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Effect of foliar application of secondary and micronutrients on growth and yield of potato

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Abstract
The influence of foliar application of secondary and micronutrients on potato was investigated to determine its growth and yield. The experiment was laid out in randomized block design with 16 treatments replicated thrice. All the growth and yield parameters were improved significantly. The highest numerical value of plant height 23.55, 28.43 and 33.89cm at 45, 60, and 75 DAP respectively. Total number of tubers (4.84) per plant, Total tuber yield per plant (233.53g), yield per plot (14.07kg), yield per hectare (22.52t/ha) recorded with the sole application treatments of foliar application of Magnesium (Mg). The highest numerical value of plant height 25.87, 31.33 and 36.71cm, at 45, 60, 75 DAP, Total number of tubers (8.18) per plant, Total tuber yield per plant (346.80g), total tuber yield plot (23.04kg), total tuber yield hectare (36.87t/ha) was recorded with the foliar application of Magnesium (Mg), sulphur (S), zinc (Zn) and boron (B).

Keywords: foliar application, micronutrients, potato, growth, yield

Introduction
Potato (*Solanum tuberosum* L.) is originally a native of South American continent. About 7000 to 9000 years ago, it used to grow as a wild plant. During early 17thcentury, Portuguese introduced Potato to India. Potato (seed) exported to Nepal followed by Sri Lanka followed by Oman followed by Mauritius followed by Kuwait. Including Potato and tuber crops, the compound annual growth rate (%) of vegetables is 7.0. Total quantity of potato exported from India is 384.24 thousand MT that value in Indian currency 64,056.48 lakh rupees (2016-17). India ranks fifth in production area in the world. Potato is grown almost throughout the country in India major producing states are Uttar Pradesh, West Bengal, Bihar, Assam, Madhya Pradesh, Orissa, Karnataka, Punjab, Himachal Pradesh, Meghalaya, Maharashtra and Gujarat. Basically potato is a crop of temperate region. In India, potato is cultivated in almost all the states under very diverse condition which makes it possible to see the crop in field round the year in one part or the other. However, in the sub-tropical plains of India potato crop is raised when maximum day temperature is below 33°C and night temperatures are not above 20°C. Foliar fertilization is a very efficient technique of supplementary fertilization which facilitates easy and quick consumption of nutrients is used as a means of supplying supplemental doses of macro and micro-nutrients, plant hormones, stimulants, and other beneficial substances (Rajasekar *et al.*, 2017) [9]. In terai agro-ecological region, most of the farmers are not supplying balanced nutrients, particularly macro and micro nutrients to the crop and there is a possibility to loss of nutrients in soil for its acidic light texture soil and heavy rainfall. Hence, there is an urgent need to standardize the balance nutrient composition by incorporating secondary and micro nutrient sources considering its amount of requirement. Keeping in view the above facts, an experiment was taken up to study the effect of foliar application of secondary and micronutrients on growth and yield of potato.

Materials and Methods
The present investigation was conducted during *rabi* season of year 2017-18 to study the effect of foliar application of secondary and micronutrients on growth and yield of potato at the Horticulture Instructional Farm, Uttar Banga Krishi Viswavidyalaya (U.B.K.V.), Pundibari, Coochbehar. The potato variety Khufri Jyoti used as experimental material and the experiment was laid out in randomized block design with three replicated 16 treatments viz T_1: Magnesium; T_2:Sulphur; T_3:Zinc; T_4:Boron; T_5: Magnesium, Sulphur; T_6: Magnesium, Zinc; T_7: Magnesium, Boron; T_8: Sulphur, Zinc; T_9: Sulphur, Boron; T_{10}: Zinc, Boron; T_{11}: Magnesium, Zinc, Sulphur; T_{12}: Magnesium, Zinc, Boron; T_{13}: Magnesium, Boron, Sulphur; T_{14}: Sulphur, Zinc, Boron; T_{15}: Magnesium, Sulphur, Zinc, Boron; T_{16}: Control (No nutrient).

