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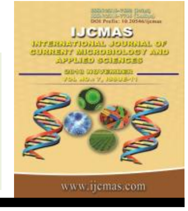

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Studies on Development of Specific Micronutrient Formulation for Growth and Yield of Potato (*Solanum tuberosum* L.)

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ABSTRACT

A field experiment was conducted at Horticulture Research and Extension Centre (HREC), Somanahallikaval, Hassan during 2016 to study the effect different micronutrients and their formulation on growth, yield and quality of potato (*Solanum tuberosum* L.) Cv. KufriJyoti. The experiment was conducted with Randomized Complete Block Design with twelve treatments and three replication. Treatments included were T_1 (control)- RDF (FYM 25 t/ha + N:P:K at 75:75:100 kg/ha), T_2: T_1+ boron, T_3: T_1+ zinc, T_4: T_1 + zinc + boron, T_5: T_1 + IIHR vegetable special, T_6: T_1 + IIHR potato special, T_7: T_1 + UHSB 1, T_8: T_1 + UHSB 2, T_9: T_1 + UHSB 3, T_{10}: T_1 + UHSB 4, T_{11}: T_1 + UHSB 5, and T_{12}: RDF of N:P:K without FYM. In each formulation different concentration of micronutrients were used. The micronutrients and their formulation were sprayed at 30, 45 and 60 days after sprouting of tubers. Among the different formulations, T_{11}-foliar spray of UHSB-5 micronutrient formulation along with RDF recorded the maximum plant height (66.87 cm) whereas, T_9-foliar spray of UHSB-3 micronutrient formulation along with RDF recorded significantly highest number of branches per plant (4.60), number of compound leaves per plant (24.67) and plant canopy spread (1612.64 cm^2) at 60 days after sprouting of tubers. Same treatment was also recorded significantly highest tubers per plant (7.87), tuber weight per plant (687.87 g/plant), tuber yield per hectare (25.18 t/ha) and dry matter content (19.76%).

Introduction

Potato is a very popular vegetable grown all over the world and is an important food crop grown in more than 150 countries in the world. Potato (*Solanum tuberosum* L.) is an important food crop after wheat, maize and rice, contributing to food and nutritional security in the world. It is also called as poor man's strength or king of vegetables (Mustafa, 1997).

Potato developed as a temperate crop and was later distributed throughout the world. It was introduced to India by early 17th century probably through British missionaries or Portuguese traders. India is now producing 43.77 million tonnes of potato tubers in an area about 2.13 million hectare (Anon., 2016).

Nutrient management in potato is very important to achieve optimum yield and quality of tubers. Potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers per unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium, as well as micro nutrients. High potato yields can only be obtained through the application of optimal nutrient doses in balanced proportions (Poljak *et al.,* 2007). But Indian agricultural production heavily depends on fertilizer application which results in greater rate of nutrient collapse and soil health problems. Regular depletion of nutrient resources from soils has led to emergence of several nutrient deficiencies. Most of the Indian soils are widely deficient in micronutrients especially Zn, Mn, B and Fe. The efficiency of applied inorganic micronutrients is rather low due to their fixation in the soil.

However, soil mineral reserves and soil fertilization are not always sufficient to satisfy the needs of crops. Nutritional disorders in potato occur in acidic and alkaline soils. In acidic soils, there is a lack of calcium, magnesium and phosphorus for growing crop and in alkaline soil there is lack of boron, manganese and zinc. The alternative approach is the application of these nutrients to plant leaves and stems through foliar fertilization.

Micronutrients play a very important role in vital processes of plants. They increase the chlorophyll content of leaves, improve photosynthesis which intensify the assimilating activity of the whole plants (Marschner, 1995). Spray of micro-element solution (B, Cu, Mn, Zn and Mo) on potato leaves increased the uptake of N, P, K; chlorophyll content and photosynthesis in leaves, promoted the tuber expansion and increase potato yield (Meng *et al.,* 2004).

Thus micronutrients are important key elements which stimulates the uptake of other primary and secondary nutrients when applied in optimal concentration because of their interaction effect like zinc associated with uptake of phosphorous, iron associated with uptake of copper, copper associated with uptake of zinc and iron associated with uptake of magnesium *etc*. And foliar application of micronutrients readily available to plants moreover easy to apply compared to soil application.

