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Original Research Article

Influences on Growth and Yield Attributes of Potato: Via Split Doses of Nitrogen

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A B S T R A C T

In order to evaluate the effect of split application of nitrogen on growth, yield attributes and yield of Potato cv. Kufri Khyati, an experiment was undertaken during winter season of 2018-19 at Vegetable Research Centre of GBPUAT, Pantnagar, Uttarakhand. The experiment was consisted of seven treatments replicated thrice in Randomized Block Design. During the experiment, various observations such as emergence per cent, growth and yield attributes, harvest index and economics of the treatments were evaluated with respect to split application of nitrogen. The emergence per cent was recorded at 30 days after planting (DAP). Among growth parameters, plant height, number of haulms, diameter of haulms was recorded at 30, 45 and 60 DAP. Whereas, yield and yield attributing characters *viz*., grade wise number of tubers per plot, total number of tubers per plot & per hectare, grade wise weight of tubers per plot, total weight of tubers per plot & per hectare and harvest index was recorded at the time of harvest. The study revealed that the growth, yield attributing characters and yield was influenced by split application of nitrogen and significantly increased values were obtained. Among seven treatments, 50 % basal N of RDF + 25 % top dressing at 25 DAP + two foliar spray @ 2 % urea at 40 and 55 DAP was found best regarding growth, tuber yield and B-C ratio.

Keywords

Potato, Nitrogen, Split application, Tuber yield, Harvest index

Introduction

Potato (*Solanum tuberosum* L., 2n=48) is world's major non-cereal food crop essential to global food security. It is considered 3rd most consumed food crop after wheat and rice worldwide, especially in Asian and European countries (FAO, 2017). Depending upon taxonomic school, it belongs to the family Solanaceae. Potato is highly responsive to nitrogen nutrition and it is usually the most limiting essential nutrient for potato growth and development. Application method also influences size of the tubers. Foliar application can immediately fulfill the nutrient requirement of the crop hence produces tubers of increased size. Optimal nitrogen application is essential for achieving commercial tuber yield and size requirements which results in maximum economic return. Thus the right rate, right method and right timing of nitrogen application are important in managing potato tuber size.

Materials and Methods

An experiment was conducted during *rabi* season 2018-19at Vegetable Research Centre of GBPUAT, Pantnagar, Uttarakhand. The experiment was consisted of seven treatments replicated thrice in Randomized Block Design. The treatments were allocated randomly in to the plots in such a way that each and every treatment received only once to each block. The details of the treatment are described in Table 1.

Results and Discussion

Emergence per cent

The maximum emergence per cent (97.84%) was recorded under treatment T_3 whereas, the minimum emergence per cent (96.33%) was recorded under treatment It is evident from the data (Table 2) that the split application of nitrogen didn't have any impact on emergence of potato tubers. Kumar (2015) and Ayyub *et al.,* (2018) have also reported similar findings of split application of nitrogen fertilizer on plant emergence. According to Pandey *et al.,* (2018) tuber emergence depends on the physiological stage and sprouts present on the tuber**.**

Plant height

The maximum plant height (49.66 cm) was recorded with treatment T_6 at 30 DAP which was statistically at par with T_5 (47.66 cm) and T_3 (43.11 cm). At 45 days stage, maximum plant height (59.44 cm) was obtained withT_5 whichwas statistically at par with all the treatments except T_7. At 60 DAP maximum plant height (69.33 cm) was obtained with the treatment T_6 which was statistically at par with T_4 (68.11 cm) and T_5 (67.22 cm). The minimum plant height (33.44 cm, 40.66 cm and 46.11 cm, respectively) was obtained with T_7 at all the stages of crop growth.

It is depicted in the table 2 that the tallest plant was observed with spilt application of nitrogen as basal + top dressing + foliar spray. This might be due to the better availability of nitrogen which results in the increase in cell division and cell elongation. Rizk *et al.,* (2013) also reported that tall potato plants were obtained with foliar spray of urea and concluded that it might be due to the speed absorption by leaf tissues. Kumar *et al.,* (2017), Pandey *et al.,* (2017) and Bhatt *et al.,* (2020) also observed that plants get more height due to sufficient nitrogen availability.

Number of haulms per hill

The maximum number of haulms per hill (3.3 and 4.5) was recorded under treatmentT_3 at 30 and 45 DAP of crop growth whereas, at 60 DAP maximum number of haulms per hill was (4.8) with T_1 and T_3. The minimum (2.7 and 3.0) was recorded with treatment T_4 at 30 and 45 DAP, respectively and 4.1 with T_2 and T_5 at 60 DAP.

