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IMMA NEWS

Indian Micro Fertilizers Manufacturers Association

Manganese Def. in Groundnut — *Manganese Def. in Potato*

Salt Accumulation — *Soil Compaction*

Rs. 10/-

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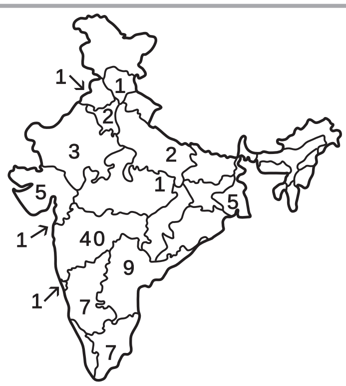

CONTENTS Page

1. Manganese (Mn^{++})

Sukritee Hazarika, ... 4

2. Problem Soil Management in Agriculture:

Sukritee Hazarika 6

3. *Role of micronutrients in aromatic plants*

Dr. Preeti Verma...10

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from the editor's desk

The increasing area under problematic soils is a serious concern for highly populated countries like India, since it is one of the major causes of diminishing area under agriculture. Particularly arid and semi-arid areas are badly affected due to the problem of soil salinity.

Manganese is one of the essential nutrients required for growth and development of any crop whose deficiency is demonstrated by characteristic 'chequered' symptoms on the leaves.

Aromatic plants are valued for the essential oils they contain within. These oils are in high demand in the international trade.

Invitation for Technical Data

We are publishing 'IMMA News' Bulletin every quarter with Technical Data on Fertilizers in general and Micronutrient Fertilizers in particular. We do forward the same as an complimentary to the Agriculture Scientists & officers, all over India.

We request all the readers to please send us Technical matter to be published in our 'IMMA News', which will assist the extension officers to disseminate your ideas to farmers, to increase crop yields.

Manganese (Mn^{++})

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Functions

Manganese is essential for many plant functions. Some of them are:

- The assimilation of carbon dioxide in photosynthesis.
- It aids in the synthesis of chlorophyll and in nitrate assimilation.
- Manganese activates fat forming enzymes.
- It functions in the formation of riboflavin, ascorbic acid, and carotene.
- It functions in electron transport during photosynthesis.
- It is involved in the Hill Reaction where water is split during photosynthesis.

Factors Affecting Availability

- Soil pH: High soil pH reduces Mn availability while low soil pH will increase availability, even to the point of toxicity.
- Organic Matter: Mn can be "tied up" by the organic matter such that high O.M. soils can be Mn deficient.
- Soil Moisture: Under short-term waterlogged conditions, plant available Mn^{++} can be reduced to Mn^{+}, which is unavailable to plants. However, under long-term reducing (e.g. waterlogged) conditions, available Mn can be increased. As soil dries, Mn availability undergoes changes. Some unavailable Mn^{+} is oxidized to available Mn^{++}, while some available Mn^{++} can be oxidized to unavailable Mn^{++++}. When the soil is in transition from flooded to normal moisture content, there can be a temporary "flush" of excess Mn^{++} giving the possibility of a temporary toxicity, especially if other conditions are favorable to the presence of excess Mn^{++}.
- Mn:Fe Balance: Soils high in available Iron (Fe), or high Fe applications can reduce Mn uptake.
- Mn:P Balance: There is conflicting research that high soil P can either increase, or decrease Mn uptake by various plants species. Until more definite evidence is available, we probably should not include the soil P level in our consideration of Mn availability.
- Mn:Zn Balance: There is conflicting research high soil Zn can either increase, or decrease Mn uptake by various plant species. Until more definite evidence is available, we probably should not include the soil Zn level in ourconsideration of Mn availability.
- Mn:Mo Balance: One researcher observed that Mn concentrations were reduced in half by molybdenum (Mo) fertilization. This limited evidence should not be used to make Mo recommendations due to the possible toxic reactions of high Mo contents that could occur in animals grazing or eating the crops grown on high Mo soils.
- Mn:Si Balance: Research has shown that silicon (Si) applications can alter the Mn distribution in leaf tissue in such a way as to reduce the possibility of Mn toxicity from excess Mn uptake.
- N STRESS: Low N availability decreases the vigor of plants to an extent that it may fail to take up adequate amounts of many other nutrients. Manganese uptake can be affected in this way.
- Mn:S Balance: The Sulfur interaction is primarily one-way, as the Sulfur content of the plant is diminished so also is the Manganese content.
- Mn:Anion Balance: Heavy fertilization with materials containing Cl^{-}, NO_3^{-}, SO_4^{--}, can also enhance Mn uptake (termed the anion effect).

