International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 1158-1162

Received: 09-08-2020
Accepted: 16-09-2020

Assessment of harvest index and nutrient-conservation in potato via foliar nutrition

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DOI: https://doi.org/10.22271/chemi.2020.v8.i5p.10451

Abstract

The major nutrients *viz*., N, P and K are supplied to the crop through soil application which decreases the nutrient uptake efficacy due to various losses and fixation in soil. Hence, a study was carried out in order to explore the response of foliar nutrients on harvest index and conserved nutrients of potato (cv. Kufri Surya) at Vegetable Research Centre of GBPUA&T, Pantnagar, Uttarakhand during *rabi* season of 2017-18. The experiment having eleven treatments with replicated four times. The results indicated that there was an increase in harvest index with the foliar feeding and maximum harvest index (83.82 %) was observed in treatment $T_{8,}$ which is 5.9% more harvest index than T_1 (100% Recommended Dose of Fertilizer). The maximum value of nutrient (nitrogen, phosphorus and potassium) content and uptake by haulms, tubers and plants was obtained from different foliar treatments, whereas, treatment T_{11} (75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP) was recorded 24.91%, 37.93% and 33.46% more nitrogen, phosphorus and potassium uptake in tubers over than recommended practices, respectively. The conclusion comes out from this experiment that, application technique of foliar nutrients significantly affected the harvest index and nutrient uptake by haulms, tubers and plants of potato.

Keywords: Potato, foliar nutrition, harvest index, nutrient content, nutrient uptake

Introduction

India rank 2nd next to China in potato production (51,310 thousand metric tons) in the world. In India, potato having an area of 2.14 million hectares with average productivity of 23.90 t ha^{-1}, whereas in Uttarakhand, Potato share 25.89 thousand-hectare areas with 358.24 thousand metric tons production and productivity of 13.83 t ha^{-1} (Anon., 2018) [1]. For exploiting the genetic potential of potato, adequate amount of nutrients is a prerequisite. Soil fertilization with foliar feeding of nutrients which affect the growing period of plant foliage and tuber formation as well as the nutrient use efficacy of plant (Gabr *et al*., 2001 and Bekhit *et al*., 2005) [5, 2]. 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.

Nitrogen (N) has very low use efficiency and is lost easily due to leaching, runoff, volatilization and de-nitrification which crop cannot use it. Foliar application of nitrogen is more advantageous as it depends less on soil conditions and in saline or dry soils where root nitrogen uptake is impaired, plants can easily be supplied nitrogen from the foliar application. Nitrogen applications which are split between pre-plant and in-season provide opportunities to increase nitrogen use efficiency and minimize leaching by preventing excess availability. Potato responds differentially to phosphorus (P) application depending upon soil phosphorous contents and with soil pH (Ekelof J., 2007) [3]. For maximum tuber yields, phosphorus should be mixed into the seed bed prior to planting to support, early shoot and root growth, tuber initiation, and tuber bulking. Plant phosphorus levels in mid and late-season (tuber initiation, and tuber bulking) may be raised by applications of phosphorus using foliar sprays which is more effective than soil surface application. Applying a major portion of total season potassium (K) fertilizer prior to planting has been found effective in obtaining maximum yields (Tindall *et al*., 1993) [15]. Due to limited uptake by foliage, in-season aerial application of potassium does not appear to meet plant (tuber) demands. Foliar application could be used when potassium levels are found to be within adequate concentrations during the growing season.

Beholding to the important role of nutrients with sensible applications in potato crop, an experiment had been planned to be conducted with the aim to investigate the influence of different levels and application strategy of nutrients on harvest index, nutrient content and uptake of potato and to perceive the best strategy of nutrient application for achieving the higher nutrient use efficiency with maximum net return.

