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Review Article

EFFECT OF MICRONUTRIENTS ON OIL SEED CROPS

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A B S T R A C T

The word micronutrients represent some essential nutrients that are required in very small quantities for the growth of plants and micro-organisms. There are 17 essential elements and 8 elements are considered as micronutrients they are Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (B), Molybdenum (Mo), Nickel (Ni) and Chlorine (Cl). Out of these micronutrients Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), behave like cations and boron (B), Molybdenum (Mo), Chlorine (Cl) behave as anion. Micronutrients play a significant role in plant growth and metabolic processes associated with photosynthesis, chlorophyll formation, cell wall development and respiration, water absorption, xylem permeability, resistance to plant diseases and enzyme activities. They are involved in the synthesis of primary and secondary metabolites, and nitrogen fixation and reduction. Accordingly, Zn, Fe, Mn and Cu are involved in many processes controlling plant growth and their content in grains and leaves determine the quality of food consumed by humans and animals. Micronutrient deficiencies in plants lead to reduced yields and in severe cases to plant death. Among the micronutrients, Zn deficiency is the most detrimental to crop yield especially in calcareous soils.Brajkishor Rajput *et al.,*(2015) reported that enhanced removal of micronutrients as a result of high yielding varieties, intensive cropping with high analysis NPK fertilizers, limited use of organic manures and less recycling of crop residues led to the depletion of secondary and micronutrient from the soil reserves. The reduction in the yield is generally accounted to deficiency of secondary and micronutrients. The micronutrients deficiencies which are now wide spread. Under all India coordinated research project on micronutrient more than 2.5 lakh soil samples were analyzed from 20 states of the country and it has found that the 49, 33, 13 and 7 per cent of the samples were deficient in zinc (Zn), boron (B), iron (Fe), and molybdenum (Mo), respectively. India is the largest contributor to the global Castor production (79.6 per cent) and also contributes substantially to the production of Sesame (31.2 per cent) and Groundnut (25.1 per cent). It is second largest producer of Groundnut and Rapeseed - Mustard (next to China). Thus, as much of 23 million hectares area under cultivation of nine annual oilseeds is from India alone

INTRODUCTION

The word micronutrients represent some essential nutrients that are required very small quantities for the growth of plants and micro-organisms. There are 17 essential elements 8 elements are considered as micronutrients they are Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (B), Molybdenum (Mo), Nickel (Ni) and Chlorine (Cl). Out of these micronutrients Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), behave like cations and boron (B) Molybdenum (Mo), Chlorine (Cl) behave as anion.(Fakeerappa Arabhanvi *et al., 2015)*

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Among 8 micronutrients the content of iron (Fe) in soil as well as in plants is the highest and sometimes higher than even P and S content. Micronutrients are also called trace elements oligo elements or spurn elements.

Now a days Indian farmers very lack of knowledge for using micronutrient fertilizer in oil seed crops. I was collected earlier research works indicated to importants of plant growth, seed quality, (oil content) productivity and nutrient uptake role of micronutrients and reviewed research articles to oil seed production in sustainable basis as well as soil health detail discuss with here.

Micronutrients and Metabolic Processes

Micronutrients play a significant role in plant growth and metabolic processes associated with photosynthesis, chlorophyll formation, cell wall development and respiration, water absorption, xylem permeability, resistance to plant diseases, enzyme activities involved in the synthesis of primary and secondary metabolites, and nitrogen fixation and reduction. Accordingly, Zn, Fe, Mn and Cu are involved in many processes controlling plant growth, and their content in grains and leaves determine the quality of food consumed by humans and animals. Micronutrient deficiencies in plants lead to reduced yields and, in severe cases, to plant death. Among the micronutrients, Zn deficiency is the most detrimental to crop yield, especially in calcareous soils.

