

## Influence of foliar nutrients on growth and yield of potato (*Solanum tuberosum* L.)

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### Abstract

To promote optimum growth and yield, the potato plant requires a steady stream of the nitrogen along with an adequate supply of phosphorus, potassium and micro nutrients. Hence, the present investigation was undertaken to evaluate the effect of foliar nutrients on growth, and yield of potato at Vegetable Research Centre of GBPUA&T, Pantnagar (Uttarakhand) during *rabi* season of 2017-2018. The experiment was laid out in Randomized Block Design consisting of eleven treatments with four replications. During the study, various observations in growth attributing character *viz.* plant height, number of leaves per hill, number of haulms per hill and stem diameter was recorded at de-haulming stage whereas, fresh and dry weight of haulms per hill were recorded at de-haulming stage. The yield and yield attributing character such as grade wise number of tubers, total number of tubers and total weight of tubers per plot and per hectare was recorded at harvesting stage. The findings of present investigation revealed that performance of potato crop was significantly influenced by different foliar application treatments. Among all treatments, 75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP ( $T_{11}$ ) was found best with respect to overall plant growth and yield attributing characters.

**Key words:** Potato, foliar nutrition, growth, number of tubers, tuber yield

### Introduction

Potato is the 3<sup>rd</sup> most important food crop in the world after wheat and rice. The supply of the adequate amount of nutrients is a prerequisite for exploiting the genetic potential of Potato. The major nutrients *viz.*, N, P and K are supplied to the crop through soil application which decreases the efficiency of fertilizers applied in soil due to various losses and fixation in soil. Application of

nutrients through foliar spray is an important substitute for soil fertilization and has no problems of fixation and immobilization which help to maximize yields of crops. Foliar nutrients usually penetrate the cuticle or the stomata of the leaf and enter into the cell thus, crop shows an immediate response in less time which provides ample scope for utilization of nutrients more efficiently and for correcting the deficiencies if any, rapidly and also helping in the reduction of loss of nutrients (Fageria et al. 2009). However, broadcast or band placement of nutrients is more responsive at earlier stage when plant is small with scanty foliage but it is necessary to recognize that the critical stages of the potato plant at which it respond more to the nutrients application by a particular method. The most advantageous application of nutrients at right time by right method is essential for better growth of the plant that consequently results in more tuber yield. The time of foliar application is adjusted in such a way that the requisite amount of nutrients is made available at aforesaid critical periods. Keeping these views in consideration a field experiment was conducted to standardize the method of nutrients application for enhancing to growth and yield of potato.

### Materials and Methods

The present experiment was undertaken on potato variety Kufri Surya during *rabi* season of the year 2017-2018 at Vegetable Research Center of the G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experiment was laid out in Randomized Block Design with four replications consisting of eleven treatments *viz.*,  $T_1$ -100% Recommended Dose of Fertilizer (RDF) 160:100:120 kg N:P:K ha<sup>-1</sup> (50% basal N + 50% top dressing at 30 DAP),  $T_2$ -50% N of RDF as basal + 25% N of RDF as top dressing at 30 DAP + one foliar spray @ 2% of urea at 40 DAP,  $T_3$ -25% N of RDF as basal + 50% N of RDF as top dressing at 30 DAP + one foliar spray @ 3% urea at 40 DAP,  $T_4$ - 50% N of RDF as basal + 2% foliar spray of 19:19:19 water soluble fertilizer

