Impact of applying boron, zinc, and manganese foliarly on the yield attributes and yield of the potato (*Solanum tuberosum*) cultivar Kufri Chipsona-1 in the Gwalior climate

ABSTRACT

The current study was conducted during Rabi 2018–19 at the All India Coordinated Research Project on Potato, which was located in the Department of Horticulture at Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalya, Gwalior (M.P.). The purpose of the experiment was to determine how different foliar treatment concentrations of boron, zinc, and manganese affected the production characteristics and yield of the potato variety Kufri Chipsona-1 in Gwalior climate conditions. Eight foliar spray treatments of micronutrients were included in the experiment. Three replications of each of these treatments were arranged in a Randomized Block Design. The application of zinc, manganese, and boron had a substantial impact on the yield characteristics and yield of potatoes, according to the data. In treatment T8 (Boron + Zinc + Manganese), the highest number of tubers (27.67/plant) and weights of tubers (680 g/plant) were noted. It is determined that using boron, zinc, and manganese would increase crop yields in potato farming under the climatic circumstances of Gwalior.

Keyword: Potato Kufri chipsona -1, Boron, Zinc, Manganese and yield.

1. INTRODUCTION

Throughout the Gird region of Madhya Pradesh, the area and production of potatoes are 111.06 thousand hectares and 2425 Mt, respectively. The area and production of potatoes throughout India are 2151 thousand hectares and 48237 Mt, respectively [1]. It holds the top spot among India's vegetable crops both in terms of acreage and output. It makes up 283 percent of all vegetable output [2].

Potatoes are rich in carbohydrates, fiber, and minerals. It has a protein level comparable to that of eggs and milk. Potatoes are considered protective foods because of their high level of lysine, one of the most important amino acids. Potatoes are a fantastic source of several essential minerals and vitamins, including potassium, phosphorus, manganese, magnesium, foliate, vitamin C, and vitamin B-6, in addition to fulfilling part of the daily energy needs of people [3]. Potatoes include one of the greatest quantities of protein and starch (1.21-2.00%), along with water (74.7–75.0%), sugar and starch (22.9%), fat (0.1%), minerals, and vitamins (0.6%) [4]. Because they yield more and provide more dry matter per unit area than other crops like cereals, potatoes are thought to be a crop that needs a lot of nutrients [5].

Because of its large production within a brief growing season, potatoes are regarded as a crop that requires a lot of nutrients. There are 17 basic components needed for plant growth and reproduction, and balanced nutrition is crucial for the healthy growth and development of crops [6]. Some nutrients—referred to as macronutrients—are needed in comparatively high quantities, whilst others—referred to as micronutrients—are needed in smaller amounts. Micronutrients are just as vital as macronutrients, while being utilized in lesser amounts. Of them, zinc and boron are essential for fruit growth and pollination. Controlling micronutrients is essential to producing potatoes well. The high pH soils might lead to deficits in some micronutrients. Micronutrients added to the soil or applied topically on sandy loam soils may have additional advantages for potato development when watered. The efficiency with which a particular micronutrient is used may also be increased by choosing an efficient application technique. Micronutrients are necessary for potato plants to yield at their best [7]. Certain minor plant nutrients, such as zinc and boron, may aid in the early phases of potato culture by expanding foliage; later on, assimilate translocation accounts for increased yield [8,9].

The efficiency with which macronutrients are used is increased by the presence of micronutrients. Micronutrients play a crucial role in the compost program designed to achieve more sustainable agricultural yields. The soil fertility and reserve minerals are not always enough to meet the demands of crop establishment and growth. Potatoes have various nutritional disorders due to soil acidity and alkalinity. For crops to flourish, alkaline soils require boron, manganese, and zinc, whereas acidic soils lack calcium, magnesium, and phosphorus. Because it produces a large amount of tubers per unit area and an extensive vegetative mass, potatoes are a plant with high nutritional needs. In addition to micro and elements, it is an excellent consumer of nitrogen, phosphorus, potassium, magnesium, and calcium [7,10,11,12].

