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Effect of foliar application of boron, zinc and manganese on growth of potato (*Solanum tuberosum) Cv* Kufri Chipsona – 1 under Gwalior climatic conditions

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Abstract
The present experiment was conducted during 2018-19 at the nursery area Deptt. Of Horticulture, College of Agiculture, Gwalior, (M.P.). The experiment was laid out in Randomized Block Design (RBD) with three replications. Each replication consisted of 8 treatments of Boron, Zinc, Manganese and their combinations. The treatments were applied as foliar application in different doses. All the treatments were randomized separately in each replication. The variety Kufri Chipsona – 1 was selected for the experiment. The observations were recorded on different aspects of growth of the potato crop. The results revealed that out of the 8 treatments, the treatments T6 (Boron + Manganese), T7 (Zinc + Manganese) and T8 (Boron + Zinc+ Manganese) recorded highest plant height (cm), number of leaves, length of leaves and diameter of stem (cm).

Keywords: Foliar application, boron, zinc, manganese, *Solanum tuberosum*

Introduction

Potato (*Solanum tubrosum* L.) is widely grown in India. It belongs to family Solanaceae. The area and production of potato in India is 2151 thousand hectare and 48237 Mt respectively and in Gird region of Madhya Pradesh area and production of potato is 111.06 thousand hectare and 2425 Mt respectively (NHB 2016-2017). It occupies first position in area as well as in production among the vegetable crops in India.

Potato provides carbohydrates, minerals and fibre. The protein is as comparable to that of milk and egg. Potato is known as protective food because potato is rich in lysine which is one of the most important amino acids. Potato provides a part of daily caloric needs of human and delivers many essential nutrients and vitamins including potassium, phosphorus, manganese, magnesium, folate, vitamin C and vitamine B-6 (Haynes *et al*., 2012) [15]. Potato contains water (74.7- 75%), sugar and starch (22.9%), fat (0.1%), minerals, vitamins (0.6%) and one of the richest sources of starch and protein (1.21-2%). (Anonymous, 2008) [4]. Potatoes provide higher dry matter and yield per unit area in comparison with other crops such as cereals, therefore potato is considered as a heavy nutrient requiring crop (Bari *et al.*, 2001) [7].

Potato is considered a heavy nutrient requiring crop because of its bulk yield within a short growing season. There are 16 essential elements required for plant growth and reproduction (Stark and Westermann, 2003) [39]. Some are required in relatively large amounts (called macronutrients) while others are required in small quantities (called micronutrients). Although micronutrients are used in smaller quantities, they are just as important as the macronutrients. Among these, boron and zinc play pivotal role in pollination and fruit development. Micronutrient management is a critical component for successful potato production. Micronutrient deficiencies can occur mu *et al.*, 2014) [30]. In potato cultivation some minor plant nutrients like in the high pH soils. On sandy loam soils, soil or foliar applied micronutrients may produce added benefits for potato production under irrigated condition. Selection of an effective application method may also increase the use of efficiency of a specific micronutrient. Potato plants require micronutrients to produce optimum yield (Mur Zn, B can help in increasing the foliage at initial stage of growth and in the later stages, the translocation of assimilates is responsible for higher yield (Trehan and Grewal, 1981; Mondal *et al.*, 1993) [26, 42].

Micronutrients help build that effectiveness of the utilization of macronutrients. Micronutrients have an incredible part in the compost programmed with attain higher manageable crop yields. For satisfying the needs of the crop establishment and growth the reserve soil minerals and soil fertility not always sufficient. Soil acidity and alkalinity occurs some nutritional disorder in potato. In acid soils, there is a lack of calcium, magnesium and phosphorus for growing crop, and in alkaline there is lack of boron, manganese and zinc. The potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers at the unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium, as well as micro and elements (Fit Hangan, 2010) [14].