The results indicated in table 2 that the split nitrogen application didn't show any impact on number of haulms per hill of potato tubers because of the plant character mainly depending upon the cultivar, number of sprouts and physiological state of the seed tuber rather than the fertility of the soil. The results are in close conformity with Singh and Lal (2012), Kumar *et al.,* (2017), Pandey *et al.,* (2017) and Bhatt *et al.,* (2020).

Haulm diameter

At 30 DAP the maximum stem diameter (10.2 mm) was recorded with the treatment T_2 and T_6 which was statistically at par with all the treatments except T_7. The maximum haulm diameter (11.3 mm) was found with T_5 at 45 DAP which was statistically at par with all the treatments except T_1 and T_7. At 60 DAP the highest haulm diameter (11.6 mm)

was found in T_5 which was statistically at par with all the treatments except T_7. The minimum stem diameter (7.7 mm, 8.0 mm and 8.2 mm) was recorded with treatment T_7 at all the stages of plant growth.

The data depicted in table 2 indicated that split application of nitrogen significantly increases the stem diameter. It might be due to readily availability of nutrients to the plants at various growth stages which, ultimately helps to increase the stem diameter. Rizk *et al.,* (2013) reported increase in haulm diameter with 3% foliar spray of nitrogen. Our results are also supported by the results obtained by Pandey *et al.,* (2017), Kumar*et al.,* (2017) and Bhatt *et al.,* (2020).

Grade wise number of tubers per plot

Grade A (>75g) Potato tubers recorded the highest number of tubers (306.67) per plot in the treatment T_3 which was statistically at par with treatment T_4 (283.33). Treatment T_4 have maximum number (339.67) of B grade (50-75g) potato tubers per plot which was statistically at par with treatment T_6 (330.33). The number of tubers per plotunder grade C (25-50g) was recorded highest (352.33) in treatment T_6 which was statistically at par with treatment T_1 (332.00). The maximum number (373.33)of potato tubers per plot under grade D (<25g) was recorded in treatment T_1 which was statistically at par with treatment T_3 (353.33), T_6 (349.67) and T_5 (344.33) whereas, lowest number of tubers(232.67, 330.33, 352.33 and 349.67) was recorded with treatment T_7 in all the grades of the tuber, respectively.

The results indicated (Table 3) that there is an increase in aggregate number of tuber with the split nitrogen application. According to Anand and Krishnappa (1989) the grade wise increase in number of tubers may be due to high photosynthetic activity and translocation of photosynthates to the roots which might have helped in the initiation of more stolon in potato. These results also reported by theKumar *et al.,* (2017), Pandey *et al.,* (2017) and Bhatt *et al.,* (2020).

Total number of tubers per plot and per hectare

The maximum total number of tubers per plot and per hectare was recorded (1265.00 and 620.10 thousand) in treatment T_6 which was statistically at par with T_4 (1186.00 and 581.38 thousand) and T_3 (1183.67 and 580.23 thousand) whereas, the minimum values (757.00 and 371.08 thousand) was recorded in treatment T_7.

The observed data (Table 3) revealed that the total number of tubers per plot and per hectare was increased with different nitrogen treatments. The results indicated that split application (basal + top dressing + foliar spray) of nitrogen gave better results than that of recommended (basal + top dressing). The increase in total number of tubers might be due to more number of haulms per hill. Therefore, the total photosynthetic area will increase which results into increase in number of tubers. The results are also in agreement with the findings of Kumar *et al.,* (2017) and Pandey *et al.,* (2017) who reported an increase in total number of tubers in split application of nitrogen treatments than soil applied fertilizer.

Grade wise weight of tubers per plot

Potato tubers graded as grade A (>75g) recorded highest yield (31.43 kg/plot) in the treatment T_3 (50% N of RDF as basal + two foliar spray @2% urea at 25 and 40 DAP) which was statistically at par with treatment T_4 (30.83 kg/plot) and T_2 (30.13 kg/plot) whereas, the minimum weight (8.33 kg/plot) was recorded in treatment T_7 [control (no application of nitrogen)].

Table.1 The details of the treatment

Symbols	Treatments
T_1	RDF (50% basal N+ 50% top dressing at 25 DAP)
T_2	50% basal N + one foliar spray@ 2% urea at 25 DAP
T_3	50% basal N + two foliar spray @ 2% urea at 25 & 40 DAP
T_4	50% basal N + three foliar spray @ 2% urea at 25, 40 & 55 DAP
T_5	50% basal N + 25% top dressing at 25DAP + one foliar spray @ 2% urea at 40 DAP
T_6	50% basal N + 25% top dressing at 25 DAP + two foliar spray @ 2% urea at 40 & 55 DAP
T_7	No application of N (control)

- DAP (Days After Planting)
- RDF 160: 80: 120 NPK kg /ha
- Recommended dose of P & K was given as basal in all treatment.
- In foliar application water was used 800 l/ha.

