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Original Research Article

Determination of Nitrogen Split Doses on Quality Features and Nitrogen Conservation of Potato

Priyanka*, Manoj Raghav, Rajendra Bhatt, Atri Tapaswini Mohanty, Barkha Pandey and Renu Nitwal

Department of Vegetable Science, College of Agriculture, GBPUA&T, Pantnagar-263145, U. S. Nagar, Uttarakhand, India

**Corresponding author*

Keywords

Nitrogen, Dry matter, Protein, Nitrogen uptake, Split application, Nitrogen use efficiency and Nitrogen apparent recovery

A B S T R A C T

The present field research was carried out during *rabi* season of the year 2018-2019 at Vegetable Research Center (VRC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar (Uttarakhand). The highest dry matter content (19.85%), protein content (7.62 %) and nitrogen content (1.22%) in tuber was recorded with the treatment T_6 whereas, maximum specific gravity (1.03 g cc^{-1}), nitrogen content in haulm and whole plant (2.74 % and 3.95 %) and nitrogen uptake by haulm and whole plant (64.73 kg/ha and 155.58 kg/ha) was recorded with the treatment T_5. The effect of split application of nitrogen-on-nitrogen uptake by haulm was found non-significant. Split nitrogen application treatments have shown a positive impact on nitrogen use efficiency and nitrogen apparent recovery. Highest nitrogen use efficiency (170.76%) and NAR (59.20%) of potato plants was found with the treatment T_2.

Introduction

It plays an important role in developing countries like India with its ability to provide highly nutritious food and sustain the poor and hungry. It is important crop for the high population areas of Asia because it produces more dry matter, well balanced protein and more calories per unit area of land and time than other major food crop. The demand for potato is ever increasing both for table purpose and processing industry. The problem of under nutrition can be largely solved if potato is accepted as a major food crop and not merely as a vegetable. India ranks 2nd next to China in production in the world. In India, potato is cultivated on an area of 2.14 million hectare having production of 51.3 mt whereas, in Uttarakhand, Potato shares an area 26.31 Th. Hectare with 362.16 Th. Metric tonnes production (India, 2018).

Materials and Methods

An experiment entitled "Effect of split application of nitrogen on growth, yield and quality of Potato (*Solanum tuberosum* L.)" was conducted during *rabi* season 2018-19. The experiment was laid out in Randomized Block Design consisting of seven treatments replicated thrice *viz.*, 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 25 DAP + 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)]. each treatment was allocated randomly in each plot of block during experimentation. The basal application of 80 kg N (half), 80 kg P_2O_5 (full) and 120 kg K_2O (full) per hectare in the form of Urea, SSP and MOP, respectively were applied in the experimental field.

The remaining amount of nitrogen was top dressed at the time of earthing-up i.e., 25 days after planting (DAP) and foliar sprays of 2 % urea at 25, 40 and 55 DAP as per treatment was applied to each plot through Knap sack sprayer. Well sprouted, disease free, medium sized (2.5-5.0 cm diameter) tubers of Kufri Khyati variety having 40-50 g weight were selected for planting.

The seed tubers were treated with boric acid (3%) for 15 minutes before chitting. The treated tubers were spread in shady airy place for chitting. The chitted tubers were planted at 60cm × 20cm spacing. All the cultural practices were carried out under scientific management.

Among quality parameters dry matter content, protein content and specific gravity of tubers was calculated. In chemical analysis soil was analyzed for available nitrogen in soil before planting and after harvesting whereas, haulm, tuber and whole plant was analyzed for nitrogen content and nitrogen uptake.