Materials and Methods

The soil of the experimental area was sandy loam having good physical and chemical properties and pH of the soil was 6.2. This experiment was undertaken to find out the best micronutrient formulation to obtain good growth, yield and yield attributes in potato. The design followed was RCBD (Randomized Complete Block Design) with 12 treatments replicated thrice in a plot of 4.2 x 4 m size with 60 x 20 cm spacing during Kharif 2016. The treatments included under the study were,T_1 (control)- RDF (FYM 25 t/ha + N:P:K at 75:75:100 kg/ha), T_2 - RDF+ Foliar spray of boron at 50 ppm, T_3 -RDF+ Foliar spray of zinc 150 ppm, T_4 -RDF + Foliar spray of zinc 150 ppm + boron 50 ppm, T_5- RDF + Foliar spray of IIHR vegetable special (5g/l), T_6 - RDF + Foliar spray of IIHR potato specific nutrient formulation (4g/l), T_7 -RDF + Foliar spray of UHSB 1 potato micronutrient formulation (3g/l), T_8-RDF + Foliar spray of UHSB 2 potato micronutrient formulation (3g/l), T_9- RDF + Foliar spray of UHSB 3 potato micronutrient formulation (3g/l), T_{10} - RDF + Foliar spray of UHSB 4 potato micronutrient formulation (3 g/l), T_{11} - RDF + Foliar spray of UHSB 5 potato micronutrient formulation (3 g/l) and T_{12}- Only recommended dose of N:P:K without FYM. Composition of nutrient formulation is presented in Table 1 and was applied at 30, 45 and 60 days after sprouting of tubers.

Results and Discussion

Growth parameters

There was no significant difference between the plant emergence percent among the treatments (Table 2) indicating the uniformity in the plant emergence in the experimental plot before the imposition of treatment. Even then, the plant emergence ranged from 86.78 per cent (T_5 - RDF + FYM + IIHR Vegetable Special) to 83.71 per cent (T_9 – RDF + FYM + UHSB-3)

Foliar spray of UHSB-5 micronutrient formulation along with soil application of RDF recorded significantly highest plant height at 60 days after sprouting (66.87 cm) compared to T_1-control (53.80 cm). However, foliar spray of UHSB- 3 micronutrient formulation along with soil application of RDF recorded significantly highest number of branches (4.60), number of compound leaves per plant (24.67), plant canopy spread (1612.64 cm^2) at 60 days after sprouting. Meanwhile significantly highest haulm dry matter production was recorded in T_{11} with RDF + FYM + UHSB-5 (3177.78 kg ha^{-1}) which was on par with T_9 (3111.11 kg ha^{-1}) compared to control with RDF + FYM (2572.22 kg ha^{-1}).

Similar results were also reported by Vinod Kumar *et al.,* (2008), Basavarajeswari *et al.,* (2008), Sivaiah *et al.,* (2013), Banerjee *et al.,* (2016), Praveen Kumar *et al.,* (2008), Ali *et al.,* (2015), Acharya *et al.,* (2015) and Parmer *et al.,* (2016) in different crops. Plant height may be increased due to application of zinc which plays major role in synthesis of auxin besides the association of boron with development of cell wall and cell differentiation which helps in root and shoot growth of plants (Basavarajeswari *et al.,* 2008; Sharma and Grewal, 1988).

Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation (Hatwar *et al.,* 2003). Mallick and Muthukrishnan (1980) explained that the presence of zinc activates the synthesis of tryptophan, the precursor of IAA and which is responsible to stimulate the plant growth. Iron plays an important role in promoting growth characters, being a component of ferredoxin, an electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better vegetative growth (Hazra *et al.,* 1987).

Increase in number of leaves per plant may be due to the role of micronutrients in cell division, meristematic activity of plant tissue and expansion of cells (Acharya *et al.,* 2015).

Influence of boron either single or in combination with other micronutrients has been reported to increase the number of leaves per plant in several crops (Sivaiah *et al.,* 2013; Manas *et al.,* 2014).

Yield parameters

Significantly highest numbers of A grade >75 g tubers (4.33 tubers/plant), highest total tubers (7.87 tubers/plant), total tuber yield per plant (687.87 g), total tuber yield per hectare (25.18 t ha^{-1}) and dry matter content of tubers (19.76%) was recorded with foliar spray of UHSB-3 micronutrient formulation along with soil application of RDF (Table 3 and 4).