Zinc is essential for the production of proteins, the activation of enzymes, and the metabolism of carbohydrates. When this element is used in fertilizers, potato tubers perform better both qualitatively and quantitatively. Potato performance and quality will suffer as a result of the zinc deficit. Zinc has a significant impact on two fundamental plant life processes: (1) nitrogen metabolism, nitrogen intake, and protein quality; and (2) photosynthesis, which includes carbon anhydride activity and chlorophyll synthesis. Because manganese enhances the efficiency of photosynthesis and the synthesis of carbohydrates like starch, manganese foliar treatments boost crop output [7,13]. Manganese deficiency inhibits photosynthesis, which lowers crop production and quality. Manganese also plays a significant metabolic role in nitrate metabolism by activating enzymes involved in glucose metabolism and decreasing enzyme activity [14, 15]. The efficiency and quality of the potato crop were enhanced by using elements Zn and Mn jointly from the source sulfate Zn and Mn [7,16]. [17] It was discovered that applying zinc and magnesium topically increased the yield and quality of the potato crop. In plants, zinc is essential for metabolism. This element partly disrupts the structures of most enzymes, including isomerases, dehydrogenases, and aldolases, which are involved in the Krebs cycle's energy generation [7,13]. Zinc has a role in the production of hormones, cytoplasm, proteins, and the activation and activity of several enzymes.

This illustrates how crucial zinc is to the growth of potatoes. Potato crop sensitivity to zinc administration varies greatly depending on variety length. Ascorbic acid concentration has been observed to rise with zinc fertilization, whereas tubers' tyrosine and total phenol levels have been found to decrease, improving the tubers' processing quality [18].

When seeds and cell walls are forming, boron actively participates in the creation of proteins. Additionally, borate aids in the movement of nutrients and water from the root to the shoot [19]. The range of concentrations between a shortage and a toxicity of boron varied greatly across plant species, and boron had the narrowest concentration range of any nutrient. Plant development and calcium absorption were negatively impacted by excess boron [20].

One of the primary elements in the structures of the enzymes involved in photosynthesis is also magnesium [21,13, 22]. When zinc and magnesium are used in potato cultivation, the number of tubers and their average weight rise, producing a high yield and excellent quality of potatoes [7,17, 23].

Applying elements such as zinc, manganese, copper, and magnesium topically rather than directly into the soil is preferable because it eliminates nutrient shortages quickly, facilitates simple usage, reduces toxicity during collection, and prevents soil-based element stability [22].

Yield and quality of potato depends upon micronutrient application,therefore, the present research by considering the above facts, carried out with the following objective:1) to test the effect of foliar application of boron, zinc and manganese on yield attributes 2) to study the effect of foliar application of boron, zinc and manganese on yield of potatounder Gwalior climatic conditions.

2 **MATERIAL AND METHODES**

2.1 Experimental Location and Climatic Conditions

The experiment was carried out in Rabi 2018–19 in the Department of Horticulture, College of Agriculture, Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalya, Gwalior (M.P.). In the Gird belt (MLS), the nursery of the College of Agriculture, Gwalior is located at 26o13 N latitude and 78o14' E longitude, 211.5 m above sea level. Its maximum temperature in May and June surpasses 45°C due to its subtropical climate. December and January saw the lowest temperatures. The last week of December through the first week of February is predicted to see frost. Typically, the monsoon season begins in the second week of June and lasts until September.

2.2 The trial field's soil

The experimental field's soil had a homogeneous contour and a texture of sandy clay loam. Using a soil auger, soil samples were randomly taken up to a depth of 20 cm from each plot in order to assess the textural class and fertility condition of the experimental area prior to seeding. To produce the primary samples, a composite soil sample was taken from each replication, and its physio-chemical characteristics were studied. Table 1 displays the information on the different physiochemical parameters.

Table 1:Physiochemical properties of soil collected from the experimental field.

S.No.	Composition	Content	Category
A. Mechanical composition			
1	Sand (%)	58	-
2	Silt (%)	19	-
3	Clay(%)	23	-
4	Textural class	-	sandy clay loam
B. Chemical composition			
S.No.	**Analysis**	**Values**	**Category**
1	Soil pH	7.6	Slightly alkaline
2	Electrical conductivity(dS/m)	0.32	Normal
3	Organic carbon(%)	0.45	Low
4	AvailableNitrogen(kg N /ha)	197	Low
5	Availablephosphorus(kg P_2O_5/ha)	19	Medium
6	Available potash(kgK_2O/ha)	241	Low

Table 2:Treatment and treatment application details

S.No.	Treatment (Application of)	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

The insecticide and micronutrient solution was made by adding the appropriate amount (Zinc: 1 g/L, Boron: 2 g/L, Manganese: 2 g/L, and Control: Water Spray) to a small container, quickly stirring with a stick, and then adding the appropriate combination of micronutrients according to treatments. To create the spray solution, these concentrate solutions were further diluted with clear water. It took two people to apply micronutrients using a foot sprayer. While the other held the sprayer's lance to spray the solution, one person controlled the foot sprayer's pedal. Thirty and forty-five days following potato planting, the first and second sprays were applied.

