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Effect of foliar application on potato yield

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Abstract

A study was carried out to explore the response of foliar nutrients on economic yield and tuber quality of potato (*Solanum tuberosum* L., cv. Kufri Surya) at GBPUA&T, Pantnagar, Uttarakhand, during *rabi* season of 2017-18. The experiment had eleven treatments replicated four times. Among all treatments, based on overall performance treatment T_{11} (75% N of RDF as basal + 2% foliar spray of 20:20:20 water-a soluble fertilizer at 30 and 45 DAP) was found best concerning marketable yield (36.71 t/ha), dry-matter content of tubers (20.42%), protein content in tubers (8.05%), specific gravity of tubers (1.11 g cc^{-1}) and benefit:cost ratio (1.96). It is concluded that foliar application of nutrients had a notable impact on both yield and quality of potato tubers.

Key words: Potato, Foliar application , Nutrients, Marketable yield, Benefit:cost ratio.

Potato (*Solanum tuberosum* L.) has emerged as a valuable crop for enhancing food security, particularly in densely populated areas, as it offers higher yield, well-balanced protein, and more calories per unit of land and time compared to other major food crops (Ahmadu *et al*., 2021). The challenges of population pressure and malnutrition in India can be effectively addressed by recognizing the potato as a primary food source rather than merely a vegetable (Jatav *et al*., 2023; Youdol *et al*., 2024). Since, it is a nutrient exhaustive crop, use of balanced doses with best application strategy of fertilizers are necessary for receiving higher yield and better tuber quality (Sharma *et al*., 2017; Bhatt *et al*., 2020a). The foliar application provides several advantages and serves as a crucial alternative to soil fertilization (Sowmya *et al*.,2024). It eliminates concerns related to nutrient fixation and immobilization, thereby contributing to maximizing crop yields and enhancing crop quality (Tomar and Kalra 2018; Bhatt *et al*., 2020b). The foliar application also helps minimize nutrient losses, providing an effective means of nutrient delivery (Fageria *et al*., 2009). Therefore, study was carried out to determine the most effective nutrient application to get higher net returns in low land conditions.

The study was undertaken on potato Kufri Surya during *rabi* season of 2017-2018 at Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Pantnagar, located in a humid subtropical zone at 29.5°N latitude, 79.3°E longitude, and 243.84 m above sea-level, experiences maximum temperatures of 32 - 44°C in summer and a minimum of 4.4°C in winter, with an annual rainfall of approximately 1300 mm, primarily during monsoon season from late-June to mid-September. The experimental soil, a sandy loam mollisol with neutral pH (7.4), contained 0.87% organic carbon, 183.69 kg/ha nitrogen, 31.17 kg/ha phosphorus, and 185.36 kg/ha potash. The Randomized Block Design with 4 replications and 11 treatments, comprised 44 plots of 16.8 m^2 gross size and 10.8 m^2 net size, with rows spaced 60 cm apart and plants 20 cm apart.

The treatments included various combinations of nitrogen (N) application methods and foliar sprays. For example, T_1 received 100% recommended dose of fertilizer (160:100:120 kg/ha N:P:K), while other treatments varied the basal N application and included foliar sprays of urea or water-soluble fertilizers (19:19:19 or 20:20:20). Soil preparation involved deep plowing, harrowing, and leveling, followed by basal application of N, P_2O_5, and K_2O. Sprouted, disease-free tubers of Kufri Surya were treated with boric acid and planted at 60cm × 20cm spacing. Phorate was applied to control tuber moths, while Dimethoate and Mancozeb were used to manage aphids and diseases.