Table 1 Micro-Nutrient Status of Indian soils (% sample deficient)

State / Territory	Zn	Cu	Fe	Mn	B	Mo
Andhra Pradesh	49	<1	3	1	-	-
Assam	34	<1	2	20	17	-
Bihar	54	3	6	2	38	-
Gujarat	24	4	8	4	2	10
Haryana	61	2	20	4	0	28
Himachal Pradesh	42	0	27	5	-	-
Jammu & Kashmir	12	-	-	-	-	-
Karnataka	73	5	35	17	32	-
Kerala	34	3	<1	0	-	-
Madhya Pradesh	44	<1	7	1	22	18
Maharashtra	86	0	24	0	-	-
Meghalaya	57	2	0	23	-	-
Orissa	54	-	0	0	69	-
Pondicherry	8	4	2	3	-	-
Punjab	48	1	14	2	13	-
Rajasthan	21	-	-	-	-	-
Tamil Nadu	58	6	17	6	21	-
Uttar Pradesh	46	1	6	3	24	-
West Bengal	36	0	0	3	68	-
All India	49	3	12	5	33	13

Micronutrient Status of Indian Soils

Systematic delineation work on massive scale for quantification of the micronutrient deficiencies under the aegis of the All India Coordinated Research Project on Secondary, Micronutrients and Pollutant Elements in Soils and Plants [AICRP (MSPE)] using uniform critical levels of deficiency has yielded database which has been critical in administering micronutrients. Deficiency of micronutrient has become a major constraint to the productivity, stability and sustainability of crops in many Indian soils and may further deteriorate due to global warming**.** In order to assess the micronutrients status of soil, a large number of soil and plant samples were collected and analyzed for micronutrients,*viz;* Zn, Mn, Fe, Cu, Mo and B under the aegis of All India Coordinated Research Project of Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants and by other state agencies. Indian soils are adequate in total micronutrient contents but low in their available levels. The contents varied widely with respect to soil types, cropping system and management conditions.

Out of more than 3, 00,000 soil samples collected from various states of the India, 44% tested deficient in Zn having less than 0.6 ppm DTPA-extractable content. Per cent samples deficient in Fe, Mn and Cu reported are 15, 6 and 8%, respectively**.** Similarly, the analysis of 50,000 soil samples showed B and Mo deficiencies of 33 and 13%, respectively. B deficiency is reported more in acid soils than other parts of the country due to leaching of available B and continuous depletion of total soil reserved B. Coarse texture, high pH, calcareousness, diminishing organic carbon and leaching often accentuated the Zn deficiency**.** Irrespective of these soil properties, irrigated crops whose productivity is two to three times higher than rainfed crops suffered more from Zn deficiency. Across soils and crops, lowland rice is invariably affected by Zn deficiency. Iron deficiency is most common in upland crops particularly grown on calcareous/ alkaline soils of arid region. Adoption of rice-wheat cropping system in place of maize-wheat or groundnut-wheat in non-traditional rice growing areas on highly permeable coarse-textured soils has been responsible for occurrence of Mn deficiency. The deficiency of Mo is common in acid soils of humid region. Deficiency of Cl and Ni has not been reported so far in the Indian soils. Now, multi-nutrient deficiencies are emerging in many states of the country. The Zn+Fe in swell- shrink soils, Zn+Mn or Zn+Fe+Mn in alluvial soils of Indo-Gangatic alluvial plains, Zn+Fe, Zn+B, Zn+Fe+B in highly calcareous soils of Bihar, Saurashtra, Zn+B in acid leached alfisols, red and lateritic soils of India are leading to stagnation or a decline in productivity**.**

Oilseeds Introduction

India holds premier position in the world not only in terms of rich diversity of vegetable oil sources and oil crops but also in cultivated are as regards oil crops. India is the largest contributor to the global Castor production (79.6 percent) and also contributes substantially to the production of Sesame (31.2 percent) and Groundnut (25.1 percent). It is second largest producer of Groundnut and Rapeseed - Mustard (next to China). Thus, as much as 23 million hectares area under cultivation of nine annual oilseeds is from India alone. If Coconut, Oil palm and a number of other currently less/under-exploited oil sources such as cotton seed, rice bran, maize etc., are added the country's share in the world's oilseed area would go up by 20 percent.