Zn play major role in proteins synthesis, enzyme activation and metabolism of carbohydrate, Utilization of fertilizers containing this element increase qualitative and quantitative performance of potato tubers, Due to shortage of Zn, performance and quality of potato will be decreased. Zinc exerts a great influence on basic plant life processes, such as (1) nitrogen metabolism, uptake of nitrogen and protein quality; (2) photosynthesis – chlorophyll synthesis, carbon anhydrate activity. Crops yield increases with manganese foliar applications due to increasing photosynthesis efficiency and synthesis of carbohydrates such as starch (Alloway, 2004) [2]. Manganese has an important metabolic role in nitrate – reducing enzyme activity and activation of enzyme involved in carbohydrate metabolism thus its deficiencies decrease photosynthesis and thereby reducing crops yield and quality (Malakouti and Tehrani, 1999; Diedrick, 2010) [24, 11]. Utilization of elements Zn and Mn together from source sulfate Zn and Mn increased efficiency and quality of potato crop (Kelling and Speth, 2001) [20]. Mohamadi (2000) [25] found that application of Zn along with Mn as foliar application caused increasing in efficiency and quality of potato crop. Zn plays main metabolic role in plants. This element partially interferes in most of the enzymes structures like, dehydrogenises, aldolase and isomerases, in production of energy in Krebs cycle (Alloway, 2004) [2]. Zinc is involved in hormone biosynthesis, cytoplasm synthesis, activation and function of different enzymes, protein synthesis etc

Low recovery of applied Zn is the main constraint in augmenting the yield of potato (Singh *et al.*, 2014), which signifies the importance of Zn in potato cultivation. Depending upon the duration of variety, potato crop is highly sensitive to Zn application. Zn fertilization has been found to increase ascorbic acid content, but it reduces the tyrosine and total phenol content in tubers and thereby improves the processing quality (Mondal *et al.*, 2015) [27].

Boron plays active role in protein synthesis during seed and cell wall formation. Boron also helps in water and nutrient transportation from root to shoot (Ziaeyan *et al*., 2009) [43]. Boron requirements differed widely among plant species toxicity and the concentration range between and deficiency was less for B than for any other nutrient. Excess boron adversely affected calcium uptake and plant growth (Abdulnour *et al.* 2000) [1].

Mn is also one of the main components in structure of enzymes involved in photosynthesis (Heckman, 2000, Alloway, 2004; Sayed *et al*, 2007) [2, 37].

Utilization of Zn and Mn in potato production causes, increase in number of tubers, mean tubers weight and results in high yield and quality (Iqbal, 1995; Mohamadi, 2000; Sayed *et al*, 2007) [37].

Foliar application of elements like Zn, Mn, Cu and Mn is better than direct application of them in soil due to removing nutrient shortage very fast, easy utilization, decrease poisonousness when gathering and prevention from stabilization of elements in soil (Sayed *et al*, 2007) [37].

Material and Method

The experiment was conducted at the College of Agriculture, Department of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalya, Gwalior, (M.P.) during Rabi 2018-19. The nursery of College of Agriculture, Gwalior is situated at 26º 13 N latitude and 78º 14' E longitudes at an altitude of 211.5 m above sea level in Gird belt (MLS). It has a subtropical climate where maximum temperature exceeds 45 °C in May-June. The minimum temperature reaches as low as 0.62 °C in December and January. Frost is expected from last week of December to first week of February. Usually monsoon arrives in the second fortnight of June and lasts till September. The meteorological parameter during the crop season such as minimum and maximum temperature (0.62°C and 35.3 °C), rainfall (mm), wind speed (km $hr.^{-1}$) and relative humidity (28.2% and 99.3%) were recorded at Meteorological Observatory; College of Agriculture, Gwalior (M. P.)

The experiment was laid out in Randomized Block Design (RBD) with three replications. Each replication consisted of 8 treatments. All the treatments were randomized separately in each replication. The variety Kufri Chipsona -1 of potato was used in the experiment.