Table.2 Effect of split application of nitrogen on emergence per cent, plant height, number of haulms per hill and haulm diameter of potato plant

Treatment	Emergence %	Plant height (cm)			Number of haulms per hill			Stem diameter (mm)		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
T_1	96.33	39.22	50.88	57.78	3.1	3.6	4.8	9.5	9.7	10.1
T_2	96.88	38.22	50.33	57.89	2.9	3.3	4.1	10.2	10.4	10.8
T_3	97.84	43.11	54.33	63.00	3.3	4.5	4.8	10.1	10.4	10.9
T_4	97.27	39.43	51.66	68.11	2.7	3.0	4.4	10.0	10.2	10.8
T_5	97.64	47.66	59.44	67.22	3.2	3.9	4.1	9.9	11.3	11.6
T_6	96.92	49.66	59.11	69.33	3.2	3.5	4.2	10.2	10.4	10.7
T_7	96.72	33.44	40.66	46.11	2.9	3.3	4.4	7.7	8.0	8.2
S.Em. ±	0.58	3.04	2.98	0.88	0.29	0.29	0.38	0.22	0.52	0.25
C.D. at 5%	NS	9.48	9.30	2.76	NS	NS	NS	0.68	1.60	0.78

Table.3 Effect of split application of nitrogen on grade wise number of tubers per plot and total number of tubers per plot & thousand per ha

Treatment	Grade wise number of tubers per plot				Total number of tubers per plot	Total number of tubers 000/ha
	A (>75g)	B (50-75g)	C (25-50g)	D (<25g)		
T_1	217.00	231.67	332.00	373.33	1154.00	565.69
T_2	254.67	248.00	275.00	317.33	1095.00	536.77
T_3	306.67	222.00	301.67	353.33	1183.67	580.23
T_4	283.33	339.67	253.67	309.33	1186.00	581.38
T_5	237.00	276.67	287.67	344.33	1145.67	561.61
T_6	232.67	330.33	352.33	349.67	1265.00	620.10
T_7	84.33	183.00	233.00	256.67	757.00	371.08
S.Em. ±	8.01	15.99	15.07	15.24	26.38	12.93
C.D. at 5%	24.94	49.82	46.96	47.47	82.21	40.29

Table.4 Effect of split application of nitrogen on grade wise weight of tubers per plot, total tuber yield per plot and per hectare, and harvest index

Treatment	Grade wise weight of tubers (kg/plot)				Total yield of tubers (kg/plot)	Total yield of tubers (t/ha)	Harvest index (%)
	A (>75g)	B (50-75g)	C (25-50g)	D (<25g)			
T_1	25.30	26.20	16.13	4.72	72.35	35.47	86.80
T_2	30.13	27.37	12.80	4.03	74.33	36.44	85.56
T_3	31.43	25.87	15.40	4.70	77.40	37.94	85.40
T_4	30.83	32.93	10.73	3.66	78.16	38.31	85.41
T_5	28.53	29.27	14.93	4.40	77.13	37.81	87.60
T_6	26.13	30.13	17.93	4.68	78.88	38.67	86.27
T_7	8.33	18.20	10.60	3.06	40.19	19.70	84.12
S.Em. ±	0.74	0.57	0.84	0.34	1.20	0.88	1.30
C.D. at 5%	2.32	1.78	2.61	1.07	3.74	2.75	NA

Table.5 Economics and net profit per hectare as influenced by split application of nitrogen

Treatment	Fixed cost of cultivation (₹)	Additional cost (₹)	Total expenditure (₹)	Tuber yield (t ha^{-1})	Gross income (₹)	Net profit ha^{-1}(₹)	B-C ratio
T_1	128174	33426	161600	35.47	283760	122160	1.75
T_2	128174	33404	161578	36.44	291520	129942	1.80
T_3	128174	36126	164300	37.94	303520	139220	1.85
T_4	128174	37929	166103	38.31	306480	140377	1.84
T_5	128174	36307	164481	37.81	302480	137999	1.83
T_6	128174	38509	166683	38.67	309360	142677	1.86
T_7	128174	15990	144164	19.70	157600	13436	1.09

Selling price of potato is (₹ 8000 t^{-1}).