The observations were taken on growth parameters like plant height at 45, 60, 75 DAP, Number of shoots per plant at 45, 60, 75 DAP, fresh weight of plant, dry weight of plant at 75DAP and yield attributing characters like number of small tubers (<35 mm) per plant, number of medium tubers (35-55 mm) per plant, number of large tubers (>55 mm) per plant, weight of small, medium, large tubers per plant, total tuber yield per plant, plot and hectare.

Results and Discussion

Plant height

The plant height recorded at 45, 60 and 75 DAP was significantly influenced by the secondary nutrient and micronutrient application as presented in Table. Sole application of nutrients showed significant differences and application of Mg (T_1) recorded maximum plant height of (23.55 cm, 28.43 cm and 33.89 cm) followed by S (T_2) (23.36 cm, 28.28 cm and 33.43 cm) at 45, 60 and 75 DAP respectively. Whereas, for combined foliar spray Mg, S, Zn and B (T_{15}) recorded highest plant height (25.87cm, 31.33 cm and 36.71cm) at 45, 60 and 75 DAP respectively.

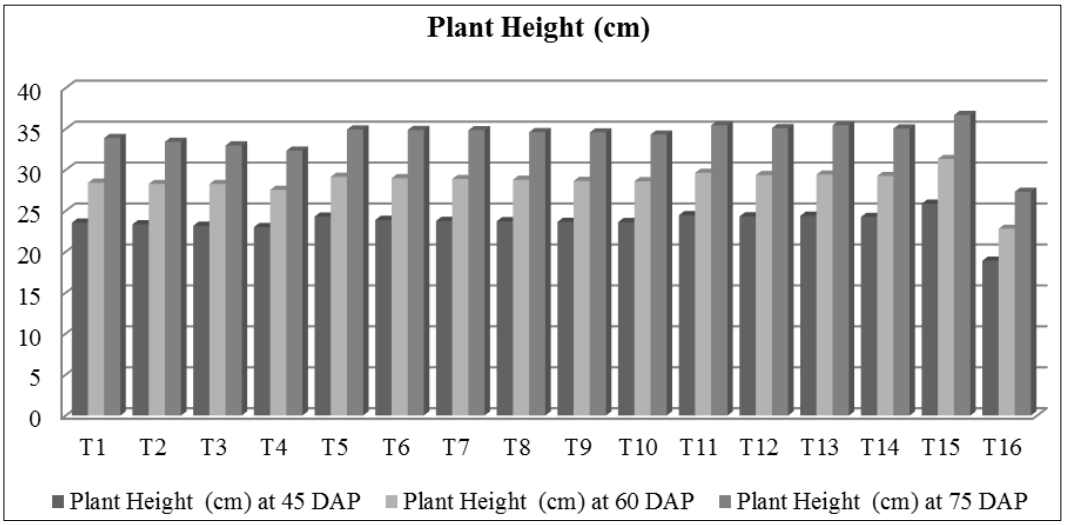

Fig 1: Plant height (cm) at different stages of crop growth as affected by foliar application of secondary and micronutrients in potato

Number of leaves per plant

Number of leaves counted per plant at 45 DAP was significantly influenced by the secondary nutrient and micronutrient application as given in Table. Sole application of nutrients has significant differences among which application of Mg recorded maximum number of leaves per plant of (26.60) followed by S (26.53) at 45 DAP. No significant difference in number of leaves was found at 60 and 75 DAP. However, numerically higher number of leaves per plant (39.53 and 47.87) was observed with treatment T_{15}.