High Response Crops

While this is an essential element for all plants, these crops have been found to be especially responsive: alfalfa, beets, cauliflower, citrus, cotton, large-seeded legumes, lettuce, onions, potatoes, small grains, sorghum, soybeans, spinach, sweet corn, and tobacco.

Deficiency Symptoms

Because Mn is not translocated in the plant, deficiency symptoms appear first on younger leaves. The most common symptoms on most plants are interveinal chlorosis. Sometimes a series of brownish-black specks appear in the affected areas. In small grains, grayish areas appear near the base of younger leaves. Manganese deficiencies occur most often on soils with a high pH and / or naturally low Mn content. Conifers will exhibit a general yellowing of the current season's needles.

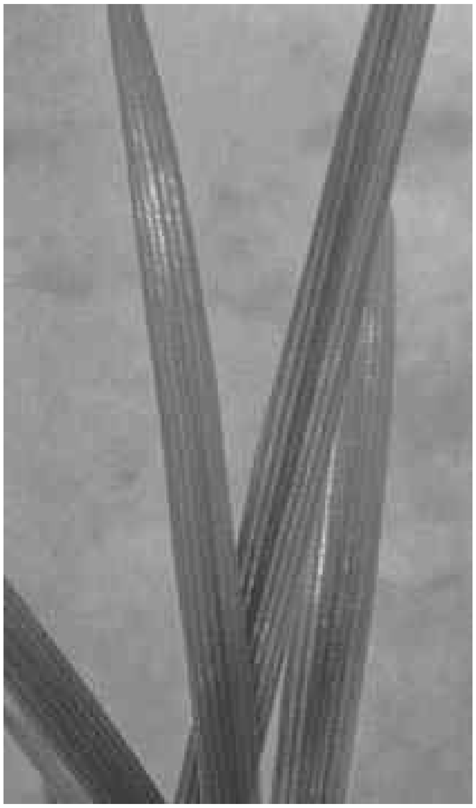
1) The most apparent symptom of Mn deficiency is chlorosis between the veins of young leaves.

2) The smallest branches of the vein remain green while the tissues between the veins are light green, yellow or almost white.

3) Leaves of reticulate venation as that of sugarbeet, tomato, cauliflower etc. show chlorotic mottling which soon becomes necrotic.

4) Tthese symptoms may appear first on the middle leaf.

Using Manganese in a Fertility Program



Recommended rates of Mn	
Method	Rate
Broadcast :	NOT RECOMMENDED
In-row :	1 to 5 lb./A
Foliar :	1 to 2 lb./A

Broadcast applications are not recommended because Mn that is not concentrated in a band or similar method is quickly converted to unavailable forms when it comes into contact with the soil. Liming soils to the proper pH for the crop is the most practical way to avoid the majority of problems with Mn. On high pH soils, the use of acid-forming fertilizers in the row can increase the uptake of Mn, and other micronutrients. One example of an acid-forming fertilizer blend would be one based on monammonium phosphate and ammonium sulfate. Where foliar Mn is used, multiple applications throughout the season are often needed to compensate for soil deficiencies.

Toxicity

Manganese toxicity is a relatively common problem compared to other micronutrient toxicity. It normally is associated with soils of pH 5.5 or lower, but can occur whenever the soil pH is below 6.0. Symptoms include chlorosis and necrotic lesions on old leaves, dark-brown or red necrotic spots, accumulation of small particles of MnO_2 in epidermal cells of leaves or stems, often referred to as "measles", drying leaf tips, and stunted roots. Sometimes the interveinal tissue will show "puckering" or raised areas in the leaves. Toxic symptoms can sometimes be alleviated by using Iron chelates applied to either the soil or preferably the foliage. Some acid-loving plants such as blueberries, cranberries, Christmas trees, azaleas, etc. may accumulate very high levels of Mn in their tissue due to the required low soil pH. However, these plants normally will tolerate much higher tissue Mn than other species.