At last nitrogen use efficiency and nitrogen apparent recovery of plants was also calculated. The formulae used in the calculations are as follows:

Quality parameter

Dry matter content of potato tubers

The dry matter content of tuber was determined by oven drying method. 100 g fresh tuber weight from each treatment was taken and dried in oven at 80ºC till constant weight than dry weight of tuber was measured in per cent and calculated by using following formula:

Dry matter content (%) =

$$\frac{\text{Oven dried weight of tuber (g)}}{\text{Fresh weight of tuber (g)}} \times 100$$

Specific gravity

A representative sample of tubers was taken from each plot after harvesting. The volume of tubers was determined by water displacement method. The specific gravity was determined by following formula:

Specific gravity of tuber (g/g) =

$$\frac{\text{Weight of tuber (g)}}{\text{Weight of same given volume of tuber (g)}}$$

Protein content

Micro-kjeldhal method was used to estimate protein content (Ranganna, 1986). Nitrogen content in the sample was computed by using following formula:

Nitrogen (%) =

$$\frac{\text{Sample titre} - \text{Blank titre}}{\text{Weight of sample (g)} \times 1000} \times 100 \times N \times 14$$

Protein content was calculated by following conversion formula:

Protein (%) = 6.25 × Nitrogen (%)

Chemical analysis in soil

Available nitrogen in soil

Available nitrogen in soil was estimated by alkaline $KMnO_4$ method (Subbiah and Asija, 1956).

Calculation

Mineralizable nitrogen (kg/ha) = R × 31.36
Where, R is volume of 0.02 *N* H_2SO_4 in ml required for titration.

$$\text{Available N (kg/ha)} = \frac{(S - B) \times N\, H_2SO_4 \times 0.014 \times 100 \times 10^4 \times 2.24}{\text{Weight of soil sample}}$$

Sample Where, S = burette reading of treated sample, B = reading of blank sample

Chemical analysis in plant

Nitrogen content in potato plant and tuber

Nitrogen content in plant and tuber is commonly determined by Kjeldahl's method (Singh *et al.*, 2007).

Observation and calculation

Weight of sample	=	0.5g
Normality of H_2SO_4 (*N*/200)	=	0.005
Volume of digestion	=	100 ml
Volume of aliquot taken	=	5 ml
Titration value (TV)	=	Sample

titration (ml) - blank titration (ml)

$$\text{N \% in plant} = \frac{TV \times 0.00007 \times 100 \times 100}{(0.5 \times 5)}$$

$$= \quad 0.28 \times TV$$

(Since, 1 ml 0.01 *N* H_2SO_4 = 0.00014 g N; 1 ml 0.005 *N* H_2SO_4 = 0.00007 g N).

Nitrogen uptake by potato plant and tuber

Nitrogen uptake by can be calculated by the formula:

Nitrogen uptake (kg/ha) =

$$\frac{\text{Nitrogen content (\%)}}{100} \times \text{Dry weight (kg/ha)}$$

Total nitrogen uptake (kg/ha) = N uptake by haulms + N uptake by tubers.

Nitrogen use efficiency

Nitrogen use efficiency (NUE, Kg of tuber produced per kg of nitrogen applied) for each treatment was determined by subtracting the control (N_C) yield from the yield obtained at a particular N level (Y_N) and then dividing the outcome value by the quantity of the N fertilizer applied at that level :

$$\text{Nitrogen use efficiency \%} = \frac{Y_N - Y_C}{N_R} \times 100$$

Where,
Y_N is yield at the particular N level, Y_C is yield at N_C level (control) and N_R is the particular N rate.

Nitrogen apparent recovery

Nitrogen apparent recovery for each treatment was determined by subtracting the nitrogen uptake by plant at control (NU_C) from the N uptake by plant at a particular N level (NU_N) and then dividing the outcome value by the quantity of the N fertilizer applied at that level :

Nitrogen apparent recovery (%) =

$$\frac{NU_N - NU_C}{N_R} \times 100$$

Where,
NU_N is N uptake by plant at the particular N level, NU_c is N uptake by plant at N_C level (control) and N_R is the particular N rate.