Table 1: Treatments details

S. No.	Treatment	Dose per litre
T_1	Control	water spray
T_2	Boron	2g
T_3	Zinc	1g
T_4	Manganese	2g
T_5	Boron + Zinc	2g + 1g
T_6	Boron + Manganese	2g + 2g
T_7	Zinc + Manganese	1g + 2g
T_8	Boron + Zinc+ Manganese	2g + 1g + 2g

Healthy tubers with uniform size of 35-40 mm and about 45-50 g in weight were selected for sowing. Pre-planting seed treatment was done with Mancozeb 0.2% solution for 10 minutes and spread at a cool and moisture place to check fungal infection. Healthy, uniform and medium sized tubers were used for planting. The tubers were kept in furrows at a spacing of 60x 20cm and covered with soil using a ridger.

The planting was done in the morning to avoid heated up soil covering during mid-day in plains. Tubers were treated with carbendazim 50% WP, Mancozeb 75% WP, before sowing. Imidacloprid @4m /15 litre water was used to check the aphid population and to prevent the infestation of viral diseases in potato after planting. Mancozeb @25gm /15 litre of water is sprayed after tuber planting to check the infestation of late blight of potato. Tubers digging was done manually at maturity of crop from each treatment separately. Spraying of micronutrients was done with a Foot sprayer First and second spray were at done 30, 50 and 70 days respectively after planting of Potato.

Result

Plant height (cm)

30 days after sowing, the plant height was observed between 22.43 cm (T_1) and 26.17 cm (T_4). There was no significant difference between mean plant heights among different

treatments while, 60 days after sowing, the significantly maximum 55.23 cm mean plant height was recorded in treatment T_7 (Zinc + Manganese) followed by T_8 (54.40 cm) T_6 (54.23 cm) which were at par and 90 days after sowing, mean plant height was recorded significantly maximum (69.63 cm) in treatment T_8 (Boron + Zinc+ Manganese) followed by T_7 (68.23 cm) which were at par. T_6 (66.23 cm) followed T_7.

Number of leaves per plant
30 days after sowing, the mean number leaves per plant were observed between 8.0 (T_1) and 10.67 (T_5). There was no significant difference between mean number leaves per plant among different treatments while 60 days after sowing, mean number of leaves per plant were recorded significantly maximum (20.0) in treatment T_6 (Boron + Manganese) followed by T_8 (19.0) T_7 (18.67) which were at par and 90 days after sowing, the significantly maximum 24.33 mean number leaves per plant were observed in treatment T_8 (Boron + Zinc+ Manganese) followed by T_6 (24.0) and T_7 (22.0) which were at par.

Number of leaf length (cm)
30 days after sowing, the mean numbers of leaf lengths were observed between 3.53 cm (T_1) and 3.83 (T_3). There was no significant difference between mean numbers of leaf lengths among different treatments while 60 days after sowing, mean numbers of leaf lengths were recorded significantly maximum 5.60 cm in treatment T_8 (Boron + Zinc+ Manganese) followed by T_7 (5.50 cm) T_6 (5.20 cm) which were at par and 90 days after sowing, mean numbers of leaf lengths was observed in significantly maximum 7.1 cm treatment T_8 (Boron + Zinc+ Manganese) followed by T_7 (7 cm) and T_6 (6.7 cm) which were at par.

Stem diameter (cm)
30 days after sowing, the significantly maximum 3.87 cm mean stem diameter was recorded in treatment T_8 (Boron + Zinc+ Manganese) followed by T_7 (3.77 cm) which were at par. Next better treatment found to be T_6 (3.60 cm) while 60 days after sowing, mean stem diameter was recorded significantly maximum 4.03 cm treatment m T_8 (Boron + Zinc+ Manganese) followed by T_7 (3.97 cm) which were at par. Next better treatment found to be T_6 (3.80 cm) and 90 days after sowing, the significantly maximum 4.23 cm mean stem diameter was recorded in treatment T_8 (Boron + Zinc+ Manganese) followed by T_7 (4.17 cm) which were at par. Next better treatment found to be T_6 (4 cm).

Conclusion
Out of the 8 treatments tested in the present experiment, the treatments T_6 (Boron + Manganese), T_7 (Zinc + Manganese) and T_8 (Boron + Zinc+ Manganese) recorded highest plant height (cm), number of leaves, length of leaves and diameter of stem (cm).