Some common fertilizer products containing Manganese

Product	Chemical Formula	Typical Mn Content
Manganese Sulfate	$MnSO_4h4H_2O$	23-28%
Manganese (manganous) Oxide	MnO	41-68%
Manganese Chelate	various	5-12%

NOTE : It has been reported that if a Mn-chelate (EDTA) is added to the soil to correct an apparent deficiency problem, the most common result is increased Mn deficiency. This occurs because the affinity of chelates for Iron is greater than their affinity for Manganese and substitution occurs. The Fe-chelate is rapidly taken up by the plant and the ensuing interaction increases the Mn deficiency.

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Problem Soil Management in Agriculture:

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Availability of plant nutrients to crops has a strong bearing on physic-chemical nature of soils. In has a vast area under acid soils as well as sodic soils. Productivity of such soils can be restored through well established ameliorative techniques. Use of lime or liming materials in acid soils and that of gypsum/ phosphogypsum in sodic soils has been advocated by Soil Scientists for correction of soil pH and improving physic-chemical nature of these soils. It is intended to support and popularize use of these abundantly available ameliorants in NFSM districts with large area covered by such soils.

Management of acid soils:

Acid soils occupy vast area in high rainfall, mountains and coastal regions of india. The soils are highly leached, have poor fertility and water-holding capacity. Acid soils are deficient in phosphorus, calcium, magnesium and molybdenum. Severe acidity often causes iron and aluminum toxicity to crops. Acid soils are low in organic carbon, water retention and prone to run-off induced erosion. These constraints lead to sub optimal productivity of crops raised in acid soils.

Distribution and extent of acid soils in NFSM States:

Acid soils are widely spread in eastern, north eastern and peninsular region. Table1 depicts statewise area affected by soil acidity. Total area under acid soils in NFSM states is estimated to be 66 m ha, major part of which falls in targeted districts. However, area with soil pH < 5.5 is only 15.6 m ha and needs to be treated on priority.

Table: 1. Extent of acid soils in NFSM States (m ha)

States	pH <5.5	pH 5.5-6.5	Total
Andhra Pradesh	-	0.40	0.40
Assam	2.33	2.33	4.66
Bihar	0.40	2.32	2.36
Chhattisgarh	6.45	4.39	10.84
Jharkhand	1.0	5.77	6.77
Karnataka	0.06	3.25	3.31
Kerala	3.01	0.75	3.76
M.P	1.12	10.60	11.72
Maharashtra	0.21	4.33	4.54
Orissa	0.26	8.41	8.67
Tamil Nadu	0.56	4.29	4.85
West Bengal	5.6	1.20	4.76
Total	15.6	51.04	66.64

Amelioration of acid soils:

Liming of acid soils has been advocated by soil scientists. However the lime requirement based on laboratory tests is usually too high for most of the farmers to afford. Besides, high transport cost of large quantity of lime and inadequate storage facilities at consumption sites have discouraged large scale use of the ameliorant. Now, it has been established that band placement/ incorporation of lime @ 1/10 of lime requirement along with recommended level of fertilizers every year is economical, practicable and effective.

Commonly available liming materials:

Carbonates, oxides and hydroxides of calcium and magnesium are referred to as agricultural lime. Liming materials such as calcite, dolomite are naturally occurring ameliorants. Although, they are available in abundance, their use may not always be cost-effective. Industrial by products such as basic slag (steel industry), lime sludge from paper mills, etc are rich and relatively cheap sources of calcium. Liming materials available in different states are depicted in table 2. The material should have at least 25% calcium oxide and be ground to less than 80 mesh size.