at 30 DAP, T<sub>5</sub>- 50% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 & 45 DAP, T<sub>6</sub>- 50% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 DAP, T<sub>7</sub>- 50% N of RDF as basal+ 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP, T<sub>8</sub>- 75% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 DAP, T<sub>9</sub>- 75% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 & 45 DAP, T<sub>10</sub>- 75% N of RDF as basal+ 2% foliar spray of 20:20:20 water soluble fertilizer at 30 DAP, T<sub>11</sub>- 75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP and each treatment was allocated randomly in each plot of block during experimentation. The basal application of 160kg N (half), 100 kg P<sub>2</sub>O<sub>5</sub> (full) and 120 kg K<sub>2</sub>O (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., 30 days after planting (DAP) and foliar spray at 40 DAP as per treatment. The foliar spray of water soluble fertilizer NPK (19:19:19 and 20:20:20) as per treatment was applied to each plot through Knap sack sprayer at 30 and 45 days after planting. Well sprouted, disease free, medium sized (2.5-5.0 cm diameter) tubers of Kufri Surya variety having 40-50 g weight were selected for planting and planted at 60cm × 20cm spacing. All the cultural practices were carried out under scientific management. The counting of emerged plant for emergence percent was taken from each plot at 30 DAP. The observations of plant height, number of leaves per hill, number of haulms per hill, stem diameter was recorded by randomly selected 5 plants at 45 DAP and at de-haulming stage whereas, fresh and dry weight of haulms per hill were recorded at de-haulming stage. However, yield and yield attributed characters were recorded on per plot basis and then converted into the hectare. The recorded data was analyzed through computer by using STPR3 programme, designed and developed by department of Mathematics and Statistics, College of Basic Sciences and Humanities, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand. The treatments details were as follows:

## Results and Discussion

**Growth attributing characters:** The various foliar application treatments significantly influenced the plant height at 45 DAP and at de-haulming stage. The maximum plant height (54.6 cm) at de-haulming stages of crop growth was recorded with treatment T<sub>11</sub> which was statistically at par with treatment T<sub>2</sub> (52.9cm), T<sub>3</sub>(53.8cm), T<sub>5</sub> (50.9cm), T<sub>7</sub>(51.1cm), T<sub>8</sub>(50.4cm), T<sub>9</sub> (52.6cm) and T<sub>10</sub> (50.6cm) whereas, minimum plant

height was recorded in T<sub>4</sub>(48.7 cm). It is evident from the data (Table 1) that the tallest plant was observed in treatments having two foliar sprays along with basal application of fertilizers. It might be due to the better availability of nutrients at regular intervals (particular nitrogen). It was also reported by earlier workers Shruthi (2013), Kumar *et al.* (2017) and Pandey *et al.* (2018). All of them observed that plant's get more height due to sufficient availability of nitrogen.

The data on number of leaves per hill of potato as influenced by foliar applications as per treatment their interaction effects is furnished in table 1. Different foliar spray treatments showed significant effect on number of leaves per hill at de-haulm stage. At de-haulming stage, maximum mean number of leaves per hill was recorded in treatment T<sub>3</sub> (34.80) which was statistically at par to T<sub>9</sub> (34.45), T<sub>2</sub> (33.55), T<sub>7</sub> (33.45), T<sub>5</sub> (33.40) and T<sub>11</sub> (33.25) whereas, minimum number of leaves per hills was recorded with treatment T<sub>4</sub> (31.75). It is evident from the data (Table 1) that the more number of leaves per hill was observed in treatments having two foliar sprays along with basal application of fertilizers. The probable reason for favourable increase in number of leaves per hill might be due to the fact that the spraying of nutrients had promoted the vegetative development with more number of leaves. Similar results have also been observed by Mehta *et al.* (2017), Kumar *et al.* (2017) and Pandey *et al.* (2018).

The number of haulms per hill at all stages of crop growth was not significantly affected by foliar application treatments. However, the maximum number of haulms per hill was recorded under treatment T<sub>8</sub>(5.6) at de-haulming stage of crop growth whereas, the minimum was recorded with treatment T<sub>4</sub> (4.7) at de-haulming stage of crop growth. The results indicated that the various foliar application treatments didn't have any impact on number of haulms per hill of potato tubers due to the plant character mainly depends on the cultivar, seed size and its physiological stage of the seed tuber rather than the fertility of the soil. These results are in agreement with Jasim (2013) who reported that foliar fertilizer had no significant effect on stem numbers. In fact the stem numbers are formed after planting and before adding foliar fertilizer and can't affect by it. Our results were in close conformity with Singh and Lal (2012), Kumar *et al.* (2017) and Pandey *et al.* (2018).

Stem diameter was affected significantly at all stages of crop growth. At de-haulming stage of plant, stem diameter was observed maximum (10.4 mm) under treatment T<sub>9</sub> and it was statically at par from the treatment T<sub>5</sub> (10.1mm), T<sub>2</sub> (10.0mm) and T<sub>11</sub> (9.9mm) whereas, minimum stem diameter (9.3 mm) was

recorded with the treatment at de-haulming stages. The critical observation of data presented table 1 indicated that foliar application of nutrients 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. Our result is enclosing conformity with Kumar et al. (2017), Pandey et al. (2018) and Anburani (2018).

