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Essentiality of Micronutrients in Flower Crops: A Review.

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Review Article

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ABSTRACT

Proper plant nutrition is essential for successful production of floricultural crops in open and also under protected conditions. Quality is one of the most important characters in the cut flower industry and this is influenced by application of nutrients. To reach out the competitive export and domestic markets, quality plays a vital role. Integrated supply of micronutrients with macronutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth in flower crops. Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients, and we will focus here only on those elements that are generally accepted as essential for all higher plants: boron (B), chloride (Cl), Copper (Cu), iron (Fe), Zinc (Zn), manganese (Mn), molybdenum (Mo) and Nickel (Ni). In this review, we focus on the major functions of mineral micronutrients in flower production.

INTRODUCTION

Flowers are an integral part of human civilization and culture. Floriculture is the art and knowledge of growing flowers to perfection. Floriculture is a fast emerging and highly competitive industry. The importance of micronutrients in Indian agriculture is truly well recognized and their use had significantly contributed to the increased productivity of several crops. The nutrient elements which are required comparatively in small quantities are called as *micro or minor nutrients* or trace elements. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. In the past, there was no need of micronutrients because these trace elements were naturally supplied by soil. But due to intensive cultivation, increase in salinity and soil pH in most of soils, these nutrients are present but are not available to plants [1]. Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application for good growth and yield of crops and maximizing the efficient use of applied N, P and K. In the absence of these micronutrients, the plants are known to suffer from physiological disorders which eventually lead to imbalanced growth and low yield. The role of micronutrients in various metabolic processes and the enzymes involved in these processes has been reported by Zende [43].

Micronutrients are involved in all metabolic and cellular functions. Plants differ in their need for micronutrients; boron (B), iron (Fe), zinc (Zn), copper (Cu), chloride (Cl), manganese (Mn), molybdenum (Mo) and nickel (Ni). These elements are active that makes them essential as catalytically active cofactors of enzymes, others have enzyme-activating functions, and yet others fulfill a structural role in stabilizing proteins. Improvement in growth characters due to micronutrient application might basically be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation as opined by Hatwar et al. [15].

Nowadays, micronutrients are gradually gaining momentum among the flower growers because of their beneficial nutritional support and at the same time ensure better harvest and returns. The concept of insurance application of micronutrients may be economically utilized in the flower crops, particularly where the needs of crop has not been determined. The demand for increasing flower production will require a thorough knowledge on the relationship between micronutrients and crop growth. The available information regarding the impact of micronutrients on flower crops is scanty. Based on this background, the present review was compiled to study the role of micronutrients and its effect on different flower crops.

Essentiality of zinc

Zinc, as a micronutrient, had undoubtedly attracted maximum amount of attention since early 1960's. The essentiality of zinc for the growth has been reported by Raulin as early as 1863 [37]. Zinc is indispensable for proper growth and development of plants. Zinc is effective in plant nutrition for the synthesis of plant hormones and balancing intake of P and K inside the plant cells.

Zinc deficiency in plants resulted in stunted growth, little leaf and fruit sizes which are attributed to altered IAA metabolism [22]. Application of zinc was found to increase the green pigments of necrotic leaf of plants [34].

Zinc is important as a component of enzymes for protein synthesis and energy production and maintains the structural integrity of biomembranes. Zinc plays an important role in seed development and zinc-deficient plants show delayed maturity. Zinc is required for the synthesis of auxin IAA and for carbohydrate metabolism, protein synthesis, internode elongation for stem growth and in pollen formation [32]. Zn^{2+} ions at low concentration (0.01 ppm) slightly enhance the activity of tryptophan synthesis leading to biosynthesis of auxin [16].

Effect of zinc on flower crops

Misra [23] indicated that soil application of zinc sulphate at 2.5 g m^{-2} significantly increased the plant height, number of branches per plant, flower life and flower yield in chrysanthemum. Soil application of zinc at 20 kg per hectare increased the spike length, rachis length, number of florets per spike and number of bulbs per plant in tuberose cv. Double [41]. Hardeep kumar et al. [13,14] observed that application of nitrogen at 150 to 200 ppm + 7.5 ppm zinc had improved the growth parameters and number of florets per spike in tuberose cv. Double. They also found that increased spike length and increase in chlorophyll content at the same concentration. In gladiolus cv. 'Friendship', foliar spray of zinc sulphate at 0.6 per cent increased the plant height, spike length, number of florets per spike, number of corms and cormels per plant as reported by Sharma et al. [31]. Jauhari et al. [17] found that foliar spray of zinc sulphate at 0.2 per cent recorded maximum plant height, spike length, number of florets per spike and corms yield per m^2. Corm yield per square metre was maximum with the application of zinc sulphate at 0.4 per cent. It was also observed that higher concentration of zinc sulphate (beyond 4 per cent) had negative effects on plant growth, flowering and corm yield, revealing that 0.4 per cent zinc sulphate is the optimum concentration in gladiolus for better performance. Ganga et al. [10] indicated that foliar spray of zinc sulphate at 0.4 percent to increase in the flower yield per plant and total yield per hectare than other treatments in chrysanthemum cv. Co1. Naveen Kumar et al. [27] reported in chrysanthemum that zinc sulphate at 0.6 per cent recorded the maximum stem length against control.