Table 2. liming materials available in NFSM states in India

Acid soil region/states	Liming material	Quantity available(mt)
Assam	Limestone	15
Jharkhand	Basic slag	1
Kerala	Lime shells	4
Maharashtra	Lime	0.2
Orissa	Paper mill sludge	0.2
West Bengal	Basic slag, paper mill sludge	0.3
Others	Basic slag	3.0

Dose, schedule and method of application:

The ground material conforming to BIS specifications (80 mesh size) should be broadcast/ applied in furrows at the rate of 10% of Lime Requirement (LR), (usually 2-4 q/ha) at the time of planting of an upland crop preceding rice. It may also be applied to rice crop during puddling(2-4 q/ha) if the soil is highly acidic(soilpH < 5.5)

The quantity of lime equivalent to 10% of Lime Requirement (LR) is usually about 2-4 q/ha depending on soil type and pH. However, soil should be tested for LR by nearby Soil Testing Laboratory and the dose should be decided accordingly. Generalized LR is depicted in table 3.

Table 3. Generalized lime requirement (t/ha)

Soil Texture	Targeted soil pH change	
	From 4.5 to 5.5	From 5.5 to 6.5
Sand and Loamy Sand	0.6	0.9
Sandy Loam	1.1	1.5
Loam	1.7	2.2
Silt Loam	2.6	3.2
Clay Loam	3.4	4.3

Crop response to liming and economics:

Yield advantage attributable to liming in case of pigeon pea grown in acidic soil of Jharkhand has been 34% under farmer's practice and 105% under 100% NPK application. Corresponding figures for Orissa are 44% and 92%. Productivity gain in wheat grown on acid soils of West Bengal has been 52% under farmers practice and 86% under 100% NPK application. Rice crop grown in submerged acid soils may witness moderate yield advantage which could be increased significantly provided recommended dose of NPK is applied. Thus, liming improves crop response to fertilizers applied to the crop. Productivity of wheat, cowpea, blackgram, pigeonpea in States like Assam, Jharkhand, Orissa, West Bengal and Kerala with 50% NPK plus lime have been equal to or more than with 100% NPK application.

Management of moderately sodic soils:

Salt affected soils cover more than 7 m ha area, most of which occurs in indogenetic plane in the states of Punjab, Haryana, U.P., Bihar and parts of Rajasthan. Arid tracts of Gujarat and Rajasthan and semi-arid tracts of Gujarat, Madhya Pradesh, Maharasshtra, Karnataka and Andhra Pradesh also have large area affected by salinity/alkalinity. Crops grown on saline soils suffer on account of high osmotic stress whereas nutritional disorders, toxicities and poor soil physical conditions reduce crop productivity in alkali soils. Soils with pH >8 and exchangeable sodium more than 12-15% need to be treated with suitable ameliorant.

Distribution and extent of salt affected soils in NFSM states:

Table 4. Depicts area affected by salinity and alkalinity in NFSM-wheat States. The area includes saline soils which can be reclaimed through leaching with good quality water. However a major area cropped to wheat has moderately alkaline pH which adversely affects nutrient use efficiency and wheat productivity. In order to achieve targeted wheat production, it is necessary that exchangeable sodium and subsequently soil pH are reduced to optimum levels through appropriate interventions.

Table 4: Area of salt affected soils in NFSM-Wheat states

States	Area (000, ha)
Bihar	85
Gujarat	1649
Haryana	555
Punjab	480
Madhya Pradesh	242
Maharashtra	127
Rajasthan	1138
Uttar Pradesh	958
Total	5234

Amelioration of alkali soils:

Amelioration of alkali soils involves replacement of exchangeable sodium from soil exchange complex and leaching out of soluble salts from root zone. This is accomplished through application of chemical ameliorants (which furnish calcium for replacement of sodium from the exchange complex of the soil.) followed by leaching.

Soil of affected area should be tested for gypsum requirement(GR). However, generalized GR based on soil type and degree of sodicity is depicted in table 5. Agricultural grade gypsum or phosphogypsum should be incorporated into soil @75% of GR at least 15-30 days before planting of kharif crop. The treated field should be kept submerged with good quality water for facilitating reaction and subsequent leaching of by-product salts. Treated field should be planted to rice during kharif season followed by wheat during rabi.

Fields with marginally alkaline pH can support a wheat crop even without treatment. However, the productivity of the crop and nutrient use efficiency will improve significantly if soil is treated with gypsum or phosphogypsum at moderate (1-1.5 t/ha) rates either in kharif season or before planting irrigated wheat crop.