Table 1 is evident which showed that the fresh weight and dry weight of haulms was significantly affected by different treatments of foliar nutrients. The maximum value for fresh weight of haulms per hill (120 g) was recorded under treatment T<sub>3</sub> which was statistically at par with treatment T<sub>9</sub> (116.0g), T<sub>2</sub> (13.5g), T<sub>1</sub> (99.8g) and T<sub>5</sub> (97.5g). However the maximum value for dry weight of haulms per hill (23.4g) was recorded under treatment T<sub>9</sub> and it was statistically at par with treatment T<sub>3</sub> (22.0g), T<sub>11</sub> (21.6), T<sub>5</sub> (21.3g) and T<sub>10</sub> (20.1g) whereas, the minimum fresh and dry weight of haulms per hill (79.5 g and 17.4 g) was recorded in treatment T<sub>4</sub> respectively. Recorded data (Table 1) is an evident for significant effect on fresh and dry weight of haulms by the foliar application of nutrients. It might be due to the fact that if nutrients are supplied to the crop through soil application which reduce the fresh and dry weight of haulms and also decreases the efficiency use of fertilizers due to various losses like immobilization and fixation in soil. To remove the risk of fixation and immobilization, foliar spray of nutrients is a better substitute for soil fertilization. Similar investigation was reported by Rizk et al. (2013) and Sati et al. (2017).

**Yield characters:** Table 2 provides evident for the grade wise number of tubers per plot was significantly influenced in each grade by the application of different foliar nutrients. Potato tubers graded as grade A (>75g) recorded highest number of tubers per plot in the treatment T<sub>3</sub> (133.50 per plot) which was statistically at

par with treatment T<sub>6</sub> (120.25 per plot), T<sub>10</sub> (117.25 per plot), T<sub>11</sub> (115.00 per plot), T<sub>9</sub> (114.25 per plot), T<sub>8</sub> (113.75 per plot) and T<sub>5</sub> (112.50 per plot) whereas, the lowest was recorded in treatment T<sub>1</sub> (85.255 per plot). Treatment T<sub>11</sub> (161.50 per plot) have maximum number of B grade (50-75gm) potato tubers per plot which was statistically at par with treatment T<sub>5</sub> (154.75 per plot), T<sub>9</sub> (148.00 per plot) and T<sub>1</sub> (146.25 per plot) whereas, minimum number of tubers was recorded in treatment T<sub>6</sub> (119.25 per plot).

The maximum number of tubers per plot under grade C (25-50 g) was recorded in treatment T<sub>2</sub> (197.25 per plot) which was statistically at par with treatment T<sub>7</sub> (192.25 per plot), T<sub>10</sub> (189.25 per plot), T<sub>4</sub> (178.00 per plot), T<sub>3</sub> (169.25 per plot) and T<sub>11</sub> (168.25 per plot) whereas, the lowest was observed in treatment T<sub>1</sub> (144.00 per plot).

The maximum number of potato tubers per plot graded under grade D (<25g) was recorded in treatment T<sub>9</sub> (186.50 per plot) which was statistically at par with treatment T<sub>6</sub> (174.25 per plot), T<sub>8</sub> (165.50 per plot) and T<sub>5</sub> (159.25 per plot) whereas, the minimum number was observed in treatment T<sub>1</sub> (129.50 per plot).

The effect of foliar application treatments with respect to total number of tubers of potato per plot (kg/plot) and per hectare ('000/ha) have been presented in table 2. It is evident from the table that the total number of tubers per plot or per hectare as influenced by different application of foliar nutrients. A significant effect on total number of tubers per plot and per hectare varies with foliar nutrient management in all treatments. The maximum total number of tubers of per plot and per hectare was recorded in treatment T<sub>9</sub> (608.75 per plot and 563.65 per ha) which was statistically at par with treatment T<sub>11</sub> (591.25 per plot and 547.45 per ha), T<sub>5</sub> (580.50 per plot and 537.50 per ha), T<sub>2</sub> (575.50 per plot and 532.87 per ha), T<sub>3</sub> (573.00 per plot and 530.55