Essentiality of boron

Boron has been known to be a constituent of plants since 1857 [36]. According to Truog ([39], the importance of boron is spelt as follows, '....*plants will not make growth without boron any more than....without phosphorus or potassium which they require in considerable amounts*'. As rightly pointed out by Truog [39], no crop can reach its full potential without minute but adequate supply of boron. Several disorders in horticultural crops are found to be due to boron deficiency. Boron is essential for plant growth, new cell division in meristematic tissue, translocation of sugar, starch, nitrogen, phosphorus, certain hormones, synthesis of amino acids and protein, regulations of carbohydrate metabolism, development of phloem etc. In the absence of adequate supply, middle lamella of new cell develops poorly and phloem tubes break down [9].

The primary role of boron in plants is to improve Ca metabolism and improved solubility and mobility of Ca and helps the absorption of nitrogen. It involves in metabolism and transport of carbohydrates, regulation of meristematic tissue cell synthesis, lignifications, growth regulatory metabolism, phenol metabolism and integrity of membranes, root elongation, DNA synthesis, pollen formation and pollination [32]. Increased boron applications may promote root elongation in acidic and high-aluminium soils [5].

Effect of boron on flower crops

Boron, the non-metal compound plays an essential role in the growth and development of new cells in the plant meristem. Boron is a micronutrient of special importance because of its role in the fertilization and flowering process. It has been known to be constituent of plants since 1857. The essentiality of boron as it affects the growth of maize was first reported in France. The function of boron in plant remained obscure prior to the mid 1950's. Facilitating pollination and fruit set is considered to be the most important function of boron besides its role in the synthesis of amino acids and protein metabolism. Boron increases the translocation of sugar in plants and increases the rate of transport of sugars (which are produced by photosynthesis in mature plant leaves) to actively growing regions. It is essential to maintain the structural integrity of plant membranes along with calcium and is involved in nucleic acid metabolism. It improves the solubility and mobility of calcium in plants and regulates the carbohydrate metabolism, besides helping in the absorption of nitrogen. Boron is an essential element found in the meristematic regions of plants such as root tips, emerging leaves and buds. Generally the concentration of boron in plants is comparatively higher in flower, anthers, ovary and stigma.

Jawaharlal et al. [18] reported that calyx split in carnation can be controlled by applying balanced nutrients and avoiding over fertilization as well as ensuring temperature control. In fertigation scheduling, boron can be added @ 1.0 g/ m^2/ week. Also opined that foliar application of 0.1 per cent borax at fortnightly intervals till flower bud initiation and at weekly intervals thereafter could considerably reduced calyx splitting and enhance the yield and quality of flowers. The percentage of reduction over untreated plants is 32.63. In commercial carnation cultivation, it is essential to meet out the boron requirements of plants by application of the nutrient at appropriate levels, so as to prevent economic losses due to physiological disorders such as calyx split and flower malformation.

In chrysanthemum, Misra [23] observed that soil application of borax at the rate of 1.5 g per m^2 significantly increased the plant height, days to flower bud opening, number of flowers, flower weight and yield, but Zn and B interaction did not have any effect on other parameters. In tuberose, Nath and Biswas [26] reported that foliar application of boron 100 ppm twice at monthly interval produced the maximum height of plant and increased the number of leaves per clump resulting in improved yield of spikes per plot. Rajput et al. [28] in *Tagetus minuta*, observed that application of boron individually or in combination with zinc and sulphur increased the plant height and fresh weight of plant significantly over the control. Individual application of boron increased the dry matter yield significantly by 69.8 per cent and 71.1 per cent over the control.

Essentiality of iron

As a constituent of various enzymes, iron plays the part of a vital catalyst in plant. Iron act as catalyst in synthesis of chlorophyll molecule and helps on the absorption of other elements. It is a key element in various redox reactions of respiration, photosynthesis and reduction of nitrates and sulphates [40,42]. Iron deficiency is common in alkaline soil with typical chlorosis; the young leaves turning yellowish with veins remaining green. Iron application increased the levels of all leaf pigments, but the extent of increase in level depend on the pigment affected [34].

