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Potato Crop Growth and Yield Response to Different Levels of Nitrogen under Chhattisgarh Plains Agro-climatic Zone

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Abstract

Field investigation was carried out to study the effect of different nitrogen levels on growth and yield parameters in potato var. Kufri Surya. The experiment was laid out in a randomized block design with treatments consisting of six nitrogen levels replicated four times. Growth parameters like plant height, number of leaves per plant, number of shoot per plant, fresh and dry weight of shoot per plant and yield attributing parameters like number of stolon, fresh and dry weight of tuber per plant increased with an increase in nitrogen levels with maximum values being obtained on application of highest nitrogen level (375 kg N/ha). However, highest values for number of tuber per plant and per plot as well as tuber yield per plot and per hectare was recorded on application of 225 kg N/ha. The highest net returns (Rs. 117323) and maximum B: C ratio (1.42) was recorded on application of 225 kg N/ha.

Keywords: B:C Ratio, Nitrogen Level, Potato, Tuber Yield

1. Introduction

Potato (*Solanum tuberosum L.*) belongs to family Solanaceae and is one of the most important vegetable cum starch supplying crop having high production per unit area per unit time. Potato, an underground tuber occupies prime position among the cash crops in India. Potatoes are rich source of vitamins, especially C and B and also minerals. Tubers contain 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash[1]. Among major food crops, potato produces the highest dry matter and edible protein per unit area and time. It can fulfill the requirement of food for human consumption to a greater extent.

India is the second largest producer of potato in the world after China, with cultivation in an area of about 2.02 m ha and production of 46 million metric tons[2]. Potato is grown almost in all the states of India except Kerala. In Chhattisgarh, it is cultivated in an area of about 37,888 ha with a production of 5.5 lakh metric tons[3]. Due to its suitability and high returns, the area of potato is increasing every year in this state. In Chhattisgarh, potato is mainly cultivated in Sarguja, Raigarh, Jashpur, Bilaspur and Raipur districts in *rabi* season except in Mainpat and Samaryapat hills of Chhattisgarh, where this crop is grown during *kharif* and *rabi* season both.

The growth, development and yield of potato are mainly governed by availability of major nutrients required for its cultivation. Nitrogen is the first limiting factor for potato crop which improves vegetative growth and invariably increases yield, tuber per plant, tuber size as well as tuber numbers[4–5]. However, in the eastern plains of India including the state of Chhattisgarh, unbalanced fertilization in favour of N application is quite common among farmers[6]. Over application of N is a serious problem leading to large nitrogen losses through leaching and enrichment of reactive N constituent in the atmosphere, soil and water with consequent damage to ecosystem[7]. Moreover, excessive nitrogen leads to poor tuber quality and delayed crop maturity, whereas, nitrogen deficiency usually results in poor vegetative growth and low yield. Therefore, there is a need to optimize nitrogen dose

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under Chhattisgarh plains agro-climatic zone for higher yield with high N use efficiency in potato. Keeping these points in view, the present investigation was undertaken to standardize the dose of nitrogen and its judicious use in potato crop for Chhattisgarh plains agro-climatic zone in order to increase production.

2. Materials and Methods

The present investigation was carried out at the Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during the *rabi* season of 2011-12. Raipur, the place of investigation, is situated in central part of Chhattisgarh and lies at 21o4' N Latitude and 81o35' E Longitude with an altitude of 298.56 m above mean sea level. The average annual rainfall of the region is around 1400 mm and about 90 to 95 percent of this amount is received during southwest monsoon season (June-October). The experiment was laid out in randomized block design with six treatments consisting of different levels of nitrogen viz., 0 (control), 75, 150, 225, 300 and 375 kg/ha which were replicated four times. Nitrogen was applied in the form of urea (46% N). Recommended dose of phosphorus and potassium i.e. 100 kg/ha of each was applied. The test variety used was Kufri Surya planted on ridges of 60 cm apart with a spacing of 20 cm. The soil of experimental field was clayey loam with low level of nitrogen (220 kg/ha), medium phosphorus (14 kg/ha), and high potash (354 kg/ha). Well rotten FYM was spread in all the plots in equal quantity @ 250 q/ha and was mixed with the soil. Full dose of phosphorus and potassium @ 100 kg/ha was applied through single super phosphate and muriate of potash, respectively as basal dose at the time of planting, whereas nitrogen was applied in each plot in split doses as per the treatments. Half dose of the nitrogen of each treatment was applied through urea as basal dressing and remaining half dose was applied at 30 days after planting. All the three fertilizers used for basal dressing were mixed before application and was applied in the middle of ridges before planting the tubers. Thirty days after planting the remaining dose of nitrogen was applied through urea as top dressing just before earthing up. Earthing up was done at 30 days after planting (DAP). Weeding was done at the time of earthing to remove the weeds. Eight irrigations were provided during the entire crop growth period. Although, irrigation was given by flood irrigation method, but the precaution was taken that only ½ to ¾th ridges be wet while irrigating the field. All the recommended package and practices were followed to raise a healthy crop. Haulm cutting of potato crop was done manually at 90 DAP and then digging of tuber was done 10 days after haulm cutting by using spade. After harvesting the potato, tubers were graded into four groups for each plot in all the replication on the basis of tuber weight as <25g, 25-50g, 51-75g and >75g and weighed separately to record yield.