- Oilseeds in India constitute the principal commercial crops of India. Oils and fats, apart from forming an essential part of human diet, serve as important raw material for the manufacture of soaps, paints and varnishes, hair oils, Lubricants, textiles, auxiliaries, pharmaceuticals, etc. Oilcakes and meals are used in animal feeds and as manures. Groundnut, soybean and de-oiled meals are a source of high quality protein to both human beings and live stocks.
- The bulk of vegetable oil production in India is derived from nine oilseeds; namely, Groundnut, Rapeseed-Mustard, Sesame, Safflower, Niger, Soybean, Sunflower, forming the edible group and Linseed and Castor, forming the non-edible group. In addition Cottonseed, Rice bran, seeds of some tree species, etc., are also being exploited for vegetable oils.
- Development of oilseeds and vegetable oils holds an important place in Indian economy. There has been some gap between supply and demand of vegetable oils which has been met through imports annually. The per capita consumption of vegetable oils in the country is low as compared to the world average

Table 2 Oilseed Crops Area, Production, An Yield

Crop	Details	2009-10	2010-11	2011-12	2012-13	2013-14	Quinquennium ending 2013-14
Soybean	A	9.73	9.60	9.96	10.84	12.20	10.47
	P	9.96	12.74	12.56	14.67	11.99	12.38
	Y	1023.61	1326.56	1261.20	1352.83	982.70	1183.06
Rapeseed-Mustard	A	5.59	6.90	6.72	6.36	6.70	6.45
	P	6.61	8.18	6.04	8.03	7.96	7.36
	Y	1182.55	1185.24	899.06	1261.83	1188.06	1140.89

	A	5.48	5.86	4.71	4.72	5.53	5.26
Groundnut	P	5.43	8.26	6.02	4.70	9.67	6.82
	Y	991.00	1268.00	1341.00	995.76	1748.64	1296.26
	A	1.94	2.08	1.43	1.71	1.67	1.77
Sesame	P	0.59	0.89	0.76	0.69	0.68	0.72
	Y	302.99	428.66	530.73	401.52	404.92	407.85
	A	1.81	1.48	0.93	0.83	0.69	1.15
Sunflower	P	1.16	0.85	0.62	0.54	0.55	0.74
	Y	638.79	576.14	667.40	650.60	797.10	648.05
	A	0.29	0.24	0.19	0.18	0.18	0.22
Safflower	P	0.18	0.15	0.10	0.11	0.11	0.13
	Y	621.32	616.91	530.05	589.67	634.83	600.97
	A	0.37	0.37	0.26	0.31	0.28	0.32
Niger	P	0.10	0.11	0.10	0.10	0.09	0.10
	Y	266.78	290.32	367.56	325.39	321.30	309.68
	A	0.34	0.36	0.42	0.30	0.29	0.34
Linseed	P	0.15	0.15	0.13	0.15	0.14	0.14
	Y	449.43	407.94	314.83	503.38	498.26	425.24
	A	0.73	0.88	1.39	1.23	1.00	1.05
Castor	P	1.01	1.35	1.62	1.96	1.69	1.53
	Y	1372.81	1533.96	1167.27	1591.57	1689.00	1457.40
	A	26.29	27.77	26.01	26.48	28.53	27.02
Total of nine	P	25.19	32.68	27.95	30.94	32.88	29.93
annual oilseeds	Y	957.96	1176.68	1074.65	1168.33	1152.44	1107.71

A-Area in million ha, P- Production in million tonnes, Y-Yield in kilograms per ha

Table 3 Oilseeds productivity (kg/ha) in India *vis-a-vis* World (2012) from among the countries with >80% global contribution

Groundnut	1179	1676	4699 (USA)
Rapeseed-Mustard	1140	1873	3690 (Germany)
Soybean	1208	2374	2783 (Paraguay)
Sunflower	706	1482	2494 (China)
Sesame	426	518	1315 (Egypt)
Safflower	654	961	1489 (Mexico)
Castor	1455	1162	1455 (India)
Linseed	260	752	1358 (Canada)
Oil palm fruit	12380	14323	21901 (Malaysia)

(Source: FAOSTAT, 2012)