Table.2 Influence of foliar spray of micronutrients on plant height, number of branches, number of leaves, Plant spread and haulm yield perplant

Treatment	Plant emergence 30 DAS (%)**	Plant height (cm)	No. of branches	No. of leaves	Plant spread (cm^2)	Haulm yield on dry weight basis (kg/ha)
		60 DAS	60 DAS	60 DAS	60 DAS	
T_1: FYM (25 t/ha) + Recommended dose of N: P: K (75:75:100 Kg/ha).	84.61 (66.88)	53.80	2.67	20.40	1149.71	2572.22
T_2: T_1 + Foliar spray of boron at 30, 45 and 60 DAS	84.28 (66.65)	56.07	3.00	22.40	1331.59	2805.56
T_3: T_1 + Foliar spray of zinc at 30, 45 and 60 DAS	84.29 (66.62)	56.80	3.53	23.67	1525.97	2766.67
T_4: T_1 + Foliar spray of zinc + boron at 30, 45 and 60 DAS	84.64 (66.94)	61.47	3.73	21.47	1439.53	2877.78
T_5: T_1 + Foliar spray of IIHR vegetable special at 30, 45 and 60 DAS.	86.78 (68.66)	61.00	3.07	23.07	1331.69	2927.78
T_6: T_1 + Foliar spray of IIHR potato specific nutrient formulation at 30, 45 and 60 DAS.	85.77 (67.82)	63.60	3.53	23.27	1295.56	2983.33
T_7: T_1 + Foliar spray UHSB 1 potato micronutrient formulation at 30, 45 and 60 DAS	85.99 (68.00)	64.93	3.73	22.27	1376.75	3011.11
T_8: T_1 + Foliar spray of UHSB 2 potato micronutrient formulation at 30, 45 and 60 DAS	86.48 (68.41)	64.80	3.67	22.60	1341.07	2955.56
T_9: T_1 + Foliar spray of UHSB 3 potato micronutrient formulation at 30, 45 and 60 DAS	83.71 (66.25)	60.27	4.60	24.67	1612.64	3111.11
T_{10}: T_1 + Foliar spray of UHSB 4 potato micronutrient formulation at 30, 45 and 60 DAS	86.75 (68.64)	60.53	4.47	22.93	1285.87	2900.00
T_{11}: T_1 + Foliar spray of UHSB 5 potato micronutrient formulation at 30, 45 and 60 DAS	85.71 (67.78)	66.87	4.07	23.67	1510.65	3177.78
T_{12}: Recommended dose of N:P:K without FYM	85.71 (67.78)	53.33	2.53	20.73	1188.99	2483.33
S Em±	0.83	2.05	0.33	0.49	74.07	53.77
CD 5%	NS	6.00	0.98	1.42	217.23	157.70

Table.3 Influence of foliar spray of micronutrients on grade wise tuber number per plant

Treatments	Grade wise tuber number/plant				Total tuber number/ plant
	A Grade (>75 g)	B Grade (50-75 g)	C Grade (25-50 g)	D Grade (0-25 g)	
T_1: FYM (25 t/ha) + Recommended dose of N:P:K (75:75:100 Kg/ha).	2.60	1.13	2.00	1.47	7.07
T_2: T_1 + Foliar spray of boron at 30, 45 and 60 DAS	3.87	0.53	1.40	0.80	6.60
T_3: T_1 + Foliar spray of zinc at 30, 45 and 60 DAS	2.67	1.53	1.07	1.13	6.20
T_4: T_1 + Foliar spray of zinc + boron at 30, 45 and 60 DAS	3.27	1.20	1.00	0.67	6.13
T_5: T_1 + Foliar spray of IIHR vegetable special at 30, 45 and 60 DAS.	2.80	1.20	0.93	1.00	5.93
T_6: T_1 + Foliar spray of IIHR potato specific nutrient formulation at 30, 45 and 60 DAS.	3.27	1.33	1.13	0.8	6.40
T_7: T_1 + Foliar spray of UHSB 1 potato micronutrient formulation at 30, 45 and 60 DAS	4.27	1.40	1.00	0.53	7.20
T_8: T_1 + Foliar spray of UHSB 2 potato micronutrient formulation at 30, 45 and 60 DAS	4.13	1.47	1.00	0.13	6.60
T_9: T_1 + Foliar spray of UHSB 3 potato micronutrient formulation at 30, 45 and 60 DAS	4.33	1.53	1.53	0.47	7.87
T_{10}: T_1 + Foliar spray of UHSB 4 potato micronutrient formulation at 30, 45 and 60 DAS	2.47	1.53	1.00	0.67	5.67
T_{11}: T_1 + Foliar spray of UHSB 5 potato micronutrient formulation at 30, 45 and 60 DAS	3.53	1.53	1.53	0.40	7.00
T_{12}: Recommended dose of N:P:K without FYM	2.80	0.73	1.4	1.53	6.40
S Em±	0.33	0.18	0.18	0.12	0.37
CD 5%	1.11	0.51	0.53	0.35	1.07

Table.4 Influence of foliar spray of micronutrients total yield per plant, yield per hectare and dry weight of tubers

