Ixora a flower crop –Boon for Sodic soil farmers –To be addressed for Micronutrient deficiencies

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ABSTRACT

Ixora a flower crop growing well under sodic soils and is prized in tropical settings for its lush foliage, spectacular flowers, and ease of maintenance. They are highly preferred in gardens for their evergreen foliage and clusters of blooms in a variety of colors. Only a few of the more than 400 varieties of *Ixora* are planted as landscape plants. It has also gained momentum in recent times for its commercial value as a loose flower. Though *Ixora* prefers to grow in acidic soils, can survive under sodic soils and requires adequate micronutrients for good vegetative growth as well as quality flowering. The importance of micronutrients in Indian agriculture is truly well recognized and their use had significantly contributed to the increased productivity of several crops. Use of high yielding varieties and other management practices aimed at higher production from unit area involves a high application rate of nutrients. In Tamil Nadu, particularly in the districts of Karur, Tiruchirappalli, and Dindigul, *Ixora* is grown commercially as a loose flower. The flowers are used for religious offerings and floral decorations as loose flowers as well as value added goods such as garlands in combination with other flowers. Hence, judicious use of micronutrients is an essential aspect for yield and quality of Ixora crops.

Key words: Ixora, micronutrients, sodic soil

1.Introduction

Ixora is a popular flowering shrub belonging to the family Rubiaceae. This plant is native to Southern Asian countries. In Ayurveda, *Ixora* is also known as Jungle Geranium, Jungle Herb, Flame of the Woods and Vetchi (Neelamegam 2011). This tropical plant was given the common name "flame of woods" because of its beautiful red blossoms that stay open for a long time in contrast with the glossy, dark green leaves. Due to the introduction and hybridization efforts, new *Ixora* hybrids with diverse flower colors, forms and plant height have come to market in recent years. It has become one of the most important horticultural crops in recent years. 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. *Ixora* prefers full sun and performs well on moist, well-drained, acidic but organically rich soils. Though *Ixora* flowers throughout the year, the peak flowering season is April-May. In Tamil Nadu, per cent distribution of micronutrient deficiencies are observed as follows. Zn 63.30, Cu12.62, Fe12.01, Mn7.37 and B 20.65 (Katyal, 2001).

Foliar nutrition has been shown to improve plant growth, crop output, nutrient uptake and product quality in numerous studies. Under varied nutritional deficits, this approach can provide fast transfer of nutrients to diverse plant organs via., leaf tissues. In terms of enhancing crop output and other growth metrics, foliar application of micronutrients may be six to twenty times more effective than soil application (Balakrishnan, 2005). The commercial flower market in India has been changed dramatically over the last few years. In India, there is a profitable production system for standard crops like gladiolus, carnations, tuberose, chrysanthemum, china aster, marigold and roses (Hardeep Kumar et al., 2004). The domestic flower consumption as well as market, though not nearly as demanding as the international market, has incredible potential for expansion. 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 (Katyal and Rattan, 2003). The demand for increasing flower production will require a thorough knowledge on the relationship between micronutrients and crop growth. Today’s practice of growing flower crops includes the use of high yielding varieties, high density planting, insufficient use of organic manure, and higher rate of N, P and K fertilizers application all of which aggravate micronutrient deficiencies. A timely recognition of micronutrient deficiencies thus becomes imperative for maximum flower production and long-term planning for land and crop management.

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 their effect on Ixora crops.

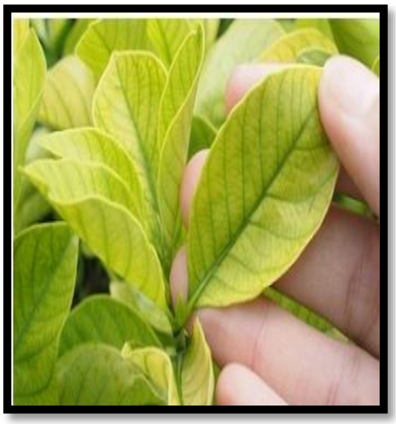
2.Importance of micronutrients on flower crops

Mineral nutrition of crop plants assumes fundamental importance in horticulture, while micronutrients play a vital role in crop production. Out of 18 essential elements, only iron, manganese, zinc, copper, boron, molybdenum, chlorine, cobalt and nickel are known as essential micronutrients for plant growth and development. 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 soils, these nutrients are present but are not available to plants (Manjunath et al., 2019). 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 (Ahamed et al., 2010). These micronutrients play their role in enzymatic reactions and regulate metabolic activities. The number of micronutrients becoming deficit in soils is increasing year after year under intensive agriculture system, resulting imbalanced in nutrients and subsequently affecting crop yield and quality. For this, soil should be tested every year, and based on soil test apply the micronutrient by proper mode.