Methods and Materials

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 (Table 1) and each treatment was allocated randomly in each plot of block during experimentation. The treatments details were as follows:

Table 1: Treatment details of the experiment

Symbol	Treatments
T_1	100% Recommended Dose of Fertilizer (RDF) 160:100:120 kg N:P:K ha^{-1}(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_5	50% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 & 45 DAP
T_6	50% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 DAP
T_7	50% N of RDF as basal+ 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP
T_8	75% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 DAP
T_9	75% N of RDF as basal+ 2% foliar spray of 19:19:19 water soluble fertilizer at 30 & 45 DAP
T_{10}	75% N of RDF as basal+ 2% foliar spray of 20:20:20 water soluble fertilizer at 30 DAP
T_{11}	75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP

*Days after planting (DAP)

The soil of experiment site was mollisol with sandy loam texture having neutral pH (7.4), organic carbon (0.87%) with 183.69 kg ha^{-1} available nitrogen, 31.17 kg ha^{-1} available phosphorus and 185.36 kg ha^{-1} available potash. The basal application of 160 kg N (half), 100 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., 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 60 cm × 20 cm spacing. All the cultural practices were carried out under scientific management. The harvest index of different treatments was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where,
Economic yield = Total tuber yield,
Biological yield = Total tuber yield + Total haulm yield
Nitrogen uptake by plant was calculated by the following formula:

$$\text{Nitrogen uptake (kg ha}^{-1}) = \frac{\text{Nitrogen content (\%)}}{100} \times \text{Dry weight (kg/ha)}$$

Nitrogen uptake plant (kg ha^{-1}) = Uptake by haulms + Uptake by tubers

Where,
Nitrogen content was estimated through alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [14] observation and calculation.
Weight of sample = 0.5g
Normality of H_2SO_4 = 0.005 (*N*/200)
Volume of digestion = 100 ml
Volume of aliquot taken = 5 ml
Titration value (TV) = Sample titration (ml) - blank titration (ml)

$$\text{N \% in plant} = \frac{\text{TV} \times 0.00007 \times 100 \times 100}{(0.5 \times 5)}$$
$$= 0.28 \times \text{TV}$$

(Since, 1 ml 0.01 NH_2S0_4= 0.00014 g N; 1 ml 0.005 NH_2S0_4 =0.00007 g N).

Phosphorus uptake by plant was calculated by the following formula:

$$\text{Phosphorus uptake (kg ha}^{-1}) = \frac{\text{Phosphorus content (\%)}}{100} \times \text{Dry weight (kg/ha)}$$

Phosphorus uptake plant (kg ha^{-1}) = Uptake by haulms + Uptake by tubers
Where,
Phosphorus content was estimated through Olsen's method (1954)
Potash uptake by plant was calculated by the following formula:

$$\text{Potash uptake (kg ha}^{-1}) = \frac{\text{Potash content (\%)}}{100} \times \text{Dry weight (kg/ha)}$$

Potash uptake plant (kg/ha) = Uptake by haulms + Uptake by tubers
Where,
Potash content in shoots was determined in di-acid digested samples using flame photometer. Standard readings were used to calculate the concentration of potash in plant.

$$\text{Potash content (\%)} = X \times \frac{\text{Dilution factor}}{10000}$$

X = Reading of flame photometer

The recorded data was subjected to analysis of variance (ANOVA) through computer 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.

Result and Discussion

Fresh weight of haulms

The maximum fresh weight of haulms per hill (11.51 kg) was recorded with treatment T_3 whereas, minimum fresh weight of haulms per hill (7.72 kg) was recorded with the treatment T_4. It is an evident form the data (Table-2) that foliar application of nutrients had significant effect on fresh weight of haulms. 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 also reported by Rizk *et al.* (2013) [11] and Sati *et al.* (2017) [12].

Weight of tubers

The highest tuber yield of potato per plot was recorded with treatment T_{11} (41.96 kg) which was 18.03 % more than treatment T_1 (35.55 kg). 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. Qadri *et al.* (2015) [10] concluded that potato supplied foliar nutrient, increased leaf nutrient contents, thus accelerates photosynthesis and develop a strong source sink relationship. 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) [7] and Pandey *et al.* (2017) [9] who also reported the maximum marketable yield with foliar application of nutrient and minimum in recommended practice treatment.

Harvest index

It is evident from the data (Table-2) that the harvest index was significantly affected by various foliar application of nutrients. The maximum harvest index (83.82 %) was obtained from treatment T_8 which was statistically at par with treatment T_{10} (83.00%), T_4 (82.63%), T_{11} (82.61%), T_6 (82.06%) and T_5 (80.19%). The minimum harvest index (77.88 %) was obtained from treatment T_3.

The results indicated that there was an increase in harvest index with the foliar application practices. Such increase in harvest index may be due to the fact that foliar application of nutrients showed immediate response in less time during critical growth stages and provides efficiently use of nutrients more, which ultimately gave higher plant biomass and might have increase the flow of assimilates to the tubers hence resulting in higher tuber yield. These results are in close conformity with the findings of Kumar *et al.* (2017) [6] and Pandey *et al.* (2017) [9].