Cultural practices such as weeding, hoeing, irrigation, and chemical spraying were manually regulated. After 15 days of de-haulming, tubers were harvested and sorted into four grades (A >75g, B 51-75g, C 26-50g, D <25g). Marketable yield was calculated by summing the weights of A, B, and C grade tubers, converted to Tonnes/ha. The oven drying method was used to determine the dry-matter content of tubers and calculated by using the formula (Saini, 1964):

$$\text{Dry-matter content (\%)} = \frac{\text{Oven dried weight of tuber (g)}}{\text{Fresh weight of tuber (g)}} \times 100$$

For the estimation of protein content, Micro-kjeldhal method was used (Ranganna, 1986). The protein content

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was determined after the estimation of nitrogen content in tubers (%) and used the following conversion formula:

$$\text{Protein (\%)} = 6.25 \times \text{nitrogen (\%)}$$

where,

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

And, 6.25 = conversion factor for protein

For specific gravity, following formula was used in which volume of tubers was estimated by water displacement method (Kleinkopf *et al.*, 1987):

$$\text{The specific gravity of tubers} = \frac{\text{Weight of tubers (g)}}{\text{Weight of same given volume of tubers (g)}}$$

For estimation of economics of potato production in different treatments, using market price of input and produce prevailing at that time. The benefit: cost ratio estimates the production efficiency of treatments. It indicates the profit value or value of rupees obtained in the production system per rupee invested and is computed by the following formula:

$$\text{Benefit: cost ratio} = \frac{\text{Gross income (₹/ha)}}{\text{Total expenditure (₹/ha)}}$$

The recorded data were subjected to analysis of variance (ANOVA) through the computer using the STPR3 programme, designed and developed by the G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand.

The grade-wise weight of tubers was significantly affected for grades A (>75g), B (50-75g), C (25-50g) and D (<25g) by various foliar application of nutrients (Table 1). Potato tubers graded as grade A (>75g) recorded highest weight (17.73 t/ha) in treatment T_3 which was statistically at par with treatment T_{10} (16.95 t/ha), T_{11} (16.39 t/ha), T_9 (16.35 t/ha) and T_2 (15.74 t/ha) whereas, the minimum weight was recorded in treatment T_1 (11.88 t/ha). In grade B (50-75g), highest weight was in treatment T_{11} (12.87 t/ha) which was statistically at par with treatment T_1 (11.62 t/ha), T_2 (11.41 t/ha) and T_9 (11.41 t/ha), whereas, lowest weight was recorded in treatment T_3 (8.56 t/ha). The highest weight (25-50g) was recorded in treatment T_2 (9.21 t/ha), which was at par with treatment T_{10} (9.17 t/ha), T_3 (8.69 t/ha), T_6 (8.56 t/ha) and T_4 (8.41 t/ha) whereas, the lowest was observed in treatment T_5 (6.71 t /ha). The maximum weight (<25g) of tubers was recorded in treatment T_9 (3.22 t/ha) which was at par with treatment T_8 (2.83 t/ha), whereas, the minimum weight was observed in treatment T_2 (1.79 t/ha).

The weight of tubers of grade A (>75g) and C (25-50g) was highest with treatment having basal + top-dress + one foliar spray, whereas, B (50-75g), and D (<25g) grade potato tubers was recorded maximum with treatment having basal + two foliar sprays. The maximum total tuber yield was recorded with treatment T_{11} (38.85 t/ha) supplied with 75% N of RDF as basal + 2% foliar spray of 20:20:20 water-soluble fertilizer at 30 and 45 DAP have yielded 18.01 % more yield/ha than the recommended practices, *i.e.,* RDF (Table 1 and Fig.1).

The foliar application of nutrients gave a better response in increasing the yield under all grades. It might be due to early root development and growth of plants because of better availability and efficient use of nutrients by plants at all growth stages which resulted in better growth of photosynthetic organs, translocation of nutrients and photosynthates to developing plant parts (Chowdhury

Table 1: Effect of different foliar treatments on grade-wise weight, total yield, marketable yield, dry-matter content, protein content and specific gravity in tubers