3. Results and Discussion

3.1 Growth Parameters

Data presented on growth parameters in Table 1 reveals that the treatment effect was found to be significantly different for plant height. Increasing trend in case of plant height was observed with the increase in nitrogen levels. At 45, 60 and 75 DAP, similar trend was observed for plant height with maximum plant height (44.25, 47.75 and 48.00 cm, respectively) recorded under 375 kg N/ha but having at par effect with 150 kg N/ha, 225 kg N/ha and 300 kg N/ha. Irrespective of days after planting, similar trend was followed with respect to number of leaves per plant. In general, an increase in nitrogen influenced the number of leaves per plant. Significantly maximum number of leaves were found on application of 375 kg N/ha followed by 150 kg N/ha, 225 kg N/ha and 300 kg N/ha, all having statistically equal effect. Maximum number of leaves recorded at 45, 60 and 75 DAP were 46.25, 48.00 and 49.75 respectively. These results are in the line with the findings of Pandey et al.[8] and Bose et al.[9] with respect to number of shoot per plant, at 45 and 60 DAP, no significant difference among the treatments was found. At 75 DAP, significantly maximum number of shoot per plant (6.50) was recorded with nitrogen level 375 kg N/ha which was having at par effect with treatments 150 kg N/ha and 300 kg N/ha. The increase in plant height, number of leaves and shoot with increase in nitrogen levels may be due to the fact that higher nitrogen concentration stimulated the assimilation of carbohydrates and protein, which in turn enhanced cell division and formation of more tissues that resulted in enhanced vegetative growth of the plant[10] and also in the production of stem and axillary branches.

In case of fresh weight of shoot per plant, beyond 75 kg N/ha there was marked response of nitrogen for enhancing the fresh weight of shoot with maximum being recorded under 300 kg N/ha (297.50 g). Maximum dry weight of shoot per plant (28.00 g) was noted in the treatment 300 kg N/ha. Dry weight of shoot per plant was directly related with fresh weight of shoot per plant. An application of higher dose of nitrogen resulted in increase in the plant height and foliage thereby increasing the fresh and dry weight of shoot per plant with increase

Table 1. Effect of nitrogen levels on vegetative parameters of potato

Nitrogen levels	Plant height (cm)			Number of leaves per plant			Number of shoot per plant			Fresh wt. of shoot (g)	Dry wt. of shoot (g)
	45 DAP	60 DAP	75 DAP	45 DAP	60 DAP	75 DAP	40 DAP	60 DAP	75 DAP		
0 kg/ha	30.53	38.50	41.50	36.75	39.50	43.00	4.50	4.50	4.50	135.75	13.00
75 kg/ha	34.75	40.50	42.25	37.25	41.50	44.50	4.50	4.75	5.00	194.25	19.25
150 kg/ha	38.85	43.25	46.75	45.00	45.25	45.25	5.00	5.75	6.00	280.75	27.00
225 kg/ha	41.80	45.75	47.25	43.00	46.50	48.50	4.75	4.75	5.00	288.50	27.75
300 kg/ha	41.25	44.75	47.25	42.25	45.00	48.75	4.50	5.00	6.00	297.50	28.00
375 kg/ha	44.25	47.75	48.00	46.25	48.00	49.75	5.50	5.75	6.50	288.50	27.50
CD (p=0.05)	**6.69**	**5.99**	**4.78**	**5.49**	**6.89**	**4.66**	**NS**	**NS**	**0.93**	**41.89**	**3.52**

in nitrogen levels. Also, nitrogen fertilizer increased the leaf area which increases the amount of solar radiation intercepted and consequently, increases dry matter production of different plant parts[11]. Present findings are in agreement with the previous reports where increase in dry weight has been recorded with an increase in nitrogen level[11–12].