Nitrogen content in haulms, tubers and plants

The impact of different foliar applications treatments on nitrogen content of potato haulms, tubers and plants was observed non-significant. Although, highest nitrogen content was recorded with treatment T_{11} (3.24, 1.29 and 4.53 %) in haulms, tubers and plants respectively, whereas lowest content of nitrogen in haulms (3.09 %) was recorded in treatment T_1 but in case of tubers the lowest nitrogen content (1.22 %) was recorded with the treatment T_4 and T_8. Finally, the lowest amount of nitrogen content in plants (4.33 %) was observed in T_4.

Phosphorus content in haulms, tubers and plants

The impact of different foliar treatment on phosphorus content of potato haulms, tubers and plants was observed non-significant. Although, highest phosphorus content in haulms (0.33 %) was recorded in both the treatment T_2 and T_{11} but, in case tubers highest phosphorus content (0.42 %) was observed in both the treatments T_9 and T_{11}. The overall highest phosphorus content in whole plants (0.75 %) was recorded in T_{11}. Among all the treatments lowest content of phosphorus in haulms (0.28 %) was recorded in treatment T_4, T_6 and T_8 but, in case of tubers and whole plants the lowest phosphorus content (0.35 and 0.63 %) respectively was recorded only in treatment T_4.

Potassium content in haulms, tubers and plants

Non-significant impact was observed by different foliar applications of nutrients treatments on potassium content of potato haulms, tubers and plants. Highest potassium content in haulms and whole plants (3.85 and 7.26 %) respectively was recorded with treatmentT_8 but, in case tubers potassium content was observed highest (3.46 %) in treatments T_{11}. Among all the treatments minimum content of potassium in haulms and whole plants (3.36 and 6.52 %) respectively was recorded in treatment T_1 but, in case of tubers the lowest potassium content (3.07 %) was recorded only in treatment T_4.

Nitrogen uptake by haulms, tubers and plants

The data pertaining to nitrogen uptake by haulms, tubers and plants have been presented in table 4 and showed significantly affected by different foliar applications of nutrients treatments. The nitrogen uptake by haulms was recorded maximum (67.23 kg ha^{-1}) in treatment T_9 which was statistically at par with treatment T_3 (62.77 kg ha^{-1}), T_{11} (61.44 kg ha^{-1}) and T_5(59.29 kg ha^{-1}) whereas, the minimum value (48.55 kg ha^{-1})of nitrogen uptake by haulms was recorded in treatment T_4. The nitrogen uptake by tuber was observed maximum (102.23 kg ha^{-1}) in treatment T_{11} which was statistically at par with treatment T_{10} (96.11 kg ha^{-1}), T_9 (99.94 kg ha^{-1}) and T_2 (95.69 kg ha^{-1}) whereas, the minimum value (130.11 kg ha^{-1})of nitrogen uptake by tubers was recorded in treatment T_4. Finally nitrogen uptake by whole plant was recorded maximum (167.17 kg ha^{-1}) in treatment T_9 which was statistically at par with treatment T_{11} (163.67 kg ha^{-1}) and T_3(155.55 kg ha^{-1}) whereas, the minimum value (130.11 kg ha^{-1}) of nitrogen uptake by whole plants was recorded in treatment T_4.

A critical observation of the data (Table 4) revealed that the nitrogen uptake by haulm, tuber and plant was affected significantly by different foliar application of nutrients. It was mainly due to application of nutrient in later stages. Qadri *et al.* (2015) [10] also reported that application of nutrients as foliar gave the best results in nitrogen content in plant which strength from source to sink. These results are in close conformity with the findings Kumar *et al.* (2017) [6] and Pandey *et al.* (2017) [9].

