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Souvik Kundu
Department of Horticulture
Lovely Professional University, Punjab, India

T Chamroy
Department of Horticulture
Lovely Professional University, Punjab, India

Corresponding Author:
Souvik Kundu
Department of Horticulture
Lovely Professional University, Punjab, India

Role of micro-nutrients in cole crops: A review

Souvik Kundu and T Chamroy

Abstract
Cole crops belong to the species *Brassica oleracea* at a primary level and those managed right now: cauliflower, Brussels sprouts, sprouting broccoli, kohl rabi, kale and three types of cabbage, red, white and savoy. These crops are cultivated mostly in winter season. Proper environmental condition, soil condition and climatic condition are needed for their proper growth and development. Plant nutrient is one of the most important factors for getting better return from any crop. Application of micronutrients with macronutrients in proper amount and ratio in an integrated manner led the plant to proper growth and development. Macro nutrients help to improve development and yield of cole crops because of the role of nitrogen, phosphorus and potassium on the meristematic action. While, boron, zinc, copper, chlorine, manganese, iron and molybdenum are fundamental micronutrients required in minute quantities, for ordinary plant development and improvement as micronutrients helps in plant metabolism, chlorophyll synthesis, nutrient regulation, reproductive growth, flower retention, fruit and seed development. Lacking of boron, zinc, manganese and molybdenum are extremely common in cole crops which causes a number of anatomical, physiological and natural changes. Considering these, the present review focus on the importance and function of micronutrients in cole crops production and for better understanding also gives a brief overview of some recent findings related to role of micronutrients in cole crops.

Keywords: Cole crops, deficiency, functions & micro nutrient

Introduction
In the ongoing past, there has been massive investment in agriculture both in broad public and private sectors with the desire that it would expand benefit of farmers, as well as upgrading business openings for the provincial poor, while at the same time giving consumers with great quality products. But the above expectations remain to a great extent unfulfilled because of a few research gaps. Effective utilization of micronutrients in agriculture is one of the research gaps.

The requirements of nutrient elements in comparatively small quantities than macronutrients are termed as micro or minor or trace elements. The applications of micronutrients in agriculture significantly improve the productivity of many crops (Tripathi *et al*., 2015) [15]. Micronutrients can massively boost horticultural crop yield and improve quality and shelf-life of horticulture produce after harvest. However their deficiencies may show several physiological disorders in crops as well as reduce the quantity and quality of the crops (Sharma and Kumar, 2016) [11]. Soil erosion, intensive cropping, nutrients leaching, liming of acid soil, improper fertilizer application including NPK and no replenishment are the causes of micronutrients deficiency in crops (Aske *et al*., 2017) [1]. On the other hand the use of excessive micronutrients can also be toxic to the crop as it stunted the growth. The aim behind this article is to highlight those areas where the effect of micronutrients has not been completely figured it out.

According to Stout (1962) [13], "If plants are thought of as biological machines, their bodies are built from macro-elements, their working parts comprise of proteins and enzymes revolving about N atoms then the 'Micronutrients' act as special lubricants required for a variety of energy transfer mechanisms within the plants". This announcement from a researcher, who was engaged in identification of Mo as basic micronutrient, succinctly depicts the significance of micronutrients in plant metabolism.

Micronutrients expect importance in horticultural crop production because of their capacity to: Improve quality, size, shading, taste and earliness, for enhancing their market value, improve input use proficiency of NPK manures and water, provide disease resistance, it helps in reducing dependence on plant protection chemicals, increase shelf-life of horticultural produce, it reduces wastage, Increase marketable yield as it prevents physiological disorders of crop, it enhances nutritional security by biofortification.

Micro nutrients in crop production

In the beginning, micronutrient deficiency was described as diseases. In this manner, their essentiality as supplements were affirmed and extraordinary strides were made in horticultural crop production by the utilization of micronutrients.

The cole crops are affected more due to deficiency of calcium, magnesium, manganese, boron, and molybdenum.

Calcium (Ca): Inadequacy inside the plant causes inward tipburn of cabbage and outside tipburn of cabbage, cauliflower, Brussels sprouts and also Chinese cabbage (Napa cabbage). There is adequate calcium for plant development and improvement in many soils. Notwithstanding, during respiring, dry climate plants develop quickly and adequate calcium doesn't arrive at the developing leaf tips, which accordingly led to tip burn. Calcium deficiency also may occur due to imbalance of nutrients in the soil including weather and soil nutrient conditions, such as low soil moisture, high humidity, high potash or high nitrogen and low pH (<6.5).