Table 5: Generalized gypsum requirement (t/ha) for reclamation of sodic soils

Soil type	Initial exchangeable sodium (%)					
	15	20	25	30	40	50
Loam Clay	0.50	1.5	2.0	3.0	5.0	6.5
Loam	0.75	2.0	3.35	4.5	7.0	10
clay	1.0	2.75	4.5	6.0	9.5	13.0

Chemical ameliorants:

Amendments used for chemical amelioration are either soluble calcium salts like gypsum, phosphogypsum or acid formers like pyrites, sulphuric acid, aluminium sulphate, sulphur etc. however, gypsum and phosphogypsum are easily available and are most economical ameliorants. Thus they have been included for financial assistance under NFSM programme for wheat crop.

Crop response and economics:

Soils with high alkalinity can be used to grow highly tolerant crops such as paddy. Productivity of even tolerant crops grown in such soils remains suboptimal. Reclamation of sodic soils requires fairly high quantity of gypsum (5-15 t/ha). Districts selected under NFSM-Wheat, however, exhibit respectable wheat yield levels and soil pH ranging from 7.5 to 8.5 thereby suggesting existence of moderate alkalinity. Application of gypsum to such soils at moderate rates (1-1.5 t/ha) is bound to improve nutrient use efficiency and crop productivity. Although yield gains attributable to gypsum application depend on many factors (existing level of sodicity, soil type, quality of irrigation water, nutrient management practices followed etc.) yield advantage of about 20% in each crop of rice-wheat sequence due to gypsum application has been observed in field studies. This amounts to additional yield of about 500-600 kg/ha of each crop. The additional annual monetary gain is therefore Rs 9000 to 10,000 in the very first year. The advantage will continue for 4-5 years with progressive decline in magnitude which can be reversed by repeating the treatment. Thus cumulative monetary gains are much higher compared to the cost of gypsum (Rs 2000 to 3000 ha) incurred. Benefit: cost ratio will remain greater than 3:0. Fields being irrigated with poor quality (high residual sodium carbonate) irrigation water should be treated with moderate doses of gypsum annually for guarding against likely sodification of the soil. Underground irrigation waters in parts of Haryana, Uttar Pradesh, Rajasthan, Gujarat and Madhya Pradesh have been observed to be sodic. Their regular use for irrigation in many cases has caused soil degradation.

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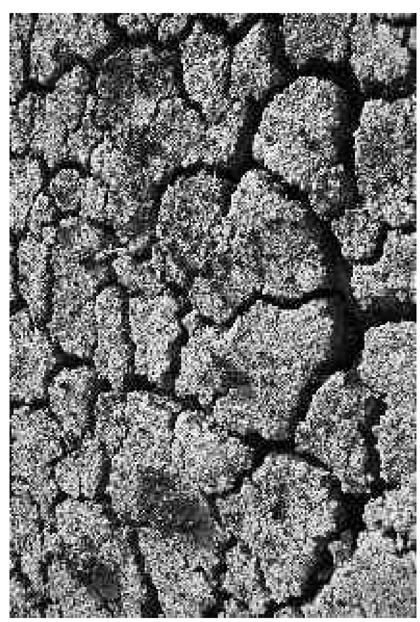
Saline Soil



Black Cotton Soil

Role of micronutrients in aromatic plants

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Background information

Aromatic (aroma producing) plants are those plants which produce a certain type of aroma. Their aroma is due to the presence of some kind of essential oil or aromatic oils naturally occurring in them with chemical constituents that contain at least one benzene ring in their chemical configuration. India is one of the few countries in the world having varied agro climatic zones suitable for the cultivation of a host of essential oil bearing plants. Due to increased awareness of health hazards associated with synthetic chemicals coupled with their increased cost, the use of essential oils has been gradually increasing. The consumers are showing increasing preference for natural material over the synthetic. During the last few years with the spurt in the production of essential oils, it is emerging as a potential agro based industry in India. At present in India about 30 % of the fine chemical used annually in perfumes and flavors come from essential oils. A number of essential oils from palmarosa, citronella ginger grass, basil, mint, lemon grass, eucalyptus cedar wood, lavender oil, davana oil, celery seed oil, fennel and other oils have been widely used in a variety of products in India. Out of these the essential oils currently being produced in India are oil of citronella, lemongrass, basil, mint, sandalwood, palmarosa, eucalyptus, cedar wood, vetiver and geranium. Rose oil, lavender, davana oil, oil of khus and ginger grass are produced in small quantities. A sizeable amount of foreign exchange can be earned annually by means of increased production of the essential oils. A balanced fertilization program with macro and micro nutrients in plant nutrition is very important in the production of high yield with high quality products. For adequate plant growth and production, micronutrients are needed in small quantities; however, their deficiencies cause a great disturbance in the physiological and metabolic processes in the plant. Soil and plant tissue tests confirm that these elements are limiting crop production over wide areas and suggest that attention to them will, in all likelihood, increase production in future.