2.3 Crop rising technology

Two ploughs of the field were made using a tractor-drawn mould board plow. To level the plot, cross harrowing was done next, and then planking. In each plot, the recommended dosages of potassium, phosphorus, and nitrogen were administered in accordance with the protocols. MOP, DAP, and urea were used to provide the nutrients nitrogen, phosphorus, and potassium. The whole prescribed dosage of potassium and phosphorus were applied as basal at the time of planting, while the remaining half of the nitrogen dose was applied as basal and the remainder was administered during the first few days of earthing-up. For seeding, tubers that were in good health and had a consistent size of 35-40 mm and weighed around 45-50 g were chosen. To check for fungal infection, pre-planting seed treatment was applied with Mancozeb 0.2% solution for 10 minutes and dispersed in a cold, damp location. Medium-sized, consistent, and healthy tubers were used for planting. Using a ridger, the tubers were preserved in furrows spaced 60 x 20 cm apart and covered with dirt. In plains, planting is done in the morning to prevent the soil from being too hot by midday. Prior to seeding, tubers were treated with carbendazim 50% WP and Mancozeb 75% WP. After sowing, imidacloprid @ 4 m/15 litres of water was used to monitor the aphid population and stop viral infections from invading the potato. After tuber planting, mancozeb @25gm/15 liter of water is sprayed to check for late blight infection. Pre-irrigation was done before potato tuber planting, and four irrigations were then applied to raise moisture levels to optimal levels.

2.4 Observation recording methodologies

2.4.1 Number of tubers/plant

The total tubers obtained from each plant in each plot including 5 observation plants.

2.4.2 Weight of tubers/plant (g)

The average weight of tuber was calculated after the harvesting as per the formula given below;

Average weight of tuber = Total weight of tuber (g) / Number of tuber.

2.5 Statistical analysis

Data collected on several fronts were tallied and statistical analysis was performed using analysis of variance methods. 'F' test was used to determine treatment significance. Critical difference (CD) testing was performed at the 5% level of significance in order to determine if the "F" test accurately expressed the significant difference between the treatment mean values.

3 RESULTS AND DISCUSSION

3.1 Number of tubers/plant

Table 3 shows the average number of tubers/plant for each treatment. Significantly, treatment T8 (Boron + Zinc + Manganese) recorded the highest mean number of tubers/plant (26.77), with T7 (25) and T6 (22.33) being the next best treatments. Similar findings were supported by [22], who noted that higher tuber counts were associated with greater Zn and Mn usage due to fourth-level Zn8 (foliar application of Zn at 8 ppt) and third-level Mn4 (foliar application of Mn at 4 ppt) applications. According to [22], spraying Zn and Mn combined at 8 and 4 ppt resulted in the greatest number of tubers per plant, a 31% increase above the control. Furthermore, [24] reported that in both years and the pooled analysis over the years, treatment T7 (zinc sulphate @ 25 kg/ha at the time of planting + RDF) had the significantly highest total number of tubers per plant at 60 DAP (8.83, 10.17 and 9.63) and 75 DAP (9.83, 11.00 and 10.42). Zinc sulfate treatment enhanced the total number of tubers per plant of potato plants because zinc influences the hormonal condition of potato plants.

Table 3: Number of tubers/plant as influenced foliar application of of different micronutrients.