Results and Discussions

Quality characters

Dry matter content of tubers

The maximum dry matter content (19.85 %) of tubers was observed in treatment T_6 which was statistically at par with all the treatments except T_1 and T_7 whereas, the minimum dry matter content (17.91 %) was found in tubers was recorded in treatment T_7. Sun *et al.*, (2012) concluded that the higher tuber dry matter accumulation was associated with a high transportation efficiency of assimilates from vine to tubers after tuberization. Rizk *et al.*, (2013) reported that the foliar application of urea at higher level *i.e.*, 3% resulted in better dry matter content of tubers. These results are harmonious with the results obtained by Pandey *et al.*, (2017) and Sriom *et al.*, (2020).

Protein content of tubers

The higher amount (7.62 %) of protein in tubers was recorded in T_6 which is statistically at par with all the treatments except T_7 whereas, lowest amount (6.84%) of protein in tubers obtained with treatments T_7. Chandra *et al.*, (2017) also reported that the effect on amount of protein could be related to the vital role of nitrogen in plants which is directly and indirectly associated with protein synthesis.

Specific gravity of tubers

The maximum value (1.03 g/g) for specific gravity was recorded with treatment T_5 whereas, the lowest value (1.00 g/g) was observed in treatment T_2. Sriom *et al.*, (2020) reported that decrease in specific gravity was due to increase in water content of the tuber, which was influenced by nitrogen levels because high levels of nitrogen leads to more moisture uptake, which ultimately increases the water content of tubers. Our results are also harmonious with the results obtained by Chandra *et al.*, (2017), Kumar *et al.*, (2017) and Pandey *et al.*, (2017).

Chemical analysis

Soil analytical parameters

Available nitrogen content in soil before planting and after harvesting of tubers

The range of available nitrogen recorded in soil before planting was 139.38 kg/ha to 147.74 kg/ha. The highest nitrogen content (135.20 kg/ha) in soil after harvesting of tubers was recorded with treatment T_6 which was statistically at par with treatments T_2. While the minimum amount (105.93 kg/ha) of available nitrogen in soil was recorded under the treatment T_4 in treatment T_7 after harvesting of potato tubers. Das *et al.*, (2015) reported that net gain of soil nitrogen gradually decreased with increased level of nitrogen application, due to increased N-uptake by the plants. Similar finding was reported by Kumar *et al.*, (2017) and Pandey *et al.*, (2017).

Plant analytical parameters

Nitrogen content in haulm, tuber and plant

Highest nitrogen content (2.74 and 3.95 %) in haulm and whole plant, respectively was recorded with treatment T_5 and the highest nitrogen content (1.22%) in tuber recorded in T_6 whereas, the lowest content of nitrogen (1.96, 1.10 and 3.06 %) in haulm, tuber and whole plant, respectively was recorded in treatment T_7. Qadri *et al.*, (2015) reported that higher nitrogen content was observed where nitrogen is applied as basal dose + five foliar spray of urea at 30 DAP and concluded that foliar spray of nitrogen fertilizer increases leaf nitrogen content which strengthen source-sink relationship. Similar observation was observed by Bhatt *et al.*, (2020).

Nitrogen uptake by haulm, tuber and plant

The nitrogen uptake by haulms was recorded maximum (64.73kg ha^{-1}) in treatment T_5 whereas, the minimum value (39.85 kg ha^{-1}) of nitrogen uptake by haulms was recorded in treatment T_7. The nitrogen uptake by tuber was observed maximum (91.86 kg ha^{-1}) in treatment T_4 which was statistically at par with all the treatments except T_1 and T_7 whereas, the minimum value (42.47 kg ha^{-1}) of nitrogen uptake by tubers was recorded in treatment T_7. Finally the nitrogen uptake by whole plant was recorded maximum (155.58 kg ha^{-1}) in treatment T_5 which was statistically at par with all the treatments except T_7 with minimum value (82.33 kg ha^{-1}) (Table 1–4).