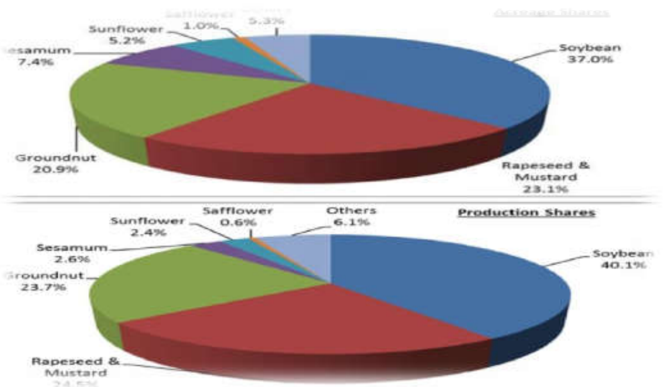


Figure 1

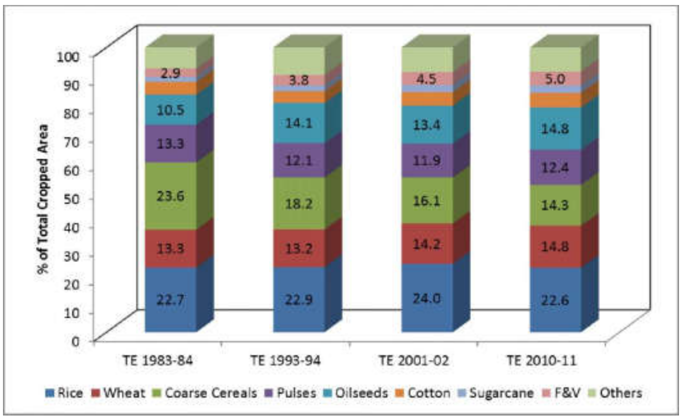


Figure2 Changing shares of major crops/crop groups in total cropped area in India: TE1983-84toTE2010-11

Table 4 Trends in the average area (million ha), production (million tonnes), and yield (kg/ha) of oilseeds in India

Year	1951-52 to 1960-61	1961-62 to 1970-71	1971-72 to 1980-81	1981-82 to 1990-91	1991-92 to 2000-01	2001-02 to 2011-12
Area	12.4	15.2	17.0	20.1	25.5	25.8
Production	6.1	7.6	9.2	13.6	21.3	25.6
Yield	488	497	538	671	836	989

Importance of Oilseeds in Indian Agriculture

Indian agriculture has made considerable progress, particularly in respect of food crops such as wheat and rice in irrigated areas; however, performance has not been so good in case of other crops particularly oilseeds, pulses, and coarse cereals. Therefore, after achieving self- sufficiency in food grains the government is focusing attention on these agricultural commodities. The oilseed sector has been an important area of concern and interventions for Indian policy makers in the post-reforms period when India became one of the largest importers of edible oils in the world, importing about half of domestic requirement in the 1990s.

On the oilseeds map of the world, India occupies a prominent position, both in regard to acreage and production. India is the 4th largest edible oil economy in the world and contributes about 10 per cent of the world oilseeds production, 6-7% of the global production of vegetable oil, and nearly 7 percent of protein meal. This sector also has an important place in the Indian agricultural sector covering an area of about 26.5 million hectares, with total production of over 29 million tone's in the triennium ending 2011-12 This constitutes about 14.8 per cent of the gross cropped area in the country. The oilseeds accounted for about 9.8 per cent (at 2004-05 prices) of the total value of output from agriculture in TE 2011-12 A wide range of oilseed crops is produced in different agro-climatic regions of the country. Three main oilseeds namely, groundnut, soybean, and rapeseed-mustard accounted for over 88 per cent of total oilseeds output during the TE2011-12. Soybean is the most important crop with an estimated production of 11.6 million tonnes in TE2011-12 grown mainly in Madhya Pradesh, Maharashtra, and Rajasthan accounting for more than 95 per cent of total production. The second most important oilseed crop is rapeseed-mustard (7.1 million tonnes) mainly grown in Rajasthan, Madhya Pradesh, Haryana, Uttar Pradesh, West Bengal and Gujarat with an estimated share of about 93 per cent in total production in the country. Groundnut, which was the largest oilseed crop in the 1990s, lost its share and Is now 3 important oilseed with an average production of 6.9 million tonnes in TE2011-12 and grown in Gujarat, Andhra Pradesh, Tamil Nadu, Rajasthan, Karnataka and Maharashtra with a combined share of about 91 per cent in total groundnut production in the country.