Magnesium (Mg): Lacking can occurs on those soils where pH level is very low. The deficiency is mainly show on cabbage and cauliflower. Due to being a mobile nutrient, Magnesium is moved inside the plants from older leaves to newly-formed leaves. So, the older leaves are suffered more due to deficiency and become mottled and yellow.

When the deficiency of magnesium is found after testing a soil then treat the soil with finely ground dolomitic limestone and lime. If crops are showing the symptoms of magnesium deficiency in between the growing seasons then apply 0.91 kg actual magnesium as 9.07 kg magnesium sulfate (Epsom salts)/acre with a foliar spray. If symptoms still remain then repeat it after 10 days.

Boron (B): Deficiency may occur in almost all cole crops. But in cauliflower hollow stems and dark colored water soaked spot on the head is the major problem due to the deficiency of boron. Hollow stem too happens in cabbage and broccoli. Boron is a highly soluble nutrient and it leaches rapidly from the soil. Due to carryover the toxicity of boron may occur to sensitive crops. Excess dose of boron to the soil also affects peas, beans, cucumber and small grains, if these are growing on the same season of cole crops.

To overcome boron deficiency the field should be treated with 1.36 kg to 1.81 kg of boron/acre and that is obtained from 13.61-18.14 kg borax or 6.80-9.07 kg Solubor followed by disc plough before planting. It can be applied by broadcasting after mixing with granular fertilizers. If additional boron is required then apply 0.14 kg boron/acre through 0.68 kg Solubor in 30 gallons of water as a foliar spary to foliage.

Manganese (Mn): Insufficiency in cole crops is as similar as magnesium deficiency but yellowing is occurred over the whole plant. Interveinal portion become light green to mottled-yellow, while veins are still green. At a higher pH level (>7.0), the soil can show the deficiency of manganese and the lower level of soil pH (<5.5) show the toxicity of manganese, although the symptoms will remain almost same in both cases.

To avoid toxicity the soil pH should be maintained as above 6.0. Due to immobility in the soil and its high fixation broadcasting of manganese is not enough to overcome the deficiency.

When deficiency of manganese is identified after soil test then apply 3.63-5.44 kg Mn/acre through 13.61-20.41 kg manganese sulfate in a band 2 inches below the seed or it can be applied as a sidedressing after plants are established. Foliar spray can also be done with 0.45-0.91 kg Mn through 1.81-3.63 kg manganese sulphate 3-4 weeks perior to transplanting or after cops got 6 inches height. If symptoms are still remain then repeat it in every 2 weeks.

Molybdenum (Mo): Insufficiency happens once in a while in cole crops, basically on low-pH soils. Cauliflower is highly susceptible to Mo deficiency. The deficiency symptoms are shown on newly mature leaves as these turns light green or slightly yellow. Leaves margins may also affected and die. Leaves are not expanding fully because of the condition called whiptail.

Apply 85.04 gram of sodium molybdate/acre through a foliar spray including a surfactant to overcome the deficiency in the field. A couple of applications can be effective to overcome the Mo deficiency.

Considering the above facts, the available research findings on “Role of micro-nutrients in cole crops” are reviewed as under:

Growth of cole crops influenced by micronutrients

Kanujia *et al.* (2006) [6] carried out a field examination to find out the impact of micronutrients (boron, manganese, iron, copper, molybdenum and zinc) on development and yield of cabbage var. 'Golden Acre' during rabi 2001 and kharif 2002. The investigation showed that the foliar use of Zn @ 100 ppm gave highest plant height during both the seasons, while most significant qualities for plant spread, number of leaves, head diameter were recorded with foliar application of blend of all micro nutrients @ 100 ppm during both the seasons.

Devi *et al.* (2012) [3] carried out an experiment to determine the enhancement of physiological efficiency of cabbage (*Brassica oleracea* var. capitata) using folier application of borax @0.1% solution. The growth of the crop e.g., height of the plant, leaf numbers, leaf length and fresh biomass production was influenced by the boron levels. The foliar application was done twice at 25 and 50 days in the days of transplanting (DAT). The result indicated that with the foliar spray of boron, the height of the plant, numbers of leaves and the head diameter was increased effectively.

Kumar *et al.* (2012) [7] carried out an experiment under Randomized Block Design with three replications during the rabi season of 2007-08. The observations were recorded on 11 characters *viz*. plant height (cm), no. of leaves/plant, weight of leaves/plant(g), length of leaves(cm), width of leaves(cm), weight of plant(kg), duration of curd maturity, curd diameter (cm), gross curd weight (kg), net curd weight and total yield(q/ha). Among all the treatments, best performance was obtained from application of a mixture of Boron 20kg + sodium molybdate 2 kg/ha and mixture of Boron, 100ppm + molybdenum, 50ppm.