Table.1 Effect of split application of nitrogen on dry matter content, protein content and specific gravity of potato tubers

Treatment	Dry matter content (%)	Protein content (%)	Specific gravity (g/g)
T_1	18.49	7.56	1.01
T_2	19.34	7.54	1.00
T_3	19.46	7.41	1.01
T_4	19.81	7.47	1.01
T_5	19.72	7.56	1.03
T_6	19.85	7.62	1.01
T_7	17.91	6.84	1.02
S.Em.±	0.25	0.13	0.01
C.D. at 5%	0.80	0.41	NA

Table.2 Effect of split application of nitrogen on available nitrogen content in soil before planting and after harvesting

Treatment	Available N content of soil (kg/ha)	
	Before planting	After harvesting
T_1	143.56	132.41
T_2	146.35	133.80
T_3	147.74	129.62
T_4	139.38	125.44
T_5	140.77	133.80
T_6	144.95	135.20
T_7	146.35	105.93
S.Em.±	1.80	3.06
C.D. at 5 %	NA	9.55

Table.3 Effect of split nitrogen application treatments on nitrogen content and nitrogen uptake by haulm, tuber and plant

Treatment	N content (%)			N uptake (kg/ha)		
	Haulms	Tubers	Plants	Haulms	Tubers	Plants
T_1	2.70	1.21	3.91	56.97	78.94	135.91
T_2	2.49	1.20	3.70	56.73	83.63	140.36
T_3	2.58	1.19	3.77	59.66	88.37	148.03
T_4	2.65	1.19	3.85	62.78	91.86	154.64
T_5	2.74	1.21	3.95	64.73	90.85	155.58
T_6	2.55	1.22	3.77	61.39	84.19	145.58
T_7	1.96	1.10	3.05	39.85	42.47	82.33
S.Em.±	0.09	0.02	0.09	6.32	3.76	6.75
C.D. at 5 %	0.29	0.06	0.29	NA	11.72	21.04

Table.4 Effect of split nitrogen application treatments on nitrogen use efficiency and nitrogen apparent recovery

Treatment	Nitrogen use efficiency (%)	Nitrogen apparent recovery (%)
T_1	98.52	33.49
T_2	170.76	59.20
T_3	157.16	56.61
T_4	138.81	53.93
T_5	131.20	53.07
T_6	121.51	40.53
T_7	-	-
S.Em.±	7.05	5.30
C.D. at 5 %	21.98	16.45

Qadri *et al.,* (2015) who reported that application of nitrogen as foliar spray gave the best results in plant which might be due to better source to sink relationship. Similar findings were also reported by Chandra *et al.,* (2015), Pandey *et al.,* (2017) and Bhatt *et al.,* (2020).

Nitrogen use efficiency

The maximum (170.76) nitrogen use efficiency observed with treatment T_2 which was statistically at par with treatment T_3. Jaamati *et al.,* (2010) emphasized the importance of splitting N applications. They reported that by dividing total nitrogen into two or more applications, nitrogen use efficiency was enhanced promoting optimum yield which helps to mitigate the loss of nutrients. Peter *et al.,* (2015) also concluded that split nitrogen application provides opportunities to enhance nitrogen use efficiency and minimize leaching by preventing excess availability. Similar finding was also reported by Kumar *et al.,* (2017) and Pandey *et al.,* (2017).

Nitrogen apparent recovery

The maximum nitrogen apparent recovery (59.20 %) was recorded with treatment T_2 which was statistically at par with all the treatments except T_1 and T_6. Qadri *et al.*, (2015) reported from his study that foliar application of fertilizers not only improves plant yield and quality but also nutrient efficiency than that of soil applied fertilizers. These results are in harmonious with the findings of Pandey *et al.*, (2017).

On the basis of present study, it can be concluded that split nitrogen applied treatments produced high protein, dry matter, specific gravity, nitrogen content, nitrogen uptake, nitrogen use efficiency and nitrogen apparent recovery as compared to the recommended practice. Thus, greater quality tubers can be achieved with the application of lesser amount of nitrogen through split nitrogen application.

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