The role of micronutrients in various metabolic processes and the enzymes involved in these processes has been reported by Zende, 1996. 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 Gowda et al (2001).

3.Micronutrient deficiencies in Ixora

Nutrient deficiency occurs when a plant lacks sufficient quantity of an essential nutrient required for growth. Without sufficient essential nutrients, plants will not grow well and show various symptoms to express the deficiency. *Ixora* is an indicator plant as it shows the symptoms immediately when the soil is affected by nutrient deficiency. It can be planted as border crop to understand the nutrient deficiencies before it affects the main crop. So, *Ixora* is called the indicator plant for micronutrient deficiency (Jeyakumar and Balamohan, 2007).

Iron (Fe) Iron chlorosis is often associated with alkaline soils. High pH soils cause iron and manganese deficiencies, the symptoms of which are yellowing leaves, small new growth, and possibly bud drop. Iron deficiency is usually associated with high EC and ESP, but it is also associated with excessive irrigation, prolonged wet soil conditions or poor drainage like sodic soil. Iron deficiency is similar to Magnesium, except that it appears on young leaves and shoots instead of older leaves. Iron is needed by plants for the synthesis of chloroplast proteins and various enzymes. **Deficiency symptoms**: Light green to yellow interveinal	

chlorosis on newly emerging leaves and young shoots. It is common to see shoots dying from the tip inwards. In severe cases, newly emerged leaves may reduce in size and turn nearly white, with necrotic spots.	
Manganese (Mn) Manganese acts as an enzyme activator for nitrogen assimilation. Manganese is needed by plants for photosynthesis, respiration and enzyme reactions. **Deficiency symptom**: Newly emerging leaves exhibit diffused interveinal chlorosis with poorly defined green areas around the veins. Chlorosis and necrotic spotting are common symptoms. In severe deficiency, new leaves become smaller and tip dieback can occur.	
Zinc (Zn) Plants require zinc to activate plant growth regulators, particularly Auxin and Indole Acetic Acid (IAA). Zinc is needed to activate plant growth regulators. **Deficiency symptoms:** Chlorosis, bronzing or mottling of younger leaves. Interveinal chlorosis of the young leaves followed by reduced shoot growth with short internodes, as well as small and discolored leaves giving the affected part a rosette appearance.	
Copper(Cu) Present in laccase and several other oxidase enzymes; important in photosynthesis, protein and carbohydrate metabolism and probably nitrogen fixation. **Deficiency symptoms:** Wilting mechanism, white twisted tips, reduction in panicle formation and disturbance of lignification. Inadequate levels of copper can lead to poor growth, delayed flowering, and plant sterility. Copper deficiency in plant growth may appear as wilting with leaf tips turning a bluish green colour.	
Boron deficiency is rather rare in trees and shrubs but has been observed regularly in *Ixora sp*. Symptoms appear on the new growth as small, upwardly cupped or puckered, dark green, brittle leaves with short internodes. Boron deficiency is caused by leaching on sandy soils, but by drying or high pH on other soil types (Timothy Broschat,2009).	

4.Functions of Micronutrients in flower crops

Micronutrients play a complex role in plant nutrition. They serve mainly as constituents of prosthetic groups of metal proteins and as activators of enzyme reactions. As constituents of prosthetic groups, micronutrients (mainly Fe, Mn, Cu and Mo) catalyze the redox process. By electron transfer they form enzyme substrate (i.e. Fe and Zn) or enhance enzyme reactions by influencing the molecular configuration of an enzyme or substrate (e.g. Zn). Certain functions of micronutrients in floricultural are summarized below:

Fe	Present in several enzymes viz., peroxides, catalase and cytochrome oxidase enzymes found in ferredoxin important in chlorophyll formation and flower colour (Jawaharlal et al.,2012; Rao, 2005; Halder and Ahmed, 2007; Shukla and Singh, 2009; Singh and

	Bhattacharjee, 2008; Ganga *et al.*,2001)
Zn	Present in several enzymes viz., dehydrogenase, proteinase and starch formation, promote seed maturation and production (Shukla,2009; Senthamizhselvi, 2000; Halder et al., 2007).
Cu	Present in laccase and several other oxidase enzymes; important in photosynthesis, protein and carbohydrate metabolism and probably nitrogen fixation
Mn	Activates decarboxylase, dehydrogenase and oxidase enzymes important in photosynthesis, nitrogen assimilation (Patel *et al.*,2010).