Phosphorus uptake by haulms, tubers and plants

The data regarding to phosphorus uptake by haulm, tuber and plant have been presented in table 4 and showed significantly affected by different treatments of foliar application. Treatment T_9 showed maximum (6.45 kg ha^{-1}) uptake of phosphorus by haulms which was statistically at par with treatment T_{11} (6.23 kg ha^{-1}), T_3 (6.08 kg ha^{-1}), T_5(5.45 kg ha^{-1}), T_2(5.38 kg ha^{-1}) andT_{10} (5.32 kg ha^{-1}) whereas, the minimum value (4.32 kg ha-1) of phosphorus uptake by haulms was recorded in treatment. The phosphorus uptake by tuber was observed maximum (33.20 kg ha^{-1}) in treatment T_{11} which was statistically at par with treatment T_9 (33.09 kg ha^{-1}), T_2 (28.94 kg ha^{-1}), T_8 (28.84 kg ha^{-1}), T_{10} (28.18 kg ha^{-1}) and T_3(27.88 kg ha^{-1})whereas, the minimum value (23.65 kg ha^{-1}) of phosphorus uptake by tubers was recorded in treatment T_4. Treatment T_9 have the maximum value (39.54 kg ha^{-1}) in uptake of phosphorus by whole plant, which was statistically at par with treatment T_{11} (39.43 kg ha^{-1}), T_2 (34.32 kg ha^{-1}), T_3(33.96 kg ha^{-1}), T_8 (33.39 kg ha^{-1}) and T_{10} (33.50 kg ha^{-1})whereas, the minimum value (27.98 kg ha^{-1}) of phosphorus uptake by whole plant was recorded in treatment T_4.

A critical observation of the data (Table 4) revealed that phosphorus uptake by haulm, tuber and plant was affected significantly by different foliar application of nutrients. It was mainly due to direct contact of nutrient to plant foliar part at growth and tuber bulking stage. The similar findings were reported by Eleiwa *et al*. (2012) [4] that the maximum phosphorus uptake by haulm, tuber and plant were reported in foliar spray of nutrients condition than the other treatments.

Potash uptake by haulms, tubers and plants

The data regarding to potash uptake by haulms, tubers and plants have been presented in table 4 and showed significantly affected by different treatments of foliar application. Treatment T_9 was observed maximum value (75.07 kg ha^{-1}) potassium uptake by haulms which was statistically at par with treatment T_{11} (69.11 kg ha^{-1}),T_5 (68.91 kg ha^{-1}) and T_3 (66.91 kg ha^{-1}) whereas, the minimum value (54.13 kg ha^{-1}) of potassium uptake by haulms was recorded in treatment T_4. The maximum amount (273.77 kg ha^{-1}) of potassium uptake by tuber was observed in treatment T_{11} which was statistically at par with treatment T_9 (267.84 kg ha^{-1}), T_{10} (260.19 kg ha^{-1}), T_2 (253.82 kg ha^{-1}), T_3 (247.15 kg ha^{-1}) and T_8 (246.30 kg ha^{-1}) whereas, the minimum amount (206.03 kg ha^{-1}) of potassium uptake by tubers was recorded in treatment T_4. Finally the potassium uptake by whole plant was recorded maximum (342.92 kg ha^{-1}) in treatment T_9 which was statistically at par with treatment T_{11} (342.89 kg ha^{-1}), T_{10} (323.60 kg ha^{-1}), T_3 (314.06 kg ha^{-1}), T_2 (310.93 kg ha^{-1}) and T_8 (307.29 kg ha^{-1}) whereas, the minimum value (260.16 kg ha^{-1}) of potassium uptake by whole plants was recorded in treatment T_4.

A critical observation of the data (Table 4) revealed that the potassium uptake by haulms, tubers and plants was affected significantly by different foliar nutrition applications treatments and it was mainly due to less amount of nutrition direct contact of nutrient to plant foliar part at growth and tuber bulking stage. The similar findings were reported by El-Tohamy *et al*. (2011) on carrot and Sati *et al.* (2017) [12] that the maximum potassium uptake by haulm, tuber and plant were reported in foliar spray condition than the soil applied fertilizer.

Eleiwa *et al*. (2012) [4] was also stated that application of foliar nutritional compound like (NPK @ 22:21:17: + ME) gave higher values of N, P and K in shoots and tubers of potato plants as compared to other treatments. In other crop findings Shruthi (2013) [13] was recorded that the significant effect of foliar nutrient application of 25:50:25 kg NPK ha-1 + foliar application of WSF (19:19:19at 0.5%) on NPK uptake of lima bean.