3.2 Yield and Yield Attributing Parameters

On the perusal of yield attributing data presented in Table 2, it is evident that the maximum number of stolon per plant (16.75) was recorded under the treatment 375 kg N/ha which was statistically similar to 300 kg N/ha, 225 kg N/ha and 150 kg N/ha. The minimum number of stolon per plant (11.25) was counted in the treatment 0 kg N/ha. At harvest, fresh weight of tuber per plant ranged from minimum of 365 g to maximum of 543 g. Significantly maximum fresh weight of tuber per plant (543 g) over control was obtained in the treatment 375 kg N/ha. The maximum dry weight of tuber per plant (21.08 g) was noted on application of 375 kg N/ha. However, all the levels of nitrogen except 75 kg N/ha were observed to be significantly superior over 0 kg N/ha, but were having at par effect on dry weight of tuber amongst themselves. The increase in dry matter percentage with nitrogen application might be due to the fact that higher doses of nitrogen might have helped in the production of photosynthesis, resulting in the accumulation of dry matter to be higher in the storage part i.e. tuber[13]. These results have been found to be in conformity with the findings of Sinha[14] and Etemad and Sarajuoghi[15]. The highest number of tuber per plant (8.14) was recorded with 225 kg N/ha which was having statistically equal effect with rest of the treatments but significantly superior over control. The observed tuber number increase in response to N fertilization could be attributed to an increase in stolon number through its effect on gibberellin biosynthesis in the potato plant. Yenagi et al.[16] also reported similar findings. Data regarding to grade wise number of tuber per plot revealed that this attribute was significantly affected by the nitrogen levels only for grades 50-75 g and >75 g tuber. The highest number of tuber per plot (103.00) for grade 50-75 g tuber was obtained under 225 kg N/ha followed by 300 kg N/ha, 375 kg N/ha, 150 kg N/ha and 75 kg N/ha, all significantly superior to control. Similar trend was observed in the grade >75 g tuber, wherein highest number of tuber per plot (135.00) was noticed in 225 kg N/ha which was having at par effect with 300 kg N/ha and 375 kg N/ha but significantly superior to treatment 150 kg N/ha and 75 kg N/ha. The present results are in conformity with the findings of Chettri et al[17]. In case of total number of tuber per plot, highest number of tuber (364.00) was noted in 225 kg N/ha which was having statistically equal effect with 300 kg N/ha and 375 kg N/ha.

With regard to the yield data, presented in Table 3, it can be inferred that highest tuber yield per plot (0.45 kg) in the grade 0-25 g was obtained under 375 kg N/ha, whereas in case of 50-75 g and >75 g grade tuber, the highest yield per plot (7.25 kg and 12.63 kg, respectively) was obtained under 225 kg N/ha which had at par effect with all the other treatments, but significantly superior over control. In case of the 25-50 g grade tuber, all the treatments exerted no significant effect on tuber yield. Belanger et al.[18] found that application of appropriate amounts of nitrogen resulted in more favorable effects than higher rates. Zelalem et al.[19] also observed that for higher tuber yield optimum nitrogen management was important. Similarly,

Table 2. Effect of nitrogen levels on yield attributing parameters of potato

Nitrogen levels	No. of stolon per plant	Fresh wt. of tuber per plant (g)	Dry wt. of tuber per plant (g)	No. of tuber per plant at harvest	Grade-wise number of tuber per plot				Total no. of tuber per plot at harvest
					0-25g	25-50g	50-75g	>75g	
0 kg/ha	11.25	365	19.26	6.18	31.00	70.00	61.00	70.00	232.00
75 kg/ha	12.50	478	19.90	7.26	38.00	76.00	89.00	85.00	288.00
150 kg/ha	13.75	490	20.02	7.40	44.00	74.00	90.00	100.00	308.00
225 kg/ha	14.25	528	21.03	8.14	42.00	84.00	103.00	135.00	364.00
300 kg/ha	16.25	500	20.87	7.87	42.00	72.00	95.00	120.00	329.00
375 kg/ha	16.75	543	21.08	7.58	31.00	77.00	94.00	118.00	320.00
CD (p=0.05)	**3.1**	**91.69**	**1.59**	**1.19**	**NS**	**NS**	**21.53**	**25.16**	**45.13**

