.65
S.Em.±	0.99	20.47	22.98	0.12	0.15
C.D. at 5%	NS	NS	NS	NS	NS

RGR (relative growth rate)

RGR g/g/day data at 30-50 days after planting ranged from 1.87 to 2.00 and 50 days after planting to harvest from 1.65 to 1.86. RGR g/g/day was statistically on par due to cultural operation and nitrogen levels. RGR g/g/day of the potato crop due to cultural operation as well as nitrogen interaction was not found to be significant.

Grading parameter

Number of tubers/plot (9 sq m)

Normal number of tubers/plot in different grades, of <25g, 25-50g, 50-75g, >75g and total number ranged from 37.67 to 57.33, 25.00 to 29.17, 25.00 to 36.33, 65.50 to 75.17 and 157 to 188.33 respectively. The number of normal tubers/plot shows non-significant variation due to nitrogen levels on <25g, 25-50g, 50-75g, >75g and total number. There was non-significant effect of the cultural operation as well as nitrogen levels interaction on number of normal tubers/plot on various grade of tubers *viz*. <25g, 25-50g, 50-75g, >75g and total number.

The number of total tubers/plot was non-significantly affected due to cultural operation on <25g, 25-50g, 50-75g and >75g, while significant effect of nitrogen levels on <25g, 50-75g and total number of green tuber/plot. The number of total tubers/plot in <25g, 25-50g, 50-75g, >75g grades and total were 56.17 to 91.50, 38.50 to 48.67, 38.33 to 51.83, 94.67 to 105 and 245.33 to 291.33 respectively.

Yield of tubers/plot

The yield of normal tubers/plot was non-significantly affected due to cultural operation in different grades *viz*. <25g, 25-50g, 50-75g, >75g and total yield, but significantly in >75g and total yield of normal tuber/plot due to nitrogen level. The yield range of normal tubers/plot for <25g, 25-50g, 50-75g, >75g and total yield were 0.45 to 0.72, 1.18 to 1.46, 3.64 to 5.53, 9.10 to 11.68 and 14.50 to 18.92 kg respectively.

Available nutrients in the soil

The data in respect of available N status in soil after harvest of the crop recorded under the different nutrient and cultural operation treatment combination. Glance of data indicated that nitrogen level and cultural operation treatment combination manifested their non-significant influence on available N status after harvest. The available N in soil was not significantly affected by nitrogen level and cultural operations. However, Available nutrient of N in soil ranged from 170.18 to 173.45 kg ha^{-1} at harvests.

Nitrogen level and cultural operation treatment combination manifested their significant influenced on available P status after harvest. The available P in soil was significantly affected by nitrogen level and cultural operations. However, available P ranged from 28.83 to 43.74 kg ha^{-1} at harvest.

Table 3: Effect of nitrogen levels and cultural practices on number of normal, green and total tuber (grade wise)

Treatments	Number of normal tubers/plot					Number of green tubers /plot					Number of total tubers/plot				
	<25g	25-50g	50-75g	>75g	Total	<25g	25-50g	50-75g	>75g	Total	<25g	25-50g	50-75g	>75g	Total
Cultural operation															
Hoeing	44.42	27.08	28.92	65.50	165.92	29.17	19.33	16.17	34.00	98.67	73.58	46.42	45.08	99.50	264.58
Without hoeing	45.92	28.17	30.42	75.17	179.67	20.67	15.83	14.50	26.25	77.25	66.58	44.00	44.92	101.42	256.92
S.Em.±	5.50	1.54	1.35	10.98	8.37	3.54	1.33	0.33	4.15	8.01	7.55	2.52	1.05	11.30	2.05
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels															
0 kg N/ha	38.00	25.00	25.83	68.33	157.17	19.17	13.50	12.50	26.33	71.50	57.17	38.50	38.33	94.67	228.67
75 kg N/ha	37.67	28.17	25.00	74.83	165.67	18.50	17.00	14.00	30.17	79.67	56.17	45.17	39.00	105.00	245.33
150 kg N/ha	47.67	28.17	31.50	72.67	180.00	27.83	20.50	19.33	30.00	97.67	75.50	48.67	50.83	102.67	277.67
225 kg N/ha	57.33	29.17	36.33	65.50	188.33	34.17	19.33	15.50	34.00	103.00	91.50	48.50	51.83	99.50	291.33
S.Em.±	7.48	2.45	4.07	5.22	11.60	3.73	2.15	1.18	2.99	3.98	8.22	3.51	3.62	5.75	14.45
C.D. at 5%	NS	NS	NS	NS	NS	11.49	NS	3.64	NS	12.25	25.33	NS	11.17	NS	44.51

Table 4: Effect of nitrogen levels and cultural practices on normal, green and total tuber yield (grade wise)