Table 1: Effect of Foliar Application of Boron, Zinc and Manganese on Growth parameters of Potato

Tr. No.	Plant height (cm) at			Number of leaves/plant			Leaf length (cm)			Diameter of stem (cm) at		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	22.43	40.93	42.93	8.00	12.33	14.33	3.53	3.73	3.97	1.47	1.93	2.60
T_2	23.90	45.00	50.27	10.00	15.00	17.00	3.70	3.80	4.40	1.87	2.37	2.57
T_3	25.43	48.43	54.77	8.67	15.33	17.33	3.83	4.20	4.53	2.20	2.47	2.67
T_4	26.17	45.40	51.87	10.33	15.33	17.67	3.73	4.23	4.97	2.67	2.80	3.00
T_5	23.87	47.47	54.53	10.67	16.00	18.00	3.77	4.87	5.50	2.80	2.90	3.10
T_6	24.27	54.23	66.23	9.00	20.00	24.00	3.73	5.20	6.70	3.60	3.80	4.00
T_7	24.53	55.23	68.23	9.33	18.67	22.00	3.73	5.50	7.00	3.77	3.97	4.17
T_8	23.93	54.40	69.63	10.00	19.00	24.33	3.63	5.60	7.10	3.87	4.03	4.23
SEm±	0.8	0.59	0.68	0.69	0.83	0.99	0.10	0.03	0.08	0.06	0.06	0.06
C.D	NS	1.81	2.09	NS	2.54	3.04	NS	0.11	0.24	0.2	0.2	0.19

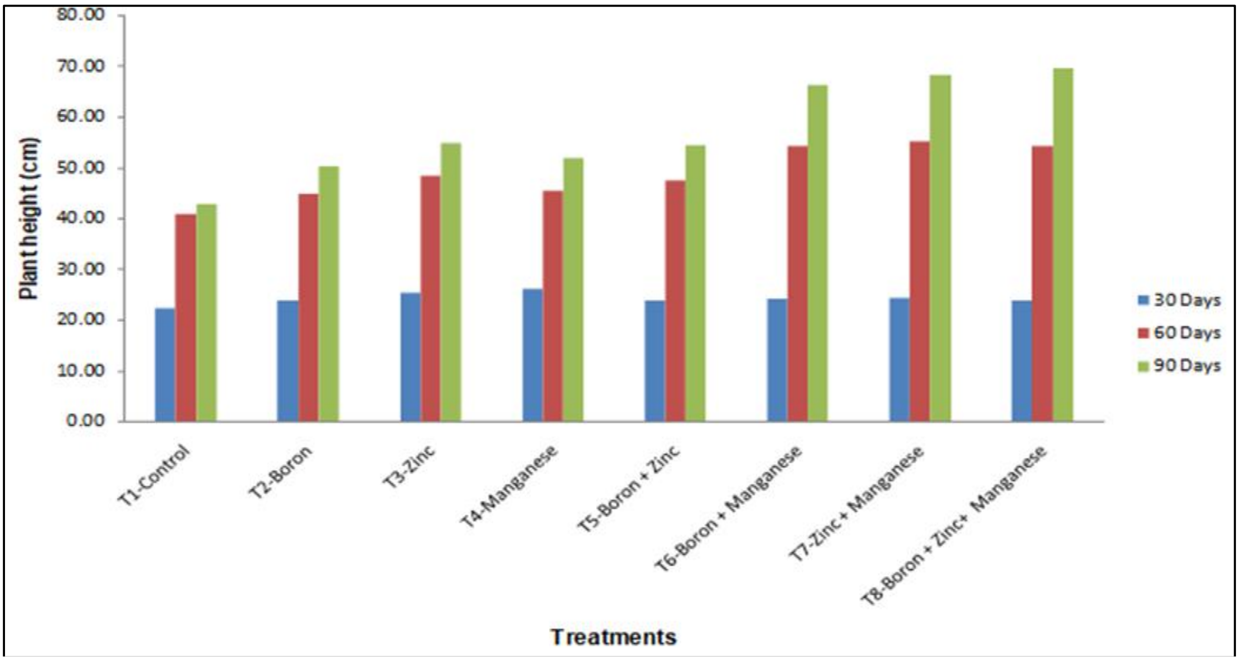

Fig 1: Effect of Foliar Application of Boron, Zinc and Manganese on plant height of Potato