Conclusion

On the basis of data analysis, it can be concluded that the foliar feeding of nutrients found more beneficial to the potato crop as compared to RDF (basal + top dressing). It not only saves the valuable nutrients but also improve their nutrient use efficacy to the crop. Foliar nutrient applied treatments produced maximum harvest index as well as high nutrient content and is more suitable to improve nutrient uptake characters as compared to recommended practices. The treatment T_{11} (75% N of RDF as basal + 2% foliar spray of 20:20:20 water soluble fertilizer at 30 & 45 DAP) was recorded more 24.91%, 37.93% and 33.46% nitrogen, phosphorus and potassium uptake in tubers over than recommended practices. Thus, the farmers can achieve maximum return with less amount of nutrient through apply foliar feeding to their field which is the sole object of farmers to grow potato crop.

Table 2: Effect of different foliar application treatments on fresh weight of haulms, weight of tubers and harvest index

Treatment	Fresh weight of haulms per plot (kg)	Weight of tubers per plot (kg)	Harvest Index (%)
T_1	9.34	35.55	79.13
T_2	10.63	41.21	79.46
T_3	11.51	40.48	77.88
T_4	7.72	36.69	82.63
T_5	9.40	37.60	80.19
T_6	8.09	36.78	82.06
T_7	7.86	37.65	82.80
T_8	7.80	40.33	83.82
T_9	11.09	41.51	78.89
T_{10}	8.48	41.13	83.00
T_{11}	8.83	41.96	82.61
S.Em. ±	0.74	1.19	1.26
C.D. at 5 %	2.14	3.45	3.66

Table 3: Effect of different foliar application treatments on content of nitrogen, phosphorus and potash by haulm, tuber and plant

Treatment	NPK content in haulms (%)			NPK content in tubers (%)			NPK content in plants (%)		
	N	P	K	N	P	K	N	P	K
T_1	3.09	0.30	3.36	1.26	0.37	3.16	4.35	0.66	6.52
T_2	3.23	0.33	3.51	1.28	0.39	3.40	4.51	0.72	6.91
T_3	3.20	0.31	3.42	1.25	0.37	3.33	4.45	0.68	6.75
T_4	3.11	0.28	3.47	1.22	0.35	3.07	4.33	0.63	6.53
T_5	3.12	0.29	3.64	1.25	0.37	3.18	4.37	0.65	6.82
T_6	3.14	0.28	3.34	1.26	0.39	3.26	4.40	0.67	6.60
T_7	3.19	0.30	3.45	1.30	0.39	3.38	4.49	0.69	6.83
T_8	3.22	0.28	3.85	1.22	0.40	3.41	4.44	0.68	7.26
T_9	3.23	0.31	3.61	1.28	0.42	3.44	4.51	0.73	7.05
T_{10}	3.20	0.30	3.59	1.26	0.37	3.40	4.45	0.67	6.99
T_{11}	3.24	0.33	3.63	1.29	0.42	3.46	4.53	0.75	7.09
S.Em. ±	0.05	0.02	0.16	0.02	0.03	0.12	0.56	0.28	0.18
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of different foliar application treatments on uptake of nitrogen, phosphorus and potash by haulm, tuber and plant

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Haulms	Tubers	Plants	Haulms	Tubers	Plants	Haulms	Tubers	Plants
T_1	51.33	81.84	133.16	4.90	24.07	28.97	55.82	205.14	260.96
T_2	52.53	95.69	148.22	5.38	28.94	34.32	57.11	253.82	310.93
T_3	62.77	92.78	155.55	6.08	27.88	33.96	66.91	247.15	314.06
T_4	48.55	81.56	130.11	4.32	23.65	27.98	54.13	206.03	260.16
T_5	59.29	87.39	146.68	5.45	25.52	30.98	68.91	222.74	291.66
T_6	55.46	83.93	139.39	4.96	26.13	31.09	59.06	217.06	276.12
T_7	54.21	89.65	143.85	5.15	26.81	31.96	58.12	234.28	292.41
T_8	51.11	88.05	139.16	4.55	28.84	33.39	60.99	246.30	307.29
T_9	67.23	99.94	167.17	6.45	33.09	39.54	75.07	267.84	342.92
T_{10}	56.54	96.11	152.65	5.32	28.18	33.50	63.41	260.19	323.60
T_{11}	61.44	102.23	163.67	6.23	33.20	39.43	69.11	273.77	342.89
S.Em. ±	3.15	3.23	4.95	0.45	2.10	2.09	3.69	10.85	11.91
C.D. at 5 %	9.13	9.34	14.30	1.30	6.16	6.05	10.70	31.35	34.40

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