S. No.	Treatments	Number of tubers / plant
T_1	Control	13.00
T_2	Boron	17.00
T_3	Zinc	17.33
T_4	Manganese	17.33

T_5	Boron + Zinc	20.33
T_6	Boron + Manganese	22.33
T_7	Zinc + Manganese	25.00
T_8	Boron + Zinc+ Manganese	27.67
SEm±		0.6
C.D. at 5%		1.8

3.2 Weight of tubers/plant

Table 4 shows the mean weight of the tubers/plants recorded according to treatment and the mean value. The average weights of the plants and tubers were measured between T8 (680g) and T1 (283.3g). The data showed that T8 had the greatest mean weights of tubers and plants (680g), followed by T7 (626.67g). This result was consistent with [6,25, 26] who found that the time of application, Zn and Mn spraying separately and together, had an adverse effect on tuber yield per plant. The mean tuber yield per plant increased from (588.80g/plant) at T1 (nutrient free water spraying application) to (721.13g/plant) in T1 (Zn application), to (751.53 g/plant) in T2 (Mn application), and to (921.40 g/plant) in T3 (Zn + Mn application). However, the increase in mean tuber yield per plant T3 (56.49%) when compared to the mean tuber yield per plant of T1 had no significant effect on yield.

Table 4: Weight of tubers/plant as influenced by as influenced foliar application of of micronutrients

S. No.	**Treatments**	**Weight of tubers / plant (g)**
T_1	Control	283.33
T_2	Boron	330.00
T_3	Zinc	336.67
T_4	Manganese	353.33
T_5	Boron + Zinc	376.67
T_6	Boron + Manganese	596.67
T_7	Zinc + Manganese	626.67
T_8	Boron + Zinc+ Manganese	680.00
SEm±		5.85

C.D. at 5%	17.94

3.3 Tuber yield

Treatment-wise, the total yield of tubers per plot was recorded, and Table 5 shows the mean value. The average yield of tubers per plot was found to be 11.83 kg for T1 and 21.63 kg for T8. Data showed that T8 (21.63 kg/ha) and T7 (21.03 kg/ha) had the maximum tuber yield/plot, which is consistent with findings reported by [6, 22, 27]. They discovered that whereas spraying Zn and Mn alone raised the tuber yield by 7.2% and 5.2%, respectively, compared to control, applying Zn and Mn together boosted the tuber yield by 17%. However, there were no significant variations in the weight of unsalable tubers per plant for any of the examined cultivars or foliar Zn + Mn treatments in 2005/2006. In contrast, Zn + Mn foliar sprays did not significantly alter the weight of unmarketable tubers/plant among the evaluated cultivars in 2006–2007. Applying Zn + Mn foliar fertilizer once every two weeks was shown to reduce the amount of unmarketable tuber production per plant for all evaluated CVS. Between T1 (11.83 kg/ha) and T8 (21.63 kg/ha), the mean weights of the tubers per plot were noted. According to the data, T8 had the greatest mean weights of tubers per plot (21.63 kg/ha). T7 (21.03 kg/ha) is next. Next, T6 (19.57 kg/ha) was a superior treatment.

Table 5: Yield of tubers/ plot (kg) as influenced foliar application of micronutrients

S. No.	Treatments	Yield of tubers/ plot (kg/ha)
T_1	Control	11.83
T_2	Boron	16.40
T_3	Zinc	18.33
T_4	Manganese	18.00
T_5	Boron + Zinc	16.50
T_6	Boron + Manganese	19.57
T_7	Zinc + Manganese	21.03
T_8	Boron + Zinc+ Manganese	21.63
SEm±		0.46
C.D. at 5%		1.42

CONCLUSION

The current study was conducted as part of the All India Coordinated Research Project on Potato (*Solanum tuberosum*), which ran from Rabi 2018 to Rabi 2019, at the Department of Horticulture at the College of Agriculture, Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalya, Gwalior (M.P.).The purpose of the research was to examine how different zinc, manganese, and boron foliar spray dosages affected the yield metrics and yield features of potatoes (Cv. Kufri Chipsona 1) cultivated in climate-friendly environments. The application of boron, zinc, and manganese had a substantial effect on the production characteristics and yield of potatoes, according to the data. The greatest weights per plant (680 g plant-1) and most tubers per plant (27.67/plant) were discovered to be generated by treatment T8 (Boron + Zinc + Manganese). Among the investigated treatments, T8 exhibited the highest mean tuber output per plot (21.63 kg). Following the Boron + Zinc + Manganese treatment T8, the findings indicated that T8 had the highest B:C ratio (1.7), net profit (Rs 193541/ha), cost (Rs 193541/ha), and B:C ratio. Utilizing boron, zinc, and manganese has been shown to increase crop yield in potato cultivation in the Gwalior climate.

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