Other important edible oilseeds are sesamum, sunflower and safflower. Apart from West Bengal (21.3%) and Rajasthan (21.2%), Madhya Pradesh (16.8%) and Gujarat (14.1%) are other major sesamum producing states in the country. Karnataka (37.3%), Andhra Pradesh (27.2%) and Maharashtra (14.6%) account for about 80 percent of total sunflower production in the country, but production of sunflower has remained more or less constant with high variability during the last one and half decade. Safflower production has witnessed a steady decline and Maharashtra (54.7%), Karnataka (27.9%), and Gujarat (12.7%) are major producers with a share of over 95 percent in total production.

Nutritional Importance

- Rich source of oil contains about 20-60%.
- Oil contain linoleic acid, linolenicacids,V it. A, E,provitaminetc
- Linoleic and linolenic acids lowers the fat and cholesterol contents of blood and hence the oils containing such acid groups are important for prevention of coronary sclerosis.

Table 5 major source of micro nutrients minerals

Fe	Hornbleude, hametite, goethite, pyrite, magnetite, olivine.
Mn	Pyrolusite, maganite, rhodonite,
Cu	Chalcopyrite, covelite, cuprite, malachite.
Zn	Sphalarite, smithsonite,
B	Tourmaline, colemanite, borex, kernite.
Cl	Apatite, murate of potash, sodium chloride.
Mo	Molybdenite, wulfenite, ferrimolybdenite.
Ni	Serpentine, olivine.

Table 6 form of micronutrients absorbed by plants

Micronutrients	Ionic forms
Fe	Fe^{2+},Fe^{3+}
Mn	Mn^{2+} , Mn^{4+} .
Cu	Cu^{2+}
Zn	Zn^{2+}
B	$H_2Bo^-_3$, HBo^{2-}_3 , Bo^{3-}_3 , $B_4o_7^{2-}$
Cl	Cl^-
Mo	Mo O_4^{2-}
Ni	Ni^{2+}

Table 7 Micronutrients essentiality discoverer

Micronutrients	Discoverer
Fe	Griss – 1843
Mn	Mcharergue – 1922
Cu	A.L.Sommer and C.B.Lipman -1931
Zn	A.L.Sommer and C.B.Lipman -1926
B	Waringdon – 1923
Cl	T.C.Broger – 1954
Mo	Aronon and Stout – 1939
Ni	Brown , Welch and Cary -1987

Table 8 Micronutrients Amount in the Soil

Micronutrients	Range	Average
Fe	0.5 – 50 %	3 -4 %
Mn	20 – 3000 ppm	600 ppm
Cu	2 – 100 ppm	9 ppm
Zn	10 -300 ppm	50 ppm
B	2 – 200 ppm	50 ppm
Cl	1 -100 ppm	50 ppm
Mo	0.2 -5.0 ppm	1.2 ppm
Ni	2 -750 ppm	5.0 ppm

Functions and Deficiency Symptoms of Micronutrients in Plants

This sub-section briefly provides a few examples of key functions and physical deficiency symptoms for Zn, Fe, Mn and Cu. When the amount of micronutrients removed by crops exceeds the amount supplied by soils and fertilizers, the result is micronutrient deficiency in food products. Micronutrient deficiency in crops is reflected by different symptoms expressed in different forms, depending on the specific element. Some of the specific functions and deficiency symptoms for the four MNs have been reported widely. In general, the published scientific literature indicates that micronutrients tend to be immobile in plants.

Iron Major Function

- Important constituent of two group of protein

1.Heme- protein 2. Fe-S protein

- Iron is involved in the production of chlorophyll.
- Oxygen carrier.
- Nucleic acid metabolism.
- Chlorophyll synthesis.
- Protein synthesis.
- Act as catalyst in N_2 Reeducates
- Structural component of phorphyrin molecules.
- Required for nitrogen fixation.