**Table 1:** Effect of foliar application on plant growth of potato

Treatment	Plant height (cm)	Number of leaves/hill	Number of haulms/hill	Stem diameter (mm)	Fresh weight of haulms/hill (g)	Dry weight of haulms/hill (g)
T <sub>1</sub>	49.8	32.28	4.8	9.4	99.8	19.1
T <sub>2</sub>	52.9	33.55	5.2	10.0	113.5	18.7
T <sub>3</sub>	53.8	34.80	5.0	9.4	120.0	22.0
T <sub>4</sub>	48.7	31.75	4.7	9.3	79.5	17.4
T <sub>5</sub>	50.9	33.40	5.1	10.1	97.5	21.3
T <sub>6</sub>	48.9	32.85	5.1	9.5	82.5	19.5
T <sub>7</sub>	51.1	33.45	4.9	9.8	84.0	19.6
T <sub>8</sub>	50.4	32.70	5.6	9.4	82.0	18.0
T <sub>9</sub>	52.6	34.45	4.8	10.4	116.0	23.4
T <sub>10</sub>	50.6	32.80	5.1	9.4	89.5	20.1
T <sub>11</sub>	54.6	33.25	5.1	9.9	91.0	21.6
S.Em. ±	1.2	0.597	0.187	0.209	8.2	1.0
C.D. at 5%	3.6	1.732	NS	0.605	23.7	2.9

**Table 2:** Effect of foliar application on yields of potato

Treatment	Grade wise number of tubers per plot				Total number of tubers / plot	Total numbers of tubers 000/ha	Total yield of tubers (kg/plot)	Total yield of tubers (t/ha)
	A (>75g)	B (50-75g)	C (25-50g)	D (<25g)				
T <sub>1</sub>	85.25	146.25	144.00	129.50	505.00	467.59	35.550	32.918
T <sub>2</sub>	101.25	140.25	197.25	136.75	575.50	532.87	41.208	38.153
T <sub>3</sub>	133.50	129.00	169.25	141.25	573.00	530.55	40.480	37.480
T <sub>4</sub>	98.25	125.50	178.00	145.25	547.00	506.48	36.690	33.973
T <sub>5</sub>	112.50	154.75	154.00	159.25	580.50	537.50	37.600	34.813
T <sub>6</sub>	120.25	119.25	154.00	174.25	567.75	525.69	36.778	34.050
T <sub>7</sub>	108.75	129.75	192.25	137.00	567.75	525.69	37.645	34.855
T <sub>8</sub>	113.75	133.00	156.25	165.50	568.50	526.39	40.333	37.345
T <sub>9</sub>	114.25	148.00	160.00	186.50	608.75	563.65	41.508	38.430
T <sub>10</sub>	117.25	120.25	189.25	145.00	571.75	529.39	41.128	38.078
T <sub>11</sub>	115.00	161.50	168.25	146.50	591.25	547.45	41.960	38.850
S.Em. ±	8.14	6.30	10.08	11.87	16.30	15.09	1.188	1.099
C.D. at 5%	23.64	18.30	29.25	34.47	47.31	43.81	3.447	3.191

per ha), T<sub>10</sub>(571.75 per plot and 529.39 per ha), T<sub>8</sub>(568.50 per plot and 526.39 per ha), T<sub>6</sub>(567.75 per plot and 525.69 per ha) and T<sub>7</sub>(567.75 per plot and 525.69 per ha) whereas, the minimum value was recorded in treatment T<sub>1</sub>(505.00 per plot and 467.59 per ha).

The increase in aggregate and total number of tubers may be due to the fact that total number of tubers mainly depends on number of haulms per hill. According to Anand and Krishnappa (1989) the increase in number of tubers may be due to high photosynthetic activity and translocation of photosynthates to the roots which might help in the initiation of more stolon in potato. The results are also in agreement with the findings of Kumar *et al.* (2017) and Pandey *et al.* (2018) who reported an increase in total number of tubers in foliar application of fertilizer treatments over soil applied fertilizer.