Singh *et al.* (2017) [12] conducted a field experiment to determine the effect of various micronutrients on growth, yield and flower bud quality of broccoli (*Brassica oleracea* var. italica) cv. Green Bud. The trial was conducted under Randomized Block Design with three replication and 10 treatments *viz*, T_0 (control), T_1 (B), T_2 (Mo), T_3 (Mn), T_4 (B + Mo), T_5 (B+ Mn +Zn), T_6 (Mo +Mn), T_7 (B +Mo +Mn +Zn), T_8 (B +Zn), T_9 (Zn) at the rate of 2kg (B), 0.5 kg (Mo), 2.5 kg (Mn) and 3 kg (Zn) per hectare. Among these treatments, T_5 showed the best result like plant height (51.30 cm), plant

spread (52.83 cm), no of leaves (22.92), head diameter (16.90 cm). While the lowest were obtained from T_0.

In the year 2018 Hassan *et al.* [5] conducted a field experiment to find out the influence of micronutrient (boron) on the growth and yield of cauliflower. Maximum plant height (41.66 cm), Leaf number (19.35) and leaf area (182.51 cm^2) were obtained from the treatment B_3 (2 kg B/ha) while lowest (14.28 cm, 6.33 leaves & 121.85cm^2) were obtained from B_0 (control).

Yield of cole crops influenced by micronutrients

In the year 2006 Kanujia *et al*. [60] reported that maximum curd weight and head yield were recorded from the foliar application of Zn @100 ppm from the experiment effect of micronutrients on growth and yield of cabbage (*Brassica oleracea* var. capitata L.).

Umesh *et al.* (1980) [15] conducted a study under greenhouse to determine the effects of Mo applied as seed treatment and to the soil, and of lime on yield and Mo content of crops. The crops were alfalfa, timothy mixture, summer cabbage and a red clover- timothy mixture. Applied Mo effectively increased cabbage yield while forage yields were generally not affected. The tissue concentrations of Mo greater than 10 ppm were found in the treatments where germinating seeds were treated with a Mo preparation while the tissue the level of Mo concentration is 0.17 ppm in cabbage were suffered from Mo deficiency. The average tissue Mo concentration from 0.42 ppm at soil pH 5.1 to 1.84 ppm at pH 6.7 in the grass–legume mixtures significantly increased by the application of lime to the soil.

Saha *et al.* (2010) [10] conducted to determine the effect of foliar application of boron i.e., 0, 0.3% at 45 DAT and 0.3% at 30+45 DAT as borax and molybdenum i.e., 0, 0.05% at 45 DAT and 0.05%at 30+45 DAT as ammonium molybdate for expecting high yield with better quality of sprouting broccoli. Maximum yield per plant obtained from single application of ammonium molybdate @0.05% at 45 DAT. Whereas a better result were found in terms of total yield/plant, with the combined application of borax @0.3% at 30+45 DAT and ammonium molybdate @0.05% at 45 DAT than their individual application over the control.

In the year 2012 Devi *et al*. [3] carried out an experiment to determine the enhancement of physiological efficiency of cabbage (*Brassica oleracea* var. capitata) using folier application of borax @0.1% solution. By the twice foliar application of borax at 25 and 50 days significantly increased the shoot weight & dry weight, fresh root weight & dry weight and yield.

In the year 2017 Singh *et al.* [12] conducted an experiment to determine the effect of various micronutrients on yield of broccoli (*Brassica oleracea* var. italic) cv. Green bud. Among ten treatments maximum yield/ha (121.48 q), average head weight (303.69 gm), plant weight (908.28 gm), root weight (45.02 gm) and dry weight (11.65cgm) were obtained from T_5 (B+ Mn + Zn).

Pankaj *et al.* (2018) [8] conducted a field experiments to find out the effect of different micronutrient on vegetative growth of broccoli (*Brassica oleracea* var. Italica) cv. Green Magic. The maximum bud diameter 18.02 cm was obtained from T_5 (B+ Mn+ Zn) followed by 16.22 cm in T_8 (B+Zn) and 16.87 cm in T_7 (B+Mo+Mn+Zn). The maximum bud weight 511.50 gm was obtained from T_5 (B+Mn+Zn) followed by 343.00 gm in T_7 (B+Mo+Mn+Zn). Whereas, the lowest bud weight was obtained from T_0 (control). Maximum number of frouds was obtained from T_5 (B+ Mn+ Zn) followed by T_4 and minimum were obtained from T_0 (control). The highest yield/ha was obtained from T_5 (138.58 q/ha) followed by T_7 (116.23 q/ha) and the lowest was obtained from T_0 (72.98 q/ha). The yield of treatment T_2 (Mo) and T_3 (Mn) was showed almost same.