Iron-Deficiency Symptoms

- younger leaves exhibit interveinalchlorosis. Without dead spot this is the only symptom - Iron
- Plant having ≤ 50 ppm (30ppm) Fe, than Fe deficiency will occur.
- Whole plants turning – necrotic.

Manganese-Major Function

- Manganese is necessary in photosynthesis, nitrogen metabolism and to form other compounds required for plant metabolism.
- Important constituent of Suproxide – dimutase (Mn-SOD).
- It take part in electron transport in photosysytem -2.
- Mn act as enzyme activation, and this enzyme produce amino acid.

Deficiency Symptoms

- In addition to interveinalchlorosis on young leaves, grey or tan necrotic spots develop in chlorotic areas.
- Plant containing less than 25 ppm Mn then deficiency symptoms will occur.
- Common micro deficiency for soybean and small grains

Susceptible soils:

- High pH (alkaline) soils (>6.8)
- High organic matter soils (>6%)

Copper-Major Function

- Copper is necessary for carbohydrate and nitrogen metabolism.
- Electron carrier in oxidation –reduction reaction.
- Utilization of iron in chlorophyll synthesis.
- Enhance the fertility of mala flower.
- Enhance disease resistance in plants

Deficiency Symptoms

While younger leaves have interveinalchlorosis, the tips and lobes of leaves remain green followed by veinalchlorosis and rapid, extensive necrosis of leaf blade

ZINC-Major Function

Zinc is an essential component of three enzymes

1. Carbonic anhydrase.
2. Alcoholic dehydrogenase.
3. Suproxide dismutase. For energy production, protein synthesis, and growth regulation.

- Important in the synthesis of IAA.
- Essential for water uptake.
- Play important role in stablization of protein.

Deficiency Symptoms

- Plant containing less than 15 ppm Zn than deficiency symptoms will occur.
- Intervinalchlorosis first appear in younger leaves.
- Reduse the size of the leaves- little leaf.
- Mainly occur in calcareous soils.

Boron– Major Function

- A primary function of boron is related to cell wall formation.
- Important for pollination and pollen germination.
- Help in k translocation as well as stomatal opening.
- Calcium metabolism.
- Act as regulator of k/Ca ratio.
- Essential for translocation of sugar.

Deficiency Symptoms

- Terminal buds die giving rise to a witch's broom.
- Young leaves become very thick and leathery and chlorotic.
- Rust-coloured cracks and corking occur on young stems, petioles and flower stalks.
- Young leaves crinkled.
- Common deficiency for alfalfa and other forages
- Susceptible soils: Sands and low OM soils, Dry soils.

Molybdenum-Major Function

- Mo is important constituent of nitrogenaseenzyme, which help in N_2 fixation in legumes crops.
- Mo is essential component of NO_3^-reductase enzymes. this enzyme concerted in chloroplast which catalzes the conversion of NO_3^- to NO_2^-
- protein synthesis and sulfur metabolism are also affected by molybdenum.
- Molybdenum has a significant effect on pollen formation.
- Also reported to have an essential role in iron absorption and translocation in plants.

Mo - Deficiency Symptoms

- The deficiency symptoms of Mo is first appear In Older leaves, interveinalchlorosis with some dead spots.

Chlorine – Functions

- Essential for stomatal opening.
- Cl is related to electrical charge balance in physiological functions in plants.
- It indirectly affects plant growth by stomatal regulation of water loss.

Deficiency Symptoms

- Highly branched root systems are the main chloride-deficiency symptoms, which are found mainly in cereal crops.
- Chloride deficiencies have been reported on sandy soils,humid region with high rainfall area.
- Wilting and twisting in wheat due to Cl deficiency.

Soil Factors That Affect the Availability of Micronutrients Organic Matter

Mineral soils very low in organic matter, such as Gray soils, may be deficient in micronutrients. Peaty and muck soils are likely to show micronutrient deficiencies.

Soil Texture

Sandy soils are more likely to show micronutrient deficiencies than claysoils.

Soil pH

Micronutrient availability generally decreases as the soil pH increases, with the exception of Mo.