Foliar application of micronutrients

Plants normally take up nutrients from soils through their roots although nutrients can be supplied to plants as fertilizers by foliar sprays. Micronutrient deficiencies are not only due to low content of these elements in soil but more often due to their unavailability to the growing plant. Since the foliar application of plant nutrients is an additional channel to nutrition, as well as regulating root uptake, thus the changing in level of mineral in above ground plant organs are not so much attributable to foliar absorption, but rather to effect of the latter on the uptake of nutrients by root system. The improvement in micronutrients uptake by micronutrient application (Fe, Mn and Zn) can be explained by their role on improving roots that lead to greater absorbing surface of root consequently increasing nutrients uptake and improves transpiration of the nutrients from the soil to plant organs via the roots. The foliar application of mineral nutrients offers a method of supplying nutrients to higher plants that is more efficient than methods involving root application when soil conditions are not suitable for nutrients availability (Edral et al., 2004). In addition, the foliar fertilizer is a beneficial technique to meet the deficiencies of one or more of macro or micro elements, strengthen weak or damaged crops, speed growth and grow better and healthier plants. Many crops respond to foliar and soil application of micronutrients in terms of growth and crop yields. It is widely reported that foliar application of micronutrients at active growth stages will improve plant growth and consequently yield and quality in various crops.

Major micronutrients

Throughout the world microelements as Fe, Zn, Mn and Cu are added to foliar fertilizers, in order to compensate their deficiency especially in arid and semi arid regions (Kaya et al., 2005). Microelements, especially Fe and Zn, act either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Thus, they are associated with saccharide metabolism, photosynthesis, and protein synthesis (Marschner, 1995). Iron is mainly present in the form of insoluble Fe (III), therefore, unavailable to higher plants, particularly in neutral and alkaline soils (Shao et al., 2007). Iron has important functions in plant metabolism, such as activating catalase enzymes associated with superoxide dismutase, as well as in photorespiration, the glycolate pathway and chlorophyll content. Zinc is an essential micronutrient for synthesis of auxin, cell division and the maintenance of membrane structure and function. Zinc deficiency reduces plant growth, pollen viability, flowering, number of fruits and seed production (Sharma et al., 1990; Marschner, 1995).

Therefore, sufficient amount of these nutrients in the plant is necessary for normal growth, in order to obtain satisfactory yield.

Perusal of the literature reveals that much of the work has been focussed on the effect of macro – nutrients supplied as inorganic source or in combination with manure on major food crops. The aromatic plants are not much studied with respect to micronutrient requirement. Khalid (1996) reported that trace elements such as Fe, Zn and Mn increased the vegetative growth characters and essential oil content of different plants such as anise, coriander and sweet fennel. The promotional effects of micronutrient foliar fertilizer on growth and production of some medicinal and aromatic plants have been revealed by several researchers, i.e. on coriander using Fe, Mn and Zn; on sunflower spraying with Zn, Mn, Cu and Fe, on Cymbopogon citratus applying B, Mo, Co and Pb and on Cineraria maritima applying B, Fe and Zn . Abd El – Wahab (2008) also reported that micronutrients such as iron, manganese and zinc have important roles in plant growth and yield of aromatic and medicinal plants. The effects of various micronutrients particularly iron and zinc on aromatic medicinal plants is reviewed as under:

Improvement in coriander grain yield and essential oil yield with foliar sprays of ZnSO4 0.5%, FeSO4 2%, CuSO4 0.2% and MnSO4 0.5%, among which best treatment being CuSO4, was reported by Maurya (1990). Similarly later, significant increase in crop growth, yield and essential oil content in coriander was reported following application of 200 ppm microelements (Fe, Zn and Mn) by Khattab and Omer, 1999. Significantly enhanced number of branches and umbels per plant in coriander was observed by soil application of 20kg $ZnSO_4$ and 25kg $CuSO_4$ / ha; Zn SO_4 at 10 kg/ha soil application + 0.25 % foliar application and $CuSO_4$ at 12.5 kg/ha soil application + 0.25 % foliar application. Soil application of $MnSO_4$ at 25kg/ha and foliar application of $CuSO_4$ at 0.5% also significantly increased number of umbels per plant. Significantly more number of grains/umbel and higher seed yield over control was obtained with soil application of $MnSO_4$ @25kg/ha and $CuSO_4$ @ 25 kg/ha; foliar application of $ZnSO_4$ @ 0.50% and $CuSO_4$ @ 0.50%, and soil + foliar application of $FeSO_4$ @ 5kg/ha + 125%, $MnSO_4$ @ 12.5 kg/ha + 0.25% and $CuSO_4$ @ 12.5 kg/ha + 0.25 % (Chaudhary and Lal, 2007).The significant positive influence of foliar application of ZnSO4 0.5%, FeSO4 0.5% and combination of ZnSO4 + FeSO4 + CuSO4 + MnSO4 all at 0.5%, on all growth parameters and yield of coriander has been reported by Kalidasu et al. (2008).

Among the treatments, ZnSO4 + FeSO4 + CuSO4 + MnSO4 all at 0.5% recorded maximum plant height, number of primary branches and secondary branches, umbels per plant and umbellets per umbel, which were significantly superior to control. The treatment, ZnSO4 + FeSO4 + CuSO4 + MnSO4 all at 0.5% also recorded significantly highest yield (940 kg/ha) followed by FeSO4 0.5% (927 kg/ha) and ZnSO4 0.5% (922 kg/ha) which were at par with each other and significantly superior over control (801 kg/ha).

Application of 0.5 % zinc as foliar spray on fenugreek showed favourable effect over control on yield and yield attributes viz., number of pods per plant, pod length, number of seeds per pod and test weight (Meena and Singh, 2007). It may be ascribed due to direct influence of zinc in production of auxin, enabling the plant to grow better. Zinc is also vital for the oxidation process in plant cell and helps in transformation of the carbohydrates and regulates sugar in the plants. Due to such physiological influences of zinc, pods per plant, pod length, seeds per pod, test weight might be improved. Positive effect of zinc application on nitrogen content may be due to active role of zinc in nitrogen metabolism as zinc acts as catalyst for the absorption by plants. Higher protein content under zinc treatment may be attributed to the synergistic effect of zinc on nitrogen content and uptake by the plant. Application of zinc significantly increased the N, P, K and zinc content in seed and straw at harvest, might be due to favourable nutritional environment both in rhizosphere and in plant system.

Lemongrass (Cymbopogon citratus L.) oil is one of the most important essential oils produced in the world due to their use in perfumery, flavour and pharmaceutical industries. The influence of foliar spray with Zn and / or Fe on growth, yield and chemical composition of Cymbopogon citratus has been studied. It has been found that supplying 200 ppm zinc in addition to 100 ppm iron gave the highest fresh and dry weight yield. Whereas, the application of 100 ppm Zn combined with 100 ppm Fe gives the highest content of essential oil, soluble sugars and phenolic compounds (Eman E. Aziz et al., 2010). Similar results were reported by Subrahmanyan et al. (1992) and Rajeswara et al. (1996).