Treatments	Normal tubers yield/plot(kg)					Green tubers yield/plot(kg)					total tubers yield/plot(kg)				
	<25g	25-50g	50-75g	>75g	Total	<25g	25-50g	50-75g	>75g	Total	<25g	25-50g	50-75g	>75g	Total
Cultural operation															
Hoeing	0.49	1.28	3.64	9.43	14.84	0.39	0.73	1.13	4.20	6.45	0.88	2.01	2.88	13.62	19.39
Without hoeing	0.57	1.35	5.53	11.39	18.92	0.30	0.58	0.87	3.40	5.15	0.88	1.93	2.62	14.78	20.21
S.Em.±	0.07	0.02	0.75	1.77	2.91	0.07	0.04	0.05	0.54	0.55	0.14	0.05	0.08	2.01	1.82
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels															
0 kg N/ha	0.45	1.18	3.77	9.10	14.50	0.33	0.55	0.70	3.03	4.61	0.78	1.73	2.16	12.12	16.80
75 kg N/ha	0.49	1.34	4.37	9.74	16.11	0.37	0.57	0.99	3.56	5.49	0.86	1.91	2.89	13.30	18.96
150 kg N/ha	0.47	1.29	5.11	11.68	18.55	0.34	0.74	1.26	3.68	6.02	0.81	2.03	2.92	15.36	21.11
225 kg N/ha	0.72	1.46	5.07	11.11	18.36	0.34	0.74	1.06	4.92	7.07	1.06	2.20	3.03	16.03	22.33
S.Em.±	0.08	0.13	0.66	0.53	0.69	0.06	0.06	0.16	0.33	0.25	0.10	0.14	0.20	0.55	0.44
C.D. at 5%	NS	NS	NS	1.63	2.12	NS	NS	NS	1.02	0.79	NS	NS	0.61	1.69	1.36

Table 5: Effect of nitrogen levels and cultural practices on available NPK nutrient in soil

Treatments	Available nutrients (kg/ha)		
	N	P	K
Cultural operation			
H1	172.89	38.25	295.12
H0	170.60	34.84	305.39
S.Em. ±	1.90	0.12	2.05
C.D. at 5%	NS	0.76	NS
Nitrogen levels			
N0	172.01	37.46	358.40
N1	171.33	28.83	284.67
N2	173.45	43.74	286.16
N3	170.18	36.15	271.79
S.Em. ±	2.44	0.45	11.61
C.D. at 5%	NS	1.40	35.77

Table 6: Effect of H × N interaction on haulm fresh weight/5 plant, tuber dry matter production and available NPK in soil at harvest of potato

Nitrogen levels	Cultural operations		Cultural operations		Cultural operations		Cultural operations		Cultural operations	
	H1	H0	H1	H0	H1	H0	H1	H0	H1	H0
	haulm fresh weight/5 plant at harvest		tuber dry matter production at 30 DAP		available N in soil kg/ha		available P in soil kg/ha		available K in soil kg/ha	
N0	856.00	788.67	15.42	13.93	166.02	178.00	30.65	44.26	330.03	386.77
N1	1183.33	721.33	12.13	16.60	174.00	168.67	28.78	28.88	299.04	270.29
N2	1100.67	786.67	13.13	14.49	176.54	170.36	60.08	27.40	299.79	272.53
N3	956.00	961.33	14.20	14.00	175.00	165.36	33.47	38.82	251.63	291.95
S.Em.±	66.38		0.27		3.45		0.64		16.42	
C.D. at 5%	204.54		0.82		10.63		1.98		50.58	

N and cultural operation treatment combination manifested their significant influence on available K status after harvest. The available K in soil was significantly affected by cultural operations and non-significantly by nitrogen level. However, available K ranged from 286.16 to 358.40 kg ha^{-1} at harvest. Response for K due to cultural operation as well as nitrogen levels interaction effect i.e. cultural operation× nitrogen level was found to be significant at harvest. Higher available N, P and K in soil with treatment combinations of H_0N_0 (178.00 kg ha^{-1}), H_1N_2 (60.08 kg ha^{-1}) and H_0N_0 (386.77 kg ha^{-1}) at harvest.

Conclusion

Application of 225 kg N kg/ha without hoeing and 150 kg N/ha with hoeing gave the best response for achieving higher agronomic parameter, physiological parameter and grading among various N levels with different cultural practices. Therefore application of 225 kg N kg/ha without hoeing and 150 kg N/ha with hoeing were best for achieving higher agronomic parameter, physiological parameter and yield in different grades.

References

1. Anonymous. Food and Agriculture, Statistics, 2015. Http//www.fao.org.in/potato
2. 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.
3. Blackman VN. The compound interest law and plant growth. Annals of Botany. 1919; 33:353-360.
4. Chongtham SK, Patel RNJ, Patel CK, Patel D, Patel CR, Zapadiya DM. Yield, nutrient and water use efficiency and economics of potato variety Kufri Surya as influenced by different nitrogen levels. International Journal of Agriculture Science. 2015; **7**:785-787.
5. 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.
6. FAO. Food and Agriculture, Statistics, 2006. Http//www.fao.org.in/potato.
7. FAO. Food and Agriculture, Statistics, 2014. Http//www.fao.org.in/potato.
8. Muhur RN, Datta NP, Sankar Subramoney H, Leley VK, Vay Donaline L. Soil testing in India. U.S. Agency for international development mission to India, 1965, 39, 40, 45,
9. Olsen SR, Code CV, Watanable FS, Dean LP. Estimation of available phosphorus in soil with sodium bicarbonate. U.S.D.A. Cer, 1954, 939.
10. Radford PJ. Growth analysis formulae-their use and abuse. Crop Science. 1967; 7:171-175.
11. Subbiah BV, Asiza GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.