Table 3. Effect of nitrogen levels on yield parameters of potato

Nitrogen levels	Grade-wise yield of tuber (kg/plot)				Tuber yield (kg/plot)			Tuber yield (q/ha)		
	0-25g	25-50g	50-75g	>75g	M*	U**	Total	M*	U**	Total
0 kg/ha	0.22	3.38	4.53	6.56	13.79	0.90	14.69	143.64	9.37	153.01
75 kg/ha	0.23	3.51	6.28	8.93	18.20	0.75	18.95	189.58	7.81	197.39
150 kg/ha	0.34	4.28	6.97	12.49	23.53	0.55	24.08	245.10	5.72	250.8 2
225 kg/ha	0.41	3.84	7.25	12.63	23.97	0.16	24.13	249.68	1.66	251.34
300 kg/ha	0.42	3.33	7.18	11.05	21.78	0.20	21.98	226.87	2.08	228.95
375 kg/ha	0.45	3.12	7.08	11.30	21.55	0.40	21.95	224.47	4.16	228.63
CD (p=0.05)	**0.11**	**NS**	**2.25**	**3.88**	**6.74**	**0.45**	**5.77**	**48.13**	**2.43**	**46.59**

M*=Marketable; U=Unmarketable**

the highest yield of marketable tuber (23.97 kg/plot) was recorded on the application of 225 kg N/ha whereas, highest unmarketable yield of tuber (0.90 kg/plot) was recorded with 0 kg N/ha which was observed to have at par effect with 75 kg N/ha and 150 kg N/ha. The highest total tuber yield (24.13 kg/plot) was recorded in 225 kg N/ha. However, no significant difference was observed between the treatments 225 kg N/ha and other treatments viz., 150 kg N/ha, 300 kg N/ha and 375 kg N/ha for this attribute. Reiter et al.[20] also observed that substantial inorganic N fertilizer sources are necessary for optimal production. The highest yield of marketable tuber (249.68 q/ha) as well as total tuber yield (251.34 q/ha) was recorded under 225 kg N/ha. However, no significant difference was observed between 225 kg N/ha and 150 kg N/ha, 300 kg N/ha and 375 kg N/ha. The highest unmarketable tuber yield was recorded with the lowest nitrogen level w 0 kg N/ha, which was at par with 75 kg N/ha. A decrease in unmarketable yield was observed with higher levels of nitrogen. Higher yield obtained with application of higher dose of nitrogen would have helped in increase in tuberization as well as increased duration of tuber bulking which would have resulted in higher production[21]. Moreover, with increasing nitrogen application, number of stolon, number of tuber and consequently yield were increased[22]. Marguerite et al.[23] and Maiti et al.[24] revealed that tuber yield per unit area increased with increasing nitrogen fertilizer up to a suitable level only. Cost of cultivation per hectare (Table 4) was maximum (Rs.84255) in treatment 375 kg N/ha whereas, the lowest cost of cultivation (Rs.79666) was found in treatment with no nitrogen application. However, the maximum gross income (Rs.199744) and net income (Rs.117323) was obtained with 225 kg N/ha. The benefit cost ratio

ranged from 0.44 to 1.42 depending on the different levels of nitrogen. It was found to be highest (1.42) under treatment 225 kg N/ha.

Table 4. Economics, net return and B:C ratio of potato crops due to different N levels under Chhattisgarh plains

Nitrogen levels	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
0 kg/ha	79666	114912	35245	0.44
75 kg/ha	80584	151664	71079	0.88
150 kg/ha	81502	196080	114577	1.40
225 kg/ha	82420	199744	117323	1.42
300 kg/ha	83338	181496	98157	1.17
375 kg/ha	84255	179576	95320	1.13

4. Conclusion

It can be inferred from the present findings that, optimum nitrogen application is essential to improve potato tuber yield. Although with the increase in nitrogen levels, vegetative parameters of crop growth increased with maximum values achieved on application of 375 kg N/ha but application of 225 kg N/ha proved to be superior for obtaining higher yield and yield attributing characters. Thus, application of optimum dose of 225 kg N/ha was observed to be superior in terms of yield, as well as more profitable and can, therefore, be economically recommended for cultivation of potato variety Kufri Surya under Chhattisgarh plains agro-climatic zone.

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