Treatments	Yield per plant (g)	Tuber yield (t/ha)	Dry weight of tubers (%)
T_1: FYM (25 t/ha) + RDF of N:P:K (75:75:100 Kg/ha).	418.33	19.18	16.86 (48.23)
T_2: T_1 + Foliar spray of boron at 30, 45 and 60 DAS	474.37	21.63	17.38 (40.66)
T_3: T_1 + Foliar spray of zinc at 30, 45 and 60 DAS	475.93	21.79	18.40 (46.49)
T_4: T_1 + Foliar spray of zinc + boron at 30, 45 and 60 DAS	490.29	21.88	18.34 (41.11)
T_5: T_1 + Foliar spray of IIHR vegetable special at 30, 45 and 60 DAS.	474.45	20.53	19.35 (44.48)
T_6: T_1 + Foliar spray of IIHR potato specific nutrient formulation at 30, 45 and 60 DAS.	484.47	23.12	18.75 (43.79)
T_7: T_1 + UHSB 1 potato micronutrient formulation at 30, 45 and 60 DAS	532.63	22.11	18.20 (36.42)
T_8: T_1 + Foliar spray of UHSB 2 potato micronutrient formulation at 30, 45 and 60 DAS	636.88	24.23	19.44 (44.46)
T_9: T_1 + Foliar spray of UHSB 3 potato micronutrient formulation at 30, 45 and 60 DAS	687.87	25.18	19.76 (34.09)
T_{10}: T_1 + Foliar spray of UHSB 4 potato micronutrient formulation at 30, 45 and 60 DAS	486.89	20.75	18.02 (39.01)
T_{11}: T_1 + Foliar spray of UHSB 5 potato micronutrient formulation at 30, 45 and 60 DAS	625.14	24.88	18.85 30.82)
T_{12}: Recommended dose of N:P:K without FYM	358.44	17.18	16.33 (52.99)
S Em±	11.00	0.79	0.13
CD 5%	32.27	2.22	0.39

DAS – Days After Sprouting

Table.1 Composition of nutrient formulation

Sl. No.	Nutrient formulation	Composition
1	IIHR Vegetable Special	Zinc (225 ppm), Boron (50ppm), Manganese (42.5 ppm), Iron (105 ppm), Copper (5 ppm)
2	UHSB-1 formulation	Zinc (50 ppm), Boron (50 ppm), Copper (20 ppm)
3	UHSB-2 formulation	Zinc (200 ppm), Manganese (100 ppm), Boron (50 ppm), Iron (75 ppm), Copper (20 ppm)
4	UHSB-3 formulation	Zinc (200 ppm), Manganese (75 ppm), Iron (100 ppm), Boron (75 ppm), Copper (25ppm)
5	UHSB-4 formulation	Zinc (150 ppm), Manganese (150 ppm), Iron (100 ppm), Boron (75 ppm), Copper (10 ppm)
6	UHSB-5 formulation	Zinc (50 ppm), manganese (150 ppm), Iron (75 ppm), Boron (75 ppm), Copper (25 ppm)

These results are in conformity with Mousavi *et al.*, (2007); Vinod Kumar *et al.*, (2008); Jobori and Hadithy (2014) and Parmar *et al.*, (2016) and Shah *et al.*, (2016)

Increase in tuber yield was due to micronutrient application which may be attributed to the enhanced photosynthesis activity, resulting into the increased production and accumulation of carbohydrates and favorable effect on vegetative growth (Davis *et al.*, 2003; and Basavarajeswari *et al.*, 2008; Parmar *et al.*, 2016) in different vegetable crops.

Increase in tuber size was may be due to improved physiological activity like photosynthesis and translocation of food materials. Applied micronutrients helped in increasing the average weight of individual tuber thereby transferring the tubers from small to medium grade and medium to large grade. Application of micronutrients significantly increased the yield of large and medium grade tubers and decrease proportionately small tubers (Vinod Kumar *et al.*, 2008 and Bari *et al.*, 2001).

In potato, the biomass and tuber yield were highest at adequate (0.55 mg/l) manganese which appears to be optimum for improved crop yield. Both low and excess Mn resulted in low concentration of chlorophyll a and b as well as reduced Hill reaction activity in potato leaves (Gopal *et al.*, 2006). The decline in biomass at both low and high Mn (<> 0.55 mg/l) might be due to lower photosynthetic efficiency of potato, because low as well as excess Mn decrease the rate of photosynthesis as Mn is directly related to biological and economic yield (Marschner, 1995).

By this experiment we can conclude that foliar application of UHSB-3 micronutrient formulation (3 g/l) along with soil application of RDF (75:75:100 kg/ha of N: P: K) and FYM (25 t/ha) was found more economical in terms of plant growth and yield parameters like number of leaves, number of branches, plant canopy spread, Tuber number per plant and tuber yield.

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