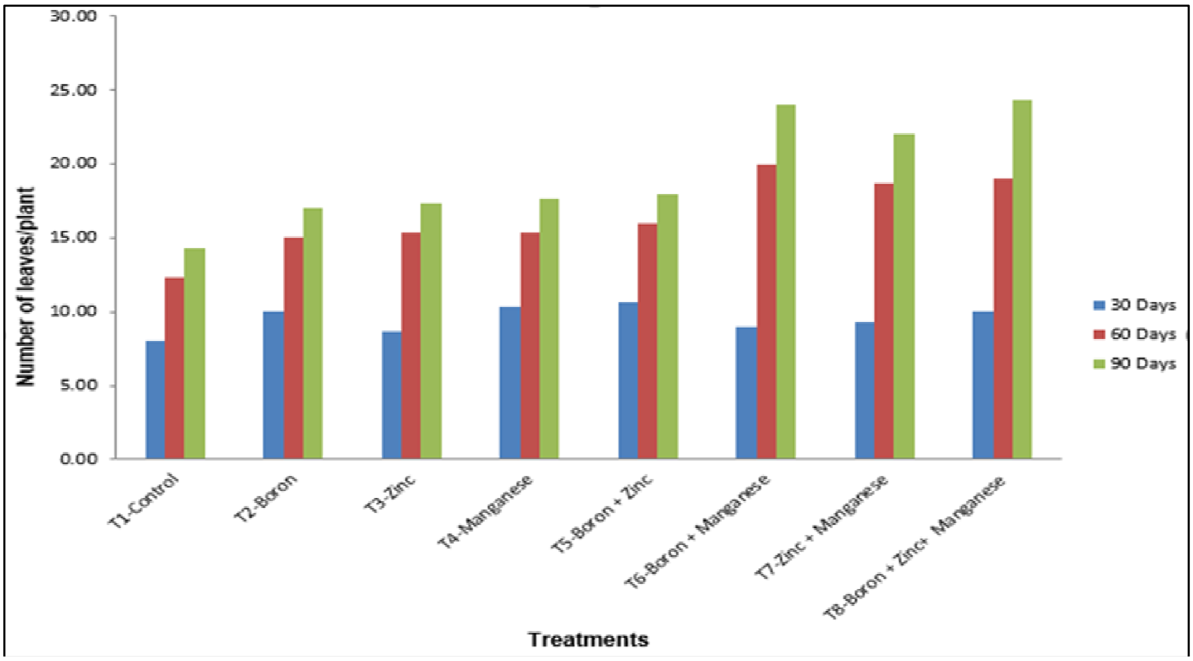

Fig 2: Effect of Foliar Application of Boron, Zinc and Manganese on number of leaves per plant of Potato