Iron is also of great importance for life of plant. As redox-active metal, it is involved in photosynthesis, mitochondrial respiration, nitrogen assimilation, hormone biosynthesis (ethylene, gibberellic acid, jasmonic acid), production and scavenging of reactive oxygen species, osmoprotection and pathogen defense [12].

Effect of iron on flower crops

Singh and Bhattacharjee [33] reported in rose that the foliar spray of 2 per cent ferrous sulphate was best for promoting early flowering and increased flower diameter and longevity. In China aster cv. 'Powder Puff', Deshmukh and Wavhal [8] revealed the positive effect of iron at 0.3 per cent on plant height and plant spread. Timothy et al. (2004) reported on the phyto toxicity of iron fertilizers like Fe EDTA and Fe DTPA in marigold and seed geranium. In gladiolus, Foliar spraying of ferrous sulphate at 0.6 per cent in gladiolus cv. 'Trader Horn' recorded the maximum plant height, increased number of florets per spike, extended flowering duration and marked increase in corm yield which was reported by Rao [29]. In Chrysanthemum cv. Co1. Naveenkumar et al. [27] reported that foliar application of ferrous sulphate at 0.8 per cent recorded longest flowering duration and maximum flower yield over the control in chrysanthemum.

Jeyakumar and Balamohan [19] reported that in Jasmine, the foliage will exhibit interveinal chlorosis as a result of iron deficiency in the soil. When the plant is infested with nematodes, availability of iron and other nutrients by translocation to the plant tissues is hampered due to blockage of vascular bundles. The leaves show faded yellow colouration; the growth of the plant is stunted which may eventually lead to the wilting of the entire plant. The flower yield will be substantially reduced. Iron chlorosis is a common occurrence in jasmine as many of the areas where it is widely grown has been infested with nematode. After one week, foliar application of 500 g of ferrous sulphate and 100g of urea along with 100 ml of soap solution mixed in 100 litre of water is done two to three times at 20 days interval depending upon the extent of severity.

Effect of combination of micronutrients in flower crops

In several studies to overcome deficiency of more than one micronutrient and to improve balanced application, combination sprays of micronutrients have been successfully resorted. In gerbera, higher flower yield per plant, increased flower diameter and plant height was obtained with foliar feeding of plants with ferrous sulphate + zinc sulphate + manganese sulphate at the rate of 0.2 per cent each [25]. Senthamizh Selvi [30] observed that combined application of 4 g of zinc sulphate and 8 g of ferrous sulphate per plant through soil and 0.5 per cent of zinc sulphate and 1 per cent of ferrous sulphate through foliage during the months of December and June exerted significant influence on plant height, number of shoots, plant spread and leaf area in *Jasminum sambac*.

Balakrishnan [3] studied that foliar application of 0.5 per cent zinc sulphate + 0.5 per cent ferrous sulphate sprayed at 30 and 45 days after planting in marigold significantly increased plant height, stem girth, plant spread, number of branches per plant and dry matter production over the check. In gladiolus, combined soil application of boron at 2 kg and zinc at 4.5 kg significantly increased the plant height, length of spike and floral characters like floret number and floret size [11]. In the same experiment also he reported that interaction of B and Zn significantly improved the characters like corm weight and number of cormels and weight of cormels per plant than the other treatments.

In rose, plant height, number of leaves branch^{-1}, leaf area, number of flowers plant^{-1}, flower stalk length and leaf Zn contents were maximum with B + Zn application followed by only B application which also resulted early flower production as compared to rest of the treatments while bud diameter, flower diameter, as well as fresh & dry weight of flowers were maximum with B application alone [1].

Essentiality of Molybdenum (Mo)

Arnon and Stout [2] demonstrated for the first time that molybdenum is essential for higher plants. The essentiality of molybdenum for plant growth can be understood from the expression of Stout [2] as '……*a gram of molybdenum may harness more energy, through greater conversion of sunlight into plant materials, than can be obtained from a gram of uranium…'.* Molybdenum is required for the assimilation of nitrates, as well as, for the fixation of atmospheric nitrogen. Low and adequate levels of molybdenum had a positive effect on carotenoid formation [34]. Molybdenum functions in the enzyme nitrate reductase which is responsible for reduction of nitrate to nitrite during N assimilation in plants. Although molybdenum deficiency is observed in many soils and pasture legumes, vegetables and occasionally fruits, it is very rare in flower crops.

Essentiality of Manganese (Mn)

Manganese is necessary for chlorophyll formation for photosynthesis, respiration, nitrate assimilation and for the activity of several enzymes. The concentration of manganese in leaves can range widely from 10-15ppm when deficient and in thousand ppm when it is toxic. Manganese is only moderately mobile in plant tissues so symptoms appear on younger leaves first, most often in those leaves just reaching their full size.

Manganese availability is reduced in high pH calcareous soils but is often very high in the acid soil commonly chosen for tropical fruit production. Over liming of the soils particularly well drained, poor, coastal sandy soils can induce deficiency. Manganese deficiency causes a light green mottle between the main veins. A dark green band is left bordering the main veins while the interveinal chlorotic areas become pale green or dull yellowish colour. Soil application of manganese can be ineffective due to immobilization especially in heavier soils or soils which have been over limed. Two to three sprays of 0.1 % manganese sulphate can be recommended.

Essentiality of Chlorine

Chlorine is known to exist more in more than 130 organic compounds in plants. Most soils contain sufficient levels of chlorine. However, chlorine deficiencies have been described in sandy soils in high rainfall areas or could be created artificially in experiments to prove its requirements as a micronutrient for higher plants [6]. Chlorine indirectly affects the plant growth by stomatal regulation. Mortazavi et al. [24] reported that Calcium chloride significantly improved relative water content and solution uptake, as well as longevity and electrolyte leakage but to a lesser extent.

Essentiality of copper

Copper is of utmost importance for life. Copper is essential for photosynthesis and mitochondrial respiration, for carbon and nitrogen metabolism, for oxidative stress protection, and is required for cell wall synthesis, to name only a few of its cellular tasks. Li [21] reported that application of single copper fertilizer promoted flower yields of medicinal *Chrysanthemum morifolium* increasing with proper fertilization of copper (0.4 mg/kg). Likewise, it increased the contents of total flavonoids, chlorogenic acids and the two flavone ingredients (cyanidenon and versulin) and improves quality. Applying copper could improve the copper content in flowers for medicinal *Chrysanthemum morifolium*. Copper centralized in roots of medicinal *Chrysanthemum morifolium*.

Sources of Micronutrients in Soils

Inorganic micronutrients occur naturally in soil minerals. The parent material from which the soil developed and soil forming processes determine what the micronutrient content of the soil will be. As minerals break down during soil formation, micronutrients are gradually released in a form that is available to plants. Two sources of readily available micronutrients exist in soil: nutrients that are adsorbed onto soil colloids (very small soil particles) and nutrients that are in the form of salts dissolved in the soil solution. Organic matter is an important secondary source of some micronutrients. Most micronutrients are held tightly in complex organic compounds and may not be readily available to plants. However, they can be an important source of micronutrients when they are slowly released into a plant and is in available form as organic matter decomposes.

SUMMARY

Micronutrients are as important as the primary and secondary nutrients in plant nutrition. However, the amounts of micronutrients required for optimum nutrition are much lower. Micronutrient deficiencies are widespread because of increased nutrient demands from the more intensive cropping practices. Soil tests and plant analyses are excellent diagnostic tools to monitor the micronutrient status of soils and crops. Visual deficiency symptoms of these nutrients are also well recognized in most economic crops. Micronutrient recommendations are based on soil and plant tissue analyses, the type of crop and expected yield, management

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level, and research results. Numerous micronutrient fertilizers are on the market. These sources are classified as inorganic, synthetic chelates, natural organic complexes, and fritted glasses. Some industrial by-products are used as micronutrient fertilizers because of their lower cost. Micronutrient sources vary considerably in physical form, chemical reactivity, cost and relative availability to plants. While most micronutrient fertilizers are applied to soils, foliar sprays also are used on tree crops and some vegetables. Because recommended rates usually are low, most micronutrients are applied with NPK fertilizers by incorporation during manufacture or bulk blending with granular fertilizers, or by mixing with fluid fertilizers just before application to soil. Choice of micronutrient source depends on the method of application, compatibility with the NPK fertilizer, convenience of application and the relative agronomic effectiveness and cost per unit of micronutrient.

CONCLUSION

The need for micronutrients in flower production has long been recognized in India. It is important to keep the need for micronutrient fertilizers in perspective. Over-promotion of micronutrients has occurred on occasions. Some farmers have applied micronutrients in the hope of increasing crop yields even though there is little evidence to suggest a deficiency exists. Farmers who are concerned about micronutrient deficiencies are encouraged to investigate the need thoroughly and apply the nutrients in test strips if necessary. The test strip areas must be carefully marked out for comparison to areas where micronutrients were not used. Visual and qualitative comparisons should be made on these test strips.

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