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Role of micronutrients in potato cultivation

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Abstract
Due to the wider adaptability, potato (*Solanum tuberosum* L.) is the single most popular vegetable-tuber crop grown in more than 150 countries in the world. Indian soils are not in condition to fulfill the requirement of all nutrients. Hence, the nutrients are supplied from the external sources. It is observed that the application of inorganic fertilizers along with micronutrients is considered essential to produce high tuber yield in case of potato. To improve the productivity, potato plant requires a balanced dose of NPK along with adequate amount of micronutrients like boron, copper, zinc and manganese. Therefore, the present review is designed to discuss the importance of various micronutrients.

Keywords: potato cultivation, inorganic fertilizers

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. India is now producing 43.77 million tonnes of potato tubers in an area about 2.13 million hectare (Zaheer and Akhtar 2016) [1]. 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. Potatoes produced in intensive management environments have high demand for plant nutrients. Producers must strive to enhance plant nutrient availability throughout the growing season. Potatoes take up approximately 40-50% of their nitrogen (N) and potassium (K) needs and about 30-40% of the phosphorus (P) and sulphur (S) requirements prior to tuber bulking (Westermann 2005) [2].
Indian agricultural production heavily depends on fertilizer application which results in greater rate of nutrient collapse and soil health problems (Patra *et al.* 2016) [3]. Nutrient management is made even more challenging due to nutrient leaching from relatively high irrigation rates required due to the combination of potato being grown commonly on sandy soils with low water holding capacity and extreme sensitivity to moisture stress (Barman *et al.* 2018) [4]. Most of the Indian soils are widely deficient in micronutrients especially Zn, Mn, B and Fe (Patel *et al.* 2015) [5]. 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 (Tripathi *et al.* 2015) [6]. Foliar application 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. Micronutrients like zinc and manganese also influences the protein and sugar content in potato tubers (Singh and Kathayat 2018) [7]. 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. Therefore, the present review is focused to investigate the influence of foliar supplementation of various micronutrients on quality and shelf life of the potato.

Effect of foliar application of boron
Boron (B) is a micronutrient necessary for plant growth. It plays an important roles in cell wall synthesis, sugar transport, cell division, cell development, auxin metabolism, good pollination

and fruit set, seed development, synthesis of amino acids and proteins, nodule formation in legumes and regulation of carbohydrate metabolism. Further, our soils having low organic matter content and high soil pH levels, many workers are in opinion that application of B in addition to essential major elements can play a good role in increasing the yield of potato (Dissoky and Abdel-Kadar, 2013) [8]. Its requirement is high after 45 days of crop emergence and remain high till crop maturity. It improves calcium absorption and stabilizes calcium in cell wall. Singh (2014) [9] recorded higher yield of tubers and increased tuber size with combined application of NPK and boron, which might be due to either direct or cumulative effect of supplied macro and micronutrients on metabolic activities of potato. This can also be partially explained by the fact that higher uptake of this nutrient in reproductive tissues results in increased metabolic activities by increasing RNA and DNA contents (Sathya 2009) [10], ultimately resulting in increased translocation of photosynthates from the source to sink tubers (Singh 2014) [9]. Moreover, foliar boron fertilization provided a continuous supply of plant nutrient for a longer period of crop growth or when required by the plants, which possibly facilitates a steady translocation of the photosynthates resulting in higher crop yield than soil application. Also, foliar applied micronutrient in readily available form, especially boron, faces less resistance as compared to the soil applied ones, which might have to compete with other antagonistic macronutrients phosphorus, to reach the absorption site of root in available form (Bhattacharyya 2015) [11]. In a study conducted by Sarkar *et al.* 2018 [12], it was found that application of recommended dose of fertilizer of NPK + 0.1% boric acid spray (thrice) exhibited its superiority by producing tubers with significantly higher specific gravity, total soluble solids, tuber hardness, total acidity, Vitamin C, protein and starch content with lowest phenol content and lighter chip colour.