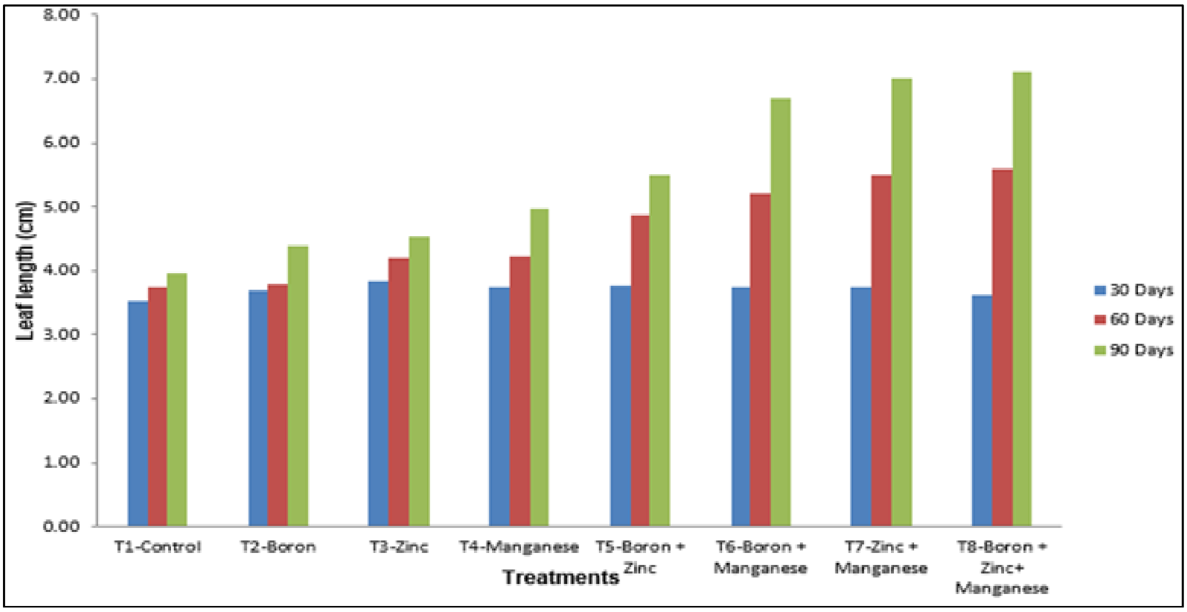

Fig 3: Effect of Foliar Application of Boron, Zinc and Manganese on leaf length of Potato

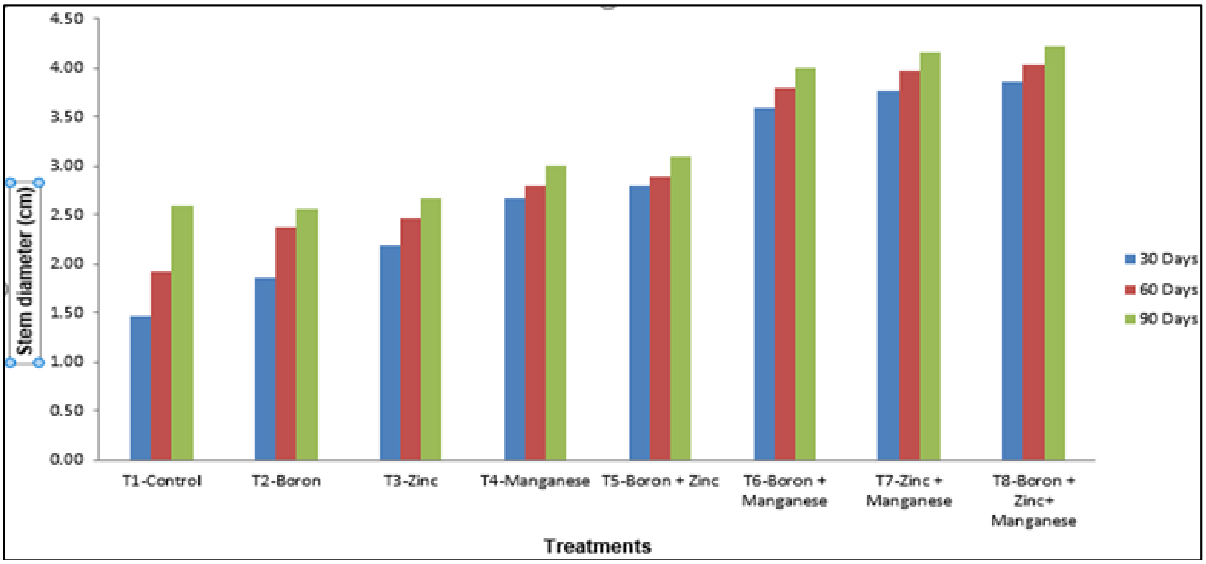

Fig 4: Effect of Foliar Application of Boron, Zinc and Manganese on stem diameter of Potato

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