Table 1: Plant height (cm) and number of leaves at different stages of crop growth as affected by foliar application of secondary and micronutrients in potato

Treatments	Plant Height (cm) at 45 DAP	Plant Height (cm) at 60 DAP	Plant Height (cm) at 75 DAP	Number of leaves per plant at 45 DAP	Number of leaves per plant at 60 DAP	Number of leaves per plant at 75 DAP
Mg	23.55	28.43	33.89	26.60	36.47	43.13
S	23.36	28.28	33.43	26.53	36.33	43.00
Zn	23.17	28.28	32.99	25.80	35.40	41.47
B	23.01	27.56	32.34	25.67	37.27	43.67
Mg, S	24.29	29.15	34.93	28.60	34.80	42.53
Mg, Zn	23.89	28.99	34.87	28.40	36.47	44.60
Mg, B	23.77	28.89	34.85	27.93	38.13	45.60
S, Zn	23.73	28.79	34.61	27.13	35.60	42.53
S, B	23.65	28.65	34.58	26.93	36.27	43.80
Zn, B	23.62	28.61	34.31	26.87	36.00	41.53
Mg, Zn, S	24.47	29.64	35.45	29.80	36.73	46.00
Mg, Zn, B	24.32	29.36	35.10	28.80	38.20	47.73
Mg, B, S	24.39	29.43	35.45	29.33	38.20	46.20
S, Zn, B	24.26	29.25	35.05	28.67	37.27	44.93
Mg, S, Zn, B	25.87	31.33	36.71	30.60	39.53	47.87
Control	18.91	22.81	27.33	24.13	34.60	39.33
SE (m)	0.66	0.79	0.98	1.18	1.71	2.37
SE (d)	0.93	1.11	1.39	1.67	2.41	3.36
CD(0.05)	1.91	2.29	2.84	3.43	N.S	N.S
CV(%)	4.82	4.77	4.97	7.41	8.07	9.35

Mg- Magnesium, S- Sulphur, Zn- Zinc and B- Boron

Number of Shoots per plant

Number of Shoots per plant recorded at 60 DAP was significantly influenced by the Secondary and micronutrient application as presented in Table. Sole application of nutrients showed significant differences and application of Mg recorded maximum number of shoot per plant (9.13 and 12.07) followed by S (9.07 and 11.40). Combined foliar spray of Mg, S, Zn and B (T_{15}) significantly increased the number of shoot per plant (11.33 and 14.27) at 60 and 75 DAP respectively.

Fresh weight and dry weight of plant (g) at 75 DAP

Fresh and dry weight of plant (g) recorded at 75 DAP was significantly influenced by the secondary nutrients and micronutrient application as presented in Table. Sole application of nutrients showed significant differences among which application of Mg recorded maximum fresh and dry weight of plant (140.94 g and 19.42g) followed by S (138.56 g and 19.19g) at 75 DAP respectively. Whereas, combined foliar spray of Mg, S, Zn and B (T_{15}) recorded 96.98% and 78.73% increase in fresh and dry weight at 75 DAP respectively.

Table 2: Number of shoots, fresh weight, dry weight (g) per plant at different stages of crop growth as affected by foliar application of secondary and micronutrients in potato

Treatments	Number of shoots per plant at 45 DAP	Number of shoots per plant at 60 DAP	Number of shoots per plant at 75 DAP	Fresh weight of plant (g) at 75 DAP	Dry weight of plant (g) at 75 DAP
Mg	6.27	9.13	12.07	140.94	19.42
S	6.13	9.07	11.4	138.56	19.19
Zn	6.13	9.00	11.13	135.41	18.37
B	5.80	8.53	11.07	132.33	17.55
Mg, S	6.67	9.73	12.60	170.88	24.64
Mg, Zn	6.53	9.47	12.53	168.86	24.53
Mg, B	6.53	9.40	12.47	152.63	24.05
S, Zn	6.40	9.33	12.33	149.86	22.67
S, B	6.40	9.33	12.33	143.50	22.40
Zn, B	6.33	9.20	12.20	141.59	20.32
Mg, Zn, S	6.87	10.20	13.40	201.73	26.84
Mg, Zn, B	6.67	9.93	13.00	183.78	25.99
Mg, B, S	6.87	10.07	13.13	187.41	26.61
S, Zn, B	6.67	9.87	12.93	178.23	24.65
Mg, S, Zn, B	7.33	11.33	14.27	226.91	30.67
Control	5.80	8.00	10.27	115.20	17.16
SE(m)	0.38	0.40	0.42	0.11	0.18
SE(d)	0.54	0.57	0.57	0.16	0.26
CD(0.05)	N.S	1.16	1.21	0.32	0.53
CV(%)	10.18	7.31	5.85	0.12	1.38