Temperature and Moisture

Micronutrients availability decreases at low temperatures and moisture content because of reduced root activity, low rates of dissolution and diffusion of nutrients.

Plant Factors

Plant factors such as root morphology (length, density, volume, surface area), root induced changes (secretion of H+, OH-, HCO''^3 ions), root exudation of organic acids (citric, malic, tartaric, oxalic, phenolic), sugars, amino acids (phytosiderophores), secretion of enzymes (phosphatase), plant demand, plant species/ cultivars and microbial associations (release of CO2, PGR, enzymes, rhizobia, mycorrhizae etc.) have profound influences on plant ability to absorb and utilize micronutrients from soil.

Micronutrient uptake by roots depends on nutrient concentrations around root surfaces, root absorption capacity and plant demand. Nutrient uptake by plant is a dynamic process in which nutrients are continuously replenished in soil solution from the soil solid phase, and then transported to roots as uptake proceeds. In soil system nutrients move to plant roots by (i) mass flow (ii) diffusion and (iii) root interception (Barber, 1995). More than 90-95% of N, B, Cu, Zn and considerable quantity of Fe (65%) supplied to plants is by mass flow.

Micronutrient Uptake

Considerable quantities (>80% in case of P, K) of Mn, B and Fe (>20%) move by diffusion. Root interception can provide significant amount of plant requirements for B, Zn and Mn.

Micronutrient Interactions

The micronutrient interactions among the various nutrients also influences and changes the nutrient concentrations in plants as well as growth responses. The concentration of one micronutrient in soil plant system may affect the level of other micronutrients through a process called antagonism. For example, too much iron may produce manganese and zinc deficiencies, while high levels of manganese may result in iron and zinc deficiencies. Copper and zinc are also antagonistic.

Table 9 Availability of Micronutrients as Affected by Antagonism in soil

Micronutrients Element	Availability reduced by
Boron	Organic nitrogenous fertilizer and high levels of phosphorus
Copper	High levels of zinc, nitrogen and phosphorus
Iron	High levels of copper, manganese and zinc, and phosphorus

Manganese	High levels of potassium, phosphorus, iron, copper and zinc
Molybdenum	High levels of manganese, and nitrate nitrogen Fertilizer
Zinc	High level of copper and phosphorus

Forms of Micronutrient Fertilizer

Sulphate (salts)

The sulphate form of micronutrients such as Cu, Zn, Fe and Mn represent a water-soluble form that is plant available. Sulphates are the most commonly used form. Sulphates can be applied to the soil or foliage. Sulphate products, applied at agronomically recommended rates, can provide long term residual value.

Oxysulphate

An oxysulphate is an oxide of a micronutrient that has been partially reacted with sulphuric acid. In the year of application, the oxide portion is not nearly as available as the sulphate portion. The amount of sulphate in the product varies. Water solubility of oxysulphates can vary greatly. It is generally accepted that a minimum of 50 per cent water solubility is required for the micronutrient to be a readily available nutrient source. In general, the higher the water solubility portion, the better. Residual value is similar to sulphates.

Oxide

Micronutrient elements (Cu, Zn, Fe, and Mn) bonded with oxygen form oxides. The bonds with oxygen are very strong, meaning these products are not soluble in water and are not in plant available form. An oxide of a micronutrient needs to be converted to a plant available form in the soil before being taken up by the plant. Oxides represent the final form to which other forms are eventually converted and may then be slowly converted back to plant available form. For crop response during the growing season, plant available forms (water-soluble forms) of micronutrients need to be used. Pure oxide forms are less commonly used.

Chelate

Micronutrients such as Cu, Fe, Mn, and Zn are held within ring-type compounds. Chelated micronutrients remain in plant-available form longer because the chelated structure slows the micronutrient reaction with soil minerals.

There are a large number of chelating agents. For example, a synthetic chelating agent is EDTA, and a natural chelating agent is citric acid. Chelated micronutrient products are not all equally available to the plant. Chelated micronutrients can be soil or foliar applied. Chelates are generally many times more expensive than the sulphate or oxide forms on a per pound actual micronutrient basis. Chelated products applied at label rates have no residual value. Soil applied chelates at recommended rates only