Treatment	Grade-wise weight of tubers (tonnes/ha)				Total yield of tubers (tonnes / ha)	Marketable yield (tonnes /ha)	Dry matter content in tubers (%)	Protein content in tubers (%)	Specific gravity of tubers
	A (>75g)	B (50-75g)	C (25-50g)	D (<25g)					
T_1	11.88	11.62	7.18	2.25	32.92	30.67	19.78	7.86	1.06
T_2	15.74	11.41	9.21	1.79	38.15	36.37	19.70	7.97	1.08
T_3	17.73	8.56	8.69	2.49	37.48	34.99	19.79	7.81	1.09
T_4	13.61	9.65	8.41	2.31	33.97	31.67	19.66	7.62	1.06
T_5	15.23	10.42	6.71	2.45	34.81	32.36	20.07	7.81	1.09
T_6	13.61	9.33	8.56	2.55	34.05	31.50	19.56	7.88	1.13
T_7	15.37	10.05	7.46	1.99	34.86	32.87	19.85	8.09	1.08
T_8	16.88	10.33	7.32	2.83	37.35	34.52	19.35	7.62	1.11
T_9	16.35	11.41	7.45	3.22	38.43	35.22	20.32	8.00	1.12
T_{10}	16.95	9.72	9.17	2.25	38.08	35.83	20.09	7.86	1.12
T_{11}	16.39	12.87	7.46	2.14	38.85	36.71	20.42	8.05	1.11
SEm (+)	0.73	0.75	0.49	0.21	1.10	1.10	0.17	0.13	0.02
CD (5%)	2.12	2.19	1.43	0.61	3.19	3.21	0.49	NS	NS

Table 2: Economics and net profit as influenced by different foliar treatments

Treatment	Fixed cost of cultivation (₹)	Additional cost (₹)	Total expenditure (₹)	Tuber yield (tonnes / ha)	Gross income (₹)	Net profit (₹/ ha)	BC ratio
T_1	122058	29865	151923	32.92	263333	111411	1.73
T_2	122058	34971	157029	38.15	305231	148202	1.94
T_3	122058	34431	156489	37.48	299852	143363	1.92
T_4	122058	30497	152555	33.97	271778	119223	1.78
T_5	122058	33075	155133	34.81	278509	123377	1.80
T_6	122058	30578	152636	34.05	272417	119780	1.78
T_7	122058	33156	155214	34.86	278843	123629	1.80
T_8	122058	33657	155715	37.34	298759	143044	1.92
T_9	122058	36478	158536	38.43	307463	148927	1.94
T_{10}	122058	34307	156365	38.08	304630	148265	1.95
T_{11}	122058	36641	158699	38.85	310806	152107	1.96

*Selling price of potato is (₹ 8000/tonne).

et al., 2002). The foliar application of fertilizer remains far better than soil-applied fertilizer regarding potato yield (Qadri *et al.,* 2015). These conclusions are also supported by Mona *et al.* (2012), Sun *et al.* (2012) and Bhatt *et al.* (2020b).

The maximum marketable yield (36.71 t/ha) was observed in treatment T_{11} which was statistically at par with treatments T_2 (36.37 t/ ha), T_{10} (35.83 t/ha), T_9 (35.22 t/ha), T_3 (34.99 t/ha) and T_8 (34.52 t/ha) whereas, the lowest yield (30.67 t/ha) was recorded in treatment T_1 (Table 1 and Fig.1). The marketable yield of tubers increased with different treatments of foliar application, whereas maximum marketable yield (19.69%) under treatment T_{11}. The increase in marketable yield might be due to availability of nutrients at regular interval, resulting in better growth and development of tubers. Our results are in agreement with those of Kumar *et al.* (2017) and Pandey *et al.* (2018).