Mg- Magnesium, S- Sulphur, Zn- Zinc and B- Boron

Number of small tubers (<35 mm), medium tubers (35-55 mm), large tubers (>55 mm) and total number of tubers per plant

Number of small, medium, large and total tubers obtained per plant recorded was significantly influenced by the secondary nutrients and micronutrient application as presented in Table. Sole application of nutrients showed significant differences and application of Mg recorded maximum number of small, medium, large and total tubers tubers per plant (1.25, 2.28, 1.30 and 4.84) followed by S (1.21, 2.23, 1.27 and 4.71) respectively. Whereas, Combined foliar spray of Mg, S, Zn and B (T_{15}) significantly increased the number of small, medium, large and total tubers per plant (2.07, 3.22, 2.97 and 8.18) respectively.

Weight (g) of small tubers (<35 mm), medium tubers (35-55 mm) and large tubers (>55 mm) per plant

Application of secondary nutrient and micronutrient application significantly influenced weight of small, medium and large tubers per plant (g) as presented in Table. Sole application of nutrients showed significant differences and application of Mg recorded maximum weight of small, medium and large tubers per plant (50.00 g, 73.90 g and 109.67g) followed by S (49.40 g, 72.80 g and 108.67g) respectively. Whereas, combined foliar spray of Mg, S, Zn and B (T_{15}) significantly increased the weight of small, medium and large tubers per plant (69.60 g, 108.50 g and 168.67 g) respectively.

Table 3: Number of small, medium, large, total tubers per plant and weight (g) of small, medium, large tubers per plant as affected by foliar application of secondary and micronutrients in potato

Treatments	Number of small tubers (<35 mm) per plant	Number of medium tubers (35-55 mm) per plant	Number of large tubers (>55 mm) per plant	Total number of tubers per plant	Weight (g) of small tubers per plant	Weight (g) of medium tubers per plant	Weight (g) of large tubers per plant
Mg	1.25	2.28	1.30	4.84	50.00	73.9	109.67
S	1.21	2.23	1.27	4.71	49.40	72.8	108.67
Zn	1.17	2.19	1.20	4.56	48.13	72.1	106.47
B	1.12	2.10	1.17	4.39	47.73	69.4	105.73
Mg, S	1.67	2.72	1.93	6.32	56.87	83.3	123.53
Mg, Zn	1.59	2.61	1.83	6.03	55.53	81.6	118.67
Mg, B	1.52	2.55	1.77	5.84	54.4	80.9	116.93
S, Zn	1.47	2.49	1.67	5.63	53.87	77.7	115.47

S, B	1.41	2.43	1.53	5.37	52.67	76.3	114.87
Zn, B	1.36	2.37	1.43	5.16	51.93	74.7	111.47
Mg, Zn, S	1.93	3.15	2.63	7.78	67.45	86.3	146.07
Mg, Zn, B	1.80	2.90	2.17	6.86	59.13	85.4	127.80
Mg, B, S	1.87	3.03	2.30	7.20	61.33	85.5	144.47
S, Zn, B	1.72	2.83	2.07	6.61	58.27	84.7	124.4
Mg, S, Zn, B	2.07	3.22	2.97	8.18	69.60	108.5	168.67
Control	1.03	1.93	0.93	3.90	39.80	59.2	89.27
SE(m)	0.09	0.15	0.12	0.22	3.74	6.5	5.83
SE(d)	0.12	0.21	0.17	0.31	5.29	9.1	8.25
CD(0.05)	0.25	0.42	0.34	0.64	10.86	18.8	16.93
CV(%)	9.77	9.77	11.66	6.55	11.84	14.1	8.37