In grade B (50-75g) tubers of potato recorded highest yield (32.93 kg/plot) per plot in the treatment T_4which was statistically at par with treatment T_6 (30.13 kg/plot)whereas, the lowest weight (18.20 kg/plot) was recorded in treatment T_7. Highest weight of potato tuber grade C (25-50g) was recorded (17.93 kg/plot) in treatment T_6 which was statistically at par with treatment T_1 (16.13 kg/plot) whereas, the lowest (10.60 kg/plot) was observed in treatment T_7. The maximum weight (4.72 kg/plot) of grade D (<25g) potato tubers per plot was recorded in treatment T_1 which was statistically at par with all the treatments except T_7 with the minimum weight (3.06 kg/plot).

The results indicate (Table 4) that the split application of nitrogen gave better response in increasing the yield under all grades. It is might be due to application of adequate amount of nitrogen increases carbon uptake and amino acid production which resulted in more yield of large and extra-large tubers. It may also be due to better plant growth because of efficient use of nitrogen which leads to the formation of larger sized tubers. Kelling *et al.,* (2015) reported that nitrogen application in split doses produces more large sized tubers. These conclusions are also supported by Eleiwa *et al.,* (2012), Kumar *et al.,* (2017) and Pandey *et al.,* (2017), who also reported higher tubers yield under split application of nitrogen application as compared to soil application.

Total tuber yield per plot and per hectare

Total tubers yield was obtained maximum (78.88 kg/plot and 38.67 t ha^{-1}) under treatmentT_6 which was statistically at par with all the treatments except T_7 whereas, the lowest yield (40.19 kg/plot and 19.70 t ha^{-1}) was recorded in treatment T_7.

A critical observation of the data (Table 4) revealed that the total yield of tubers was increased with different split application treatments. The increase in tuber yield under split application of nutrients might be due to improved soil fertility and better nutrient uptake by potato tuber which resulted easy translocation of nutrients and photosynthates to developing plant parts. The results are in close conformity with the findings of Mehta *et al.,* (2017), Kumar *et al.,* (2017) and Pandey *et al.,* (2017) who also reported the maximum yield with split application of nitrogen and minimum in recommended practice treatment.

Harvest index

The maximum harvest index (87.60 %) was obtained from treatment T_5which was statistically at par with treatment T_1 (86.80 %). The minimum harvest index (84.12 %) was obtained from treatment T_7. The results revealed (Table 4) that with split application of nitrogen fertilizer (either by top dressing or top dressing + foliar spray) at tuberization stage there was an increase in harvest index. The increase in harvest index might be due to synchrony between demand and supply of the nitrogen fertilizer, which ultimately increase plant biomass and increase the flow of assimilates to the tubers thus increases tuber yield. Sun *et al.,* (2012) observed that split application of nitrogen led to higher harvest index and tuber yield. These results are also harmonious with the findings of Kumar *et al.,* (2017), and Bhatt *et al.,* (2020).

Economics of the treatments

Cost of cultivation

The highest cost of cultivation (₹ 166683 ha^{-1}) was recorded in treatment T_6, whereas the lowest cost of cultivation (₹ 144164 ha^{-1})

was found with treatment T_7. Banjare *et al.*, (2014) recorded similar observations. It is evident from the data Table 5 that various split applied nitrogen treatments differed in their economics.

Total output

The highest total output or gross income of (₹ 309360 ha^{-1}) was estimated with the treatment $T_6$and lowest gross return (₹ 157600 ha^{-1}) was found with the treatment T_7.

Net profit

Maximum net profit (₹ 142677 ha^{-1}) was obtained with treatment T_6 and minimum net profit (₹ 13436 ha^{-1}) was obtained with treatment T_7.

Benefit- Cost ratio

The highest benefit-cost ratio (1.86) was recorded with the treatment T_6whereas, the lowest benefit-cost ratio (1.09) was observed from with treatment T_7.

On the basis of the present study, it can be concluded that split application of nitrogen (Basal + top dressing + foliar spray) found more beneficial to the potato crop than RDF (basal + top dressing) and control (no application of nitrogen). Treatment T_6 (50% basal N of RDF+ 25% top dressing at 25 DAP + two foliar spray @ 2% urea at 40 and 55 DAP) gave maximum tuber yield as well as maximum B-C ratio than rest of the treatments. The farmers can apply lesser amount of urea to their field through split application method and get higher return. Hence, on the basis of the present investigation, the split application of nitrogen *i.e.*, 50% basal N of RDF+ 25% top dressing at 25 DAP + two foliar spray @ 2% urea at 40 and 55 DAP can be recommended to get maximum tuber yield and higher net return from the potato crop.

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