Chamomile (Matricaria chamomilla L.,syn. Chamomilla recutita L.) is an important medicinal and aromatic plant of both traditional and modern systems of medicine. The blue essential oil of flowers of this plant has a wide application in medicine, cosmetics and foodstuffs, in the flavouring of alcoholic and non – alcoholic beverages. The effect of foliar application of iron and zinc at different stages of growth on flower yield and essential oil of M. chamomilla has been studied by Nasiri et al., 2010. They reported that flower yield, essential oil percentage and essential oil yield increased by foliar application of Fe and Zn compared with the control. The time of foliar application has significant effect on flower dry yield, essential oil percentage and essential oil yield. The foliar application at both stages of stem elongation and flowering had more beneficial effects on these characters as compared with spray at only one stage. A similar effect of Zn supply on this parameter was also reported on M. chamomilla (Grejtovsky et al., 2006) and Coriandrum sativum L. (Said – Al Ahl and Omer, 2009).

Essential oil of Mentha piperita increased by 28.2% by foliar application of 3 ppm zinc chloride as compared with the control (Akhtar et al., 2009). The fresh weight, dry weight, oil yield and chlorophyll content of spearmint (Mentha spicata L.) also showed a significant increase with increase in Fe supply, the optimal level being 10 mg/kg supply. Sole supply of Fe and Mn 10 mg/kg and 2.5 mg/kg, respectively, showed maximum carvone (main component responsible for the aroma of the essential oil) percentage in M. spicata oil. Zehtab – Salmasi et al. (2008) also reported that essential oil yield of M. piperita increased by the application of these micronutrients.

Essential oil biosysnthesis in basil (Ocimum sanctum L.) is strongly influenced by Fe and Zn (Misra et al., 2006). Said – Al Ahl and Mahmoud (2010) also obtained the highest values essential oil yield by foliar spraying of a mixture of iron+ zinc in sweet basil. Misra and Sharma (1991) reported that zinc application stimulated the fresh and dry matter production, essential oil and menthol concentration of Japanese mint. Foliar application with zinc (100ppm) in blue sage (Salvia farinacea L.) enhanced the length of peduncle, length of main inflorescence, number of inflorescence and florets, and fresh and dry weight of inflorescences / plant (Nahed and Balbaa, 2007).

Ruta graveolens L. (common rue), a native of South Europe and Northern Africa is a small evergreen sub - shrub or semi – woody perennial known for its medicinal and aromatic properties that come from its essential oils, rutin and methyl- nonelectone.

The influence of foliar micronutrients on growth, flowering and chemical constituents of rue was studied by Naguib et al. (2007). It was found that Fe at 100 ppm produced the highest promotion effect for most of the growth parameters. The highest uptake of potassium and zinc percentage was recorded with application of 100 ppm Fe, while highest mean values of nitrogen and Mn uptake was produced with 100 ppm Zn. Higher percentage of rutin and coumarin were observed with 50 ppm Fe and 50 ppm Mn, respectively. Essential oil yield of herb and flowers gave higher significant values with 100 ppm Fe. In general, the improvement in vegetative growth by application of different micronutrients was in agreement with the earlier findings of El – Sherbeny and Hussein (1991) on coriander.

Foliar application of Fe, Zn and Mn significantly improved vegetative growth of onion plants (as plant height, number of leaves, bulb diameter, and fresh weight of bulb) and total yield. High concentration of Fe and low concentration of both Zn and Mn had the best effect for obtaining higher concentration of essential oil (El Tohamy et al., 2009). Bhonde et al. (1995) reported that the trace elements zinc, copper and boron had a significant effect on bulb development and yield as well as bulb quality of onion when applied in combination instead of singly. Positive effects of the micronutrients like Zn, Fe, B and Zn, Fe and Mn on yield, TSS, sugar and ascorbic acid of onion were earlier also reported by Singh and Tiwari (1996) and Sindhu and Tiwari (1993), respectively.

The effect of 50 mg/l levels of micronutrients (Zn and Mn), as single and combined treatments, on the growth, oil yield and oil constituents of cumin plants were studied and it was found that the application of micronutrients had significant positive effects, in most cases, on growth measurements and chemical composition of cumin plants. A combined treatment of the two micronutrients gave the highest values in this respect (Salma and Mohamed, 2002).

Conclusion

A perusal of the above literature suggests that in general, the growth, yield and essential oil of aromatic plants can be maximized by the application of micronutrients such as Zn, Fe and Mn.

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Reinstating The S.N. Ranade Memorial Awards For Excellence In Micronutrient Research

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