5.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 would be the micronutrient content of the soil. (Memon et al., 2013). 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 are in available form as organic matter decomposes (Kumar and Singh, 1998).

Table 1: Diagnosis based on visible symptoms.

Plant part	Prevailing disorder symptoms		Nutrient
Old and mature leaf blades	Chlorosis Necrosis	Uniform Interveinal or blotched necrosis Tip and marginal scorch	N Mg K
	Necrosis	Spots Tip and marginal scorch	Mn Toxicity B
Young leaf blades and apex	Chlorosis Necrosis	Uniform Interveinal or blotched	Fe Zn
	Deformations		Ca,B,Cu,Mo

Table.2 Common micronutrient antagonism in soil

High soil level of	Results in low plant level of
Iron	Manganese, Zinc
Manganese	Iron, Zinc
Copper	Zinc
Zinc	Copper

(Manjunath *et al*,2019)

6. Micronutrient Excess can cause deficiencies

Excessive application of one micronutrient, in addition to toxicities, can lead to other micronutrient deficiencies. Deficiencies in this case are due to antagonisms between micronutrients during plant uptake. When two nutrients are antagonistic, a super optimal concentration of one in the substrate (soil) will suppress plant uptake of the other. A high level of iron in the substrate commonly causes manganese deficiency and to a lesser extent can suppress Zinc uptake (Table 2). Conversely, high levels of manganese in the substrate causes iron deficiency and to a lesser extent, zinc deficiency. Super-optimal levels of copper cause zinc deficiency and conversely, high levels of zinc cause copper deficiency. Thus, it is possible to encounter deficiencies of iron, manganese, copper, or zinc as a result of excess application of other micronutrients (Patil et al.,2010). These deficiencies can occur even when a normally sufficient concentration of the deficient micronutrient exists in the substrate.

7. Diagnosing Micronutrient Status

It is important to diagnose the status of all micronutrients before undertaking corrective measures. As discussed, micronutrient disorders can involve one or more nutrients as well as combinations of toxicities and deficiencies. The presence of one micronutrient deficiency does not indicate that all other micronutrients are low. There are three systems for diagnosing nutrient status. The best diagnostic tool for micronutrients is foliar analysis. Visual observation of symptoms works but requires that damage be present (Balakrishnan V. 2005). Most damage cannot be corrected. Commercial soil tests do not generally identify levels of all micronutrients. On the other hand, accurate tests and standards have been established for foliar analysis of all micronutrients. While the minimum and maximum critical foliar levels for micronutrients can vary for a few crops, these values do tend to be standard for most crops. The general critical foliar levels for some floral crops are presented in Table 3.

Table 3: Interpretative ranges for micronutrient values (reported in ppm) obtained from foliar analysis of selected floricultural crops.											
Carnation						**Roses**					
Nutrient	Deficient	Low	Sufficient	High	Excess	Nutrient	Deficient	Low	Sufficient	High	Excess
Boron (B)	< 25	26-29	30-100	101-699	>700	(B)	< 30	31 - 39	40-60	61-400	>401
Copper (Cu)	< 5	6-9	10-30	31-35	>36	(Cu)	< 5	6-7	7-15	16-18	>19
Iron (Fe)	< 30	31-49	50-150	151-155	>156	(Fe)	< 50	51-79	80-120	121-150	>151
Manganese (Mn)	< 30	31-99	100-300	301-799	>800	(Mn)	< 30	31-69	70-120	121-150	>251
Molybdenum (Mo)						(Mo)					
Zinc (Zn)	<15	16-24	25-75	76-80	>81	(Zn)	< 15	16-19	20-40	41-50	>51
Chysanthemum						**Other Crops**					
Nutrient	Deficient	Low	Sufficient	High	Excess	Nutrient	Deficient	Low	Sufficient	High	Excess
Boron (B)	< 20	21-49	50-100	101-124	>125	(B)	< 25	26-30	31-100	101-200	>201
Copper (Cu)	< 5	6-24	25-75	76-80	>81	(Cu)	< 5	6-10	11-20	21-24	>25
Iron (Fe)	< 50	51-59	60-500	501-525	>526	(Fe)	< 50	51-60	61-150	151-350	>351
Manganese (Mn)	< 20	21-29	30-350	351-800	>801	(Mn)	< 30	31-50	51-300	301-500	>501
Molybdenum (Mo)						(Mo)					
Zinc (Zn)	< 15	16-20	21-50	51-55	>56	(Zn)	< 14	15-20	51-75	51-75	>76