Hassan *et al.* (2018) [5] conducted a field experiment to find out the influence of micronutrient (boron) on the growth and yield of cauliflower with four treatments of boron *viz*., B_0 (Control), B_1 (1 kg/ha), B_2 (1.5 kg/ha), B_3 (2 kg/ha) in a completely Randomized Block Design with three replications. Results showed that maximum curd weight (698.20 g), curd weight with leaves (1.56 kg), 50% curd initiation (47.23 days), curd yield/plot (1.53 kg) and curd yield/ha (15.30 t) at harvest was recorded from the treatment B_3 while lowest was (418.60 g, 1.07 kg, 48.44 days, 1.05 kg, 10.49 ton/ha respectively) was obtained from B_0 (control). Therefore, result showed that application of micronutrient (Boron) at 2 kg/ha with recommended fertilizer will successfully improve the growth and yield of cauliflower.

Quality of cole crops influenced by micronutrients

In the year 2010 Saha *et al.* [10] conducted an experiment to determine the effect of foliar application of boron on sprouting broccoli. Maximum concentration of ascorbic acid and chlorophyll content of head obtained from single application of ammonium molybdate @0.05% at 45 DAT. Whereas a better result were found in terms of ascorbic acid and head chlorophyll content with the combined application of borax @0.3% at 30+45 DAT and ammonium molybdate @0.05% at 45 DAT than their individual application over the control.

Gad *et al.* (2011) [4] was conducted two experiments including a greenhouse experiment and a field experiment to see the effectiveness of cobalt on the growth and yield of broccoli using different levels of cobalt concentrations. They found that the growth, head yield and quality of broccoli effectively increased by adding of 6ppm cobalt. With the increasing of cobalt application the concentration of Mn, Zn and Cu also increased within head. On the other hand, the concentration of N, P, & K also increased by increasing the cobalt rate at 6 ppm, but further increasing in cobalt concentration leds to decreasing the level of N, P, & K within broccoli heads.

Thapa *et al.* (2016) [14] attempted to find out the growth, yield, and quality of broccoli with four levels of boron (0,15,18 and 21 kg/ha) and molybdenum (0,1.2,1.5 and 1.8 kg/ha). Biometric perceptions were recorded from the chosen plant from each plot and every replication of both the years. It was concluded from the results that under favorable agro-climatic conditions, the growth, yield and quality of broccoli was found beneficial by the application of 18 kg borax and 1.8 kg ammonium molybdate/ha.

In the year 2017 Singh *et al.* [12] conducted an experiment to determine the effect of various micronutrients on yield of broccoli (*Brassica oleracea* var. italic) cv. Green bud. Among ten treatments maximum concentration of vitamin C (93.92 mg), TSS (8.37^{0}Brix) obtained from T_5 (B + Mn + Zn).

Pankaj *et al.* (2018) [8] conducted a field experiment to study the effect of different micronutrient on plant quality of broccoli. Results showed that the maximum T.S.S (^{0}Brix) value was obtained from T_5 (B + Mn + Zn) 8.80 ^{0}Brix, followed by T_9 (Zn) with 7.90 ^{0}Brix. The lowest T.S.S (^{0}Brix) value was recorded in T_0 (control) 6.45 ^{0}Brix. The maximum vitamin 'C' 94.80 mg/100gm was obtained from T_5 (B + Mn + Zn) followed by T_6 (Mo + Mn) with 88.73 mg. The lowest vitamin C was found in case of T_0 (control) 79.02 followed by T_2 (Mo) with (82.23 mg). The four micronutrients B, Mo, Mn

and Zn were applied @ of (3:0.5:2:2.5 kg/ha) which shows significantly increase in vitamin 'C' (94.80 mg/100g), TSS (8.80 ^{0}Brix) during research.

Economics of cole crops influenced by micronutrients

Choudhary *et al.* (2012) [2] led an investigation to assess the impact of various organic and inorganic sources on the growth, yield, quality and financial aspects of sprouting broccoli under semi-arid condition of Rajasthan. The result showed that the maximum growth, yield and quality properties were obtained from the combine treatment of vermi-compost @ 5.0 t/ha and 125% RDF (NPK, 100, 80 and 60 kg/ha), which was similar with the combine application of poultry manure @ 5.0 t/ha and 100% RDF. The maximum net return and B:C ratio (4.09) also recorded from the combine application of vermicompost @ 5.0 t/ha and 125% RDF that the other treatments.

Conclusion

Micronutrients play an essential role on growth and development of cole crops as a minor mineral. Its deficiency can cause many physiological disorders to the plants. Micronutrients also help to increase the yield and quality of the crop.

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