Mg- Magnesium, S- Sulphur, Zn- Zinc and B- Boron

Total tuber yield per plant (g), per plot (kg) and per hectare (t)

Total tuber yield per plant, per plot and per hectare was significantly influenced by the secondary nutrient and micronutrient application as presented in Table. Sole application of nutrients showed significant differences and application of Mg recorded maximum total tuber yield per plant, per plot and per hectare (233.53 g, 14.07 kg and 22.52 t per ha) followed by S (230.87 g, 13.86 kg and 22.17 t per ha) respectively. Whereas, combined foliar application of Mg, S, Zn and B (T_{15}) significantly increased the total tuber yield per plant, per plot and per hectare (346.80 g, 23.04 kg and 36.87 t per ha) respectively.

Table 4: Total tuber yield per plant, plot and hectare as affected by foliar application of secondary and micronutrients in potato

Treatments	Total tuber yield per plant (g)	Total tuber yield per plot (kg)	Total tuber yield per hectare (t)
Mg	233.53	14.07	22.52
S	230.87	13.86	22.17
Zn	226.73	12.75	20.4
B	222.87	12.57	20.11
Mg, S	263.67	17.42	27.88
Mg, Zn	255.80	16.51	26.42
Mg, B	252.20	15.40	24.65
S, Zn	247.00	15.06	24.09
S, B	243.80	14.89	23.82
Zn, B	238.13	14.69	23.5
Mg, Zn, S	299.79	21.15	33.83
Mg, Zn, B	272.33	18.01	28.81
Mg, B, S	291.33	19.73	31.57
S, Zn, B	267.33	17.67	28.28
Mg, S, Zn, B	346.80	23.04	36.87
Control	188.23	10.86	17.38
SE (m)	10.18	0.66	1.05
SE (d)	14.40	0.93	1.49
CD(0.05)	29.55	1.91	3.06
CV(%)	6.92	7.08	7.09

Mg- Magnesium, S- Sulphur, Zn- Zinc and B- Boron

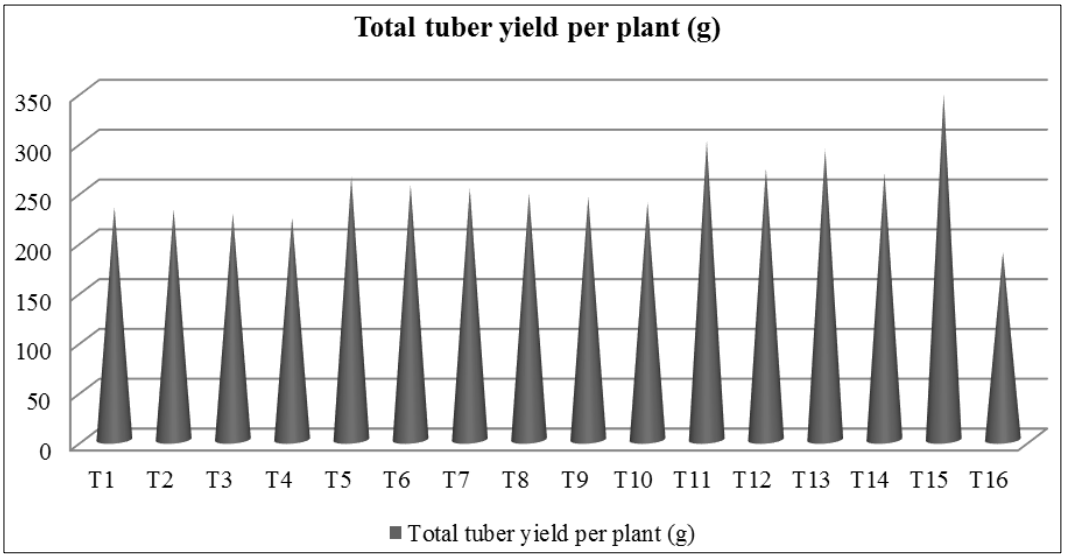

Fig 2: Total tuber yield per plant as affected by foliar application of secondary and micronutrients in potato