The maximum dry-matter content (20.42 %) of tubers was observed in treatment T_{11} which was at par with treatments T_9 (20.32 %), T_{10} (20.09 %), T_5 (20.07 %) and T_7 (19.85%), whereas, minimum dry matter content (19.35%) was recorded in treatment T_8. The treatment T_{11} has 3.24 % more dry-matter content of potato tubers than recommended practices due to the application of such nutrients as foliar at regular intervals, which, directly absorbed by leaf and helped to promote photosynthesis consequently more dry-matter formation. Sun *et al.* (2012) concluded that higher tuber dry-matter accumulation was associated with a high transportation efficiency of assimilates from plant to tubers after tuberization. Pandey *et al.* (2018) reported that foliar application of urea at a higher level resulted in better dry weight of tubers rather than using the lower level. These results correspond to those of Kumar *et al.* (2017) and Pandey *et al.* (2018).

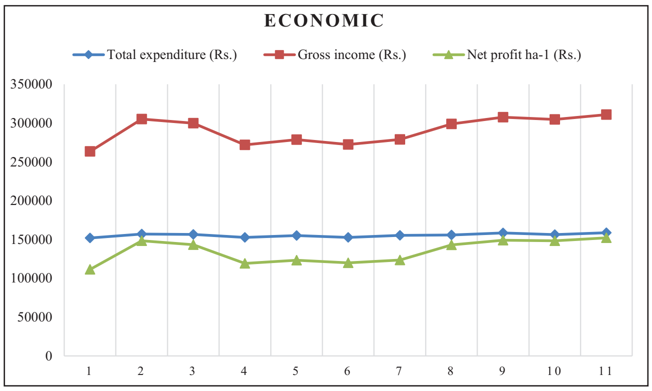

Fig. 1. Economics and net profit per hectare as influenced by different foliar application treatments

The treatment, T_7 recorded higher (8.09 %) protein contents in tubers, whereas, the lowest (7.62 %) was in tubers in T_4 and T_8. The effect of foliar applications was non-significantly increasing the protein content of tubers. It might be due to more accumulation of nutrients in tuber due to foliar sprays at later stages of growth. (Chandra *et al.,* 2014) also concluded that the effect on protein percent could be related to vital role of nitrogen in plants that is associated directly and indirectly with protein synthesis.

There was non-significant difference in specific gravity of the potato tubers due to the effect of different foliar applications treatments. However, it was observed that specific gravity of tubers applied with low amount of nutrients with foliar sprays in growth period was recorded higher. It might be due to better vegetative growth of plants and translocation of photosynthates which resulted in more reserve food accumulation in tubers. Our results confirm those of Tajner-Czopek *et al.* (2008) and Pandey *et a.,* (2018). The foliar application of nutrients was found more beneficial to potato crop as compared to RDF (basal + topdressing). It not only saved valuable nutrients but also produced maximum marketable tubers as well as maximum net.

The highest total expenditure (₹ 158699/ha) was recorded in treatment T_{11} due to high additional cost (₹ 36641), whereas the lowest total expenditure (₹ 151923/ha) was recorded with treatment T_1 due to less additional cost (₹ 29865). The maximum total output or gross income of (₹ 310806/ha) was associated with treatment T_{11} and the lowest gross return (₹ 263333/ha) was recorded with treatment T_1 (Table 2). The net profit was obtained higher (₹ 152107/ha) with treatment T_{11} while the minimum was obtained (₹ 111411/ha) with treatment T_1 (Table 2 and Fig.1). The highest benefit-cost ratio (1.96) was obtained from the treatment T_{11} (75% N of RDF as basal + 2% foliar spray of 20:20:20 water-soluble fertilizer at 30 and 45 DAP). The lowest benefit:cost ratio (1.73) was obtained under T_1 [100% Recommended Dose of Fertilizer (RDF) 160:100:120 kg/ha N: P: K (50% basal N + 50% top dressing at 30 DAP)] (Table 2).

CONCLUSION

Thus, it can be concluded that treatment T_{11} (75% N of RDF as basal + 2% foliar spray of 20:20:20 water-soluble fertilizer at 30 and 45 DAP) not only recorded 19.69% more marketable yield but also recorded more dry-matter, protein content and specific gravity in tubers as compared to that of recommended treatment. Hence, farmers can apply less nutrient to their fields through foliar method to get maximum return.

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