Table 2 is evident of grade wise weight of tubers was significantly affected for grade A (>75g), B (50-75g), C (25-50g) and D (<25g) by various foliar application of nutrients. Total tubers yield (t ha<sup>-1</sup>) was obtained maximum (38.85t ha<sup>-1</sup>) under treatment T<sub>11</sub> (75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP) which was statistically at par with treatments T<sub>9</sub> (38.43t ha<sup>-1</sup>), T<sub>2</sub> (38.15 t ha<sup>-1</sup>), T<sub>10</sub> (38.08 t ha<sup>-1</sup>), T<sub>3</sub> (37.48 t ha<sup>-1</sup>) and T<sub>8</sub> (37.35 t ha<sup>-1</sup>) whereas, the lowest yield (32.92t ha<sup>-1</sup>) was recorded in treatment T<sub>1</sub> [100% Recommended Dose of Fertilizer (RDF) 160:100:120 kg N:P:K ha<sup>-1</sup> (50% basal N + 50% top dressing at 30 DAP)]. A critical observation of the data (Table 2) revealed that the total yield of tubers was increased with different foliar sprays treatments. The increase in tuber yield under foliar application of nutrients might be due to improved soil fertility, growth and better nutrient uptake by potato tuber which resulted in better growth of photosynthetic organs, translocation of nutrients and photosynthates to developing plant

parts. Hence mode of fertilizer application also matters a lot specifically when plants need quick access to nutrients. They also observed that fertilizer dose for foliar application is too low than soil applied nitrogen. The results are in conformity with the findings of Mehta *et al.* (2017), Kumar *et al.* (2017) and Pandey *et al.* (2018) who also reported the maximum marketable yield with foliar application of nutrient and minimum in recommended practice treatment.

## Conclusion

Based on overall performance, it could be concluded that under prevalent climatic conditions of Uttarakhand *tarai* region, 75% N of RDF as basal with 2% foliar application of 20:20:20 water soluble fertilizer at 30 & 45 DAP is found best in terms of growth and economic yield of potato. Hence, these could be recommended for commercial cultivation of potato under *tarai* conditions of Uttarakhand, if provided all other scientific management practices are followed.

## सारांश

आलू के पौधे में इष्टतम विकास और उपज को बढ़ावा देने के लिए फास्फोरस, पोटेशियम और सूक्ष्म पोषक तत्वों की पर्याप्त आपूर्ति के साथ नत्रजन की एक स्थिर मात्रा आवश्यक होती है। अतः वर्तमान जांच का मूल्यांकन वर्ष 2017-2018 में रबी मौसम के दौरान सब्जी विज्ञान केन्द्र, गोविन्द बल्लभ पंत कृषि एवं प्रौद्योगिकी विश्वविद्यालय, पंतनगर (उत्तराखण्ड) में किया गया। आलू के पौधे की वृद्धि और उपज को प्रभावित करने के लिए पोषक तत्वों का पर्याप्त छिड़काव किया गया। परीक्षण को चार प्रतिकृति एवं ग्यारह उपचारों के साथ यादृच्छिक खंड अभिकल्पना में आयोजित किया गया। अध्ययन के दौरान पौधे की वृद्धि के घटकों जैसे— प्रति पौध ऊँचाई, प्रति पौध की पत्तियों की संख्या प्रति टिला तना की संख्या व कटाई के समय के साथ तनों व पत्तियों दोनों के ताजा एवं शुष्क भार का आंकलन किया गया। कुल उपज व उपज घटकों के अलावा वर्गानुसार कंदों की संख्या कुल कंद संख्या एवं प्रति भूखण्ड और प्रति हेक्टेयर कुल उपज के भार का भी आंकलन किया गया। इस जांच के निष्कर्षों से

ज्ञात होता है, कि आलू फसल का प्रदर्शन विभिन्न पोषक तत्वों के पर्णय छिड़काव वाले उपचारों से सार्थक रूप में काफी प्रभावित हुआ। सभी उपचारों में से ग्यारहवाँ उपचार बुआई के समय बुनियादी उर्वरक की निर्धारित खुराक का 75 प्रतिशत नत्रजन एवं बुआई के 30 और 45 दिनों बाद पानी में घुलनशील उर्वरक 20:20:20 के 2 प्रतिशत घोल का पर्णय छिड़काव, आलू के पौधे की वृद्धि एवं उपज के लिए सर्वश्रेष्ठ पाया गया।

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