Effect of foliar application of Copper

Late blight management in potato is heavily depends on fungicide application and in many areas the fungicide application has increased in many folds over the last decades due to the emergence of new and more aggressive races of the pathogen. The only effective fungicides currently permitted for blight control in organic agriculture are copper-based products (e.g. Bordeaux mixture, fixed-copper hydroxide, copper oxide and copper oxychloride) (Mizubuti *et al.* 2007) [13]. Copper ion (Cu^{2+}) is toxic to all cells because it reacts with sulfhydryl (-SH) of certain amino acids and cause denaturation of proteins and enzymes (Agrios 2005) [14]. Copper fungicides reliably work as contact fungicides if applied prophylactically, their environmental side effects during production (mining) of copper and also in the soil and especially towards aquatic environments are unacceptable (Alloway 1995) [15] in general and especially when considering organic principles. So the focus given to reduce the amount of copper, but the CuOH 500ppm alone was not reducing the blight severity in a significant level. But by incorporating other biomolecules or biocontrol agents such chitosan and Trichoderma along with copper it was reducing the disease as equal to mancozeb 2000ppm. In a previous study, the triple combinations of copper, chitosan and Trichoderma maintained a slow late bight disease progress with minimum disease severity as compared to single ingredients and dual combinations treatment (Sajeesh *et al.* 2016) [16].

Effect of foliar application of Manganese

Manganese (Mn) in turn, is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis. Manganese activates decarboxylase and dehydrogenase and is a constituent of complex PSII-protein, SOD and phosphatase. Several researches indicated a positive influence of Mousavi *et al.* (2007) [17] in their study reported that potato yield increased and storage dry matter improved by use of manganese and zinc. Hiller (1995) [18] and Walworth (1998) [19] in separate investigation reported that yield and quality of potato increased with foliar applications of micronutrients such as manganese. In a study conducted by Singh *et al.* 2018 [20], it is concluded that micronutrients (Zn and Mn) are very necessary to improve the yield and quality of potato tuber crop as depicted by positive resulted were obtained from foliar application of zinc and manganese sulphate on all plant characteristics relating to yield and quality of potato crop.

Effect of foliar application of Zinc

Zinc is an essential micronutrient for growth and development and is also a cofactor for approximately 300 enzymes involved in nearly all aspects of cell metabolism.Studies have shown potato mineralization with iron and zinc is heritable and therefore can be increased through breeding (Brown *et al.* 2011) [21]. In an another study, foliar application of yeast at the concentration of 5 g/l. combined with application of zinc at the concentration of 300 ppm gave the highest values of vegetative growth characters, improved tubers quality, increased the productivity of potato plants and marketable tubers percentage (Ahmed *et al.* 2011) [22]. Kelling and Speth (2001) [23] reported that utilization of elements like Zn and Mn together from resource sulfate Zn and Mn increased efficiency and quality of potato crop. The alternative approach is the application of these nutrients to plant leaves and stems through foliar fertilization. In this context, a recent study recommend foliar application of Zinc @ 30 ppm due to its contribution towards the increased superiority in yield and quality of potato cv. KufriPukhraj in the Punjab region (Singh *et al.* 2018) [24]. Mohamadi (2000) [25] found that application of Zn along with Mn foliar application caused increase in efficiency and quality of potato crop.Numerous studies separately have reported that utilization of Zn is increasing performance and quality of potato tubers (Ranjbar and Malakoty, 2000 [26]; Iqbal *et al.* 1995 [27]; Mondy *et al.* 1993 [28]). Foliar application of elements like Zn and Mn with high concentration is poisonous and with decreasing level of photosynthesis in plants performance will be less. It was observed in forth level of Mn. Foliar application of elements like Zn and Mn caused enrichment and addition concentration of elements like Zn and Mn and decline P concentration in potato tubers (Bybordy and Malakoty, 2001 [29]; Ranjbar and Malakoty, 2000 [26]).

Effect of foliar application of Iron

Fe deficiency is a widespread agricultural problem that decreases plant growth and crop yields (Mori, 1999) [30]. Results showed that Zn, Mn, Fe and Cu application increased all plant characteristics relating to yield components, yield and dry matter percentage of potato crop (Kamil *et al.* 2014) [31]. A recent study in Bolivia with two Andean potato cultivars receiving Fe sulphate (10 to 40 kg Fe ha^{-1}) applied to the soil before planting also resulted in unsuccessful

translocation of Fe to tubers (Gabriel *et al.* 2015) [32].

Conclusion

The application of micronutrients like Boron, Sulphur, Mn and Zinc has pivotal effect on different parameters of potato. In light of the reviews from different research groups, application of different micronutrients along with NPK is most appropriate nutrient management strategy for getting higher tuber yield, good quality of tuber and economic return.

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