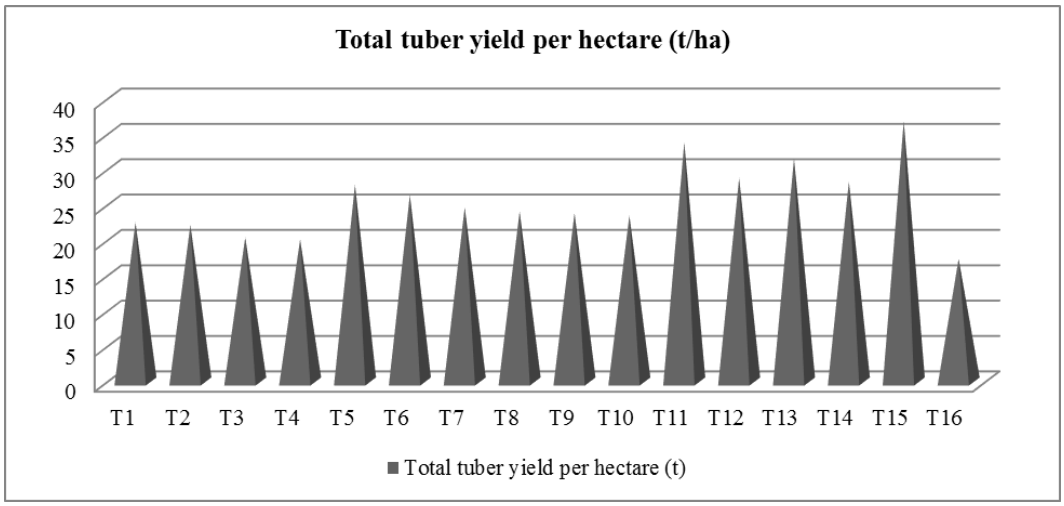

Fig 3: Total tuber yield per hectare as affected by foliar application of secondary and micronutrients in potato

The increase in yield of the plant in terms of number, weight of tubers in the plant is due to the role of different secondary nutrient and micronutrient mixture which can be attributed to the enhanced availability of essential plant nutrients at the required growth stages. Increased rate and efficiency of metabolic activities resulted in high assimilation of proteins and carbohydrates, regulating the auxin concentration, hormonal balance in plant system which in turn helps in better nutrient absorption by plants resulting in better yields. Secondary and micronutrients can help in increasing the foliage coverage at initial growth stages and in the later stages, which helps in translocation of assimilates is also responsible for higher yield. Foliar fertilization has potential to play an important role in potato production. These results are in good accordance with those obtained by Bari *et al.*, (2001) [3], White *et al.* (2012) [12], Ali *et al.* (2013) [1], Panitnok *et al.* (2013) [7], Lopez *et al.* (2014) [5], Parmar *et al.* (2016) [8], Javanmardi and Rasuli (2017) [4], Moinuddin *et al.* (2017) [6], Slosar *et al.* (2017) [11] and Singh *et al.*, (2018) [10].

Conclusion

From the present investigation it can be concluded that growing of potato with combined foliar spray of magnesium, sulphur, zinc, and boron (T_{15}) is the most effective among the various secondary and micronutrients treatments as it influence the crop throughout its growth with the resultant increase in growth and yield. Thus it can be concluded that combined foliar spray of four nutrients *viz.*, Mg, S, Zn, and B are most effective in recording maximum growth and tuber yields. So, these secondary nutrients and micronutrients (Mg, S, Zn, and B) along with normal doses of major nutrients may be recommended to the potato growers to get higher growth and yields, to prevent loss and to increase the overall production of potato in terai agro-climatic region of West Bengal.

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