8. Soil Analysis

Several extractants like water, solutions of weak acids and alkalis and chelating agents adjusted to varying pH levels have been used in extracting a particular fraction of the available micronutrient from soil (Li, 2011). Studies on the relationship between these fractions and crop response have been made to determine the critical values of micronutrients in soil. The critical levels of deficiency of micronutrients currently in use for delineating the micronutrient responsive soils from non-responsiveness are listed below.

Table.4 Critical Nutrient concentration of Micronutrients in soils

Micronutrient	Cu	Fe	Mn	Mo	Zn
Critical level (ppm)	0.2	4.5	2.0	0.2	0.6

Proper understanding of micronutrients availability in soils and extent of their deficiencies are the prerequisites for efficient management of micronutrient fertilizers to sustain the crop productivity. (Khalifa et al., 2011, Shyala et al.,2019).

Critical levels of micronutrients in plants greatly accepted in India are given in Table 6. The critical levels may differ not only for soils and crops species but also for different varieties of a given crop (Sharma, 1996). Higher concentrations can lead to toxicity and can even kill the plant. Special care has to be taken with the application of B, Cu and Mo for which the difference between deficiency and toxicity level is narrow. Some toxic levels are reported by Jones (1992) for Cu (over 20 ppm), B (over 200 ppm), Zn (over 400 ppm) and Mn (over 500 ppm) in mature leaf tissues.

Table 5: Critical levels of deficiency of micronutrients in plants usually adopted in India for delineation purposes

Nutrient	Critical level in plant dry matter (mg kg^{-1}dry matter)
Zn	10-20
Fe	50 (25-80)
Cu	4 (3-10)
Mn	20 (10-30)
B	20
Mo	0.1

(Katyal and Rattan, 2003; Tandon, 1999)

Table: 6 Critical levels of deficiency of micronutrients in soil usually adopted in India for delineation purposes

Nutrient	Extractant	Critical level (mg kg^{-1})
Zn	DTPA	0.4-1.2 (0.6)
Fe	DTPA	2.5-4.5
	Ammonium acetate	2.0
Cu	DTPA or Ammonium acetate	0.2
Mn	DTPA	2.0
B	Hot water	0.5
Mo	Ammonium oxalate	0.2
S	0.15 % $Cacl_2$ $2H_2O$	10

(Katyal and Rattan, 2003; Tandon, 1999)

9. Management of Micronutrient Deficiencies in flower Crops

Mineral nutrition of crop plants assumes fundamental importance in horticulture, while micronutrients play a vital role in crop production. Out of 18 essential elements, only iron, manganese, zinc, copper, boron, molybdenum, chlorine, cobalt and nickel are known as essential micronutrients for plant growth and development. (Kumar and Singh, 1998).For this, soil should be tested every year, and on the basis of soil test apply the micronutrient by proper mode.(Havlin *etal.*, 2000). A timely recognition of micronutrient deficiencies thus becomes imperative for maximum flower production and long term planning for land and crop management (Neelamegham ,2011).

Soil factors

Soil pH Most of micronutrients i.e. Zn, Cu, Fe, Mn and B are available to plants in acidic condition (pH 5.2-5.8), but 60-70% of the Indian soils are with pH above 7 and hence micronutrient management is a major problem. Iron and manganese are highly sensitive to soil pH (Kumar and Singh, 1998).

Table.7 Critical level of deficiency of micronutrients in soils usually adopted in India

Nutrient	Extractant	Critical level(mg/kg)
Zn	DTPA	0.4-1.2
Fe	DTPA	2.5-4.50
	Ammonium acetate	2
Cu	DTPA or ammonium acetate	0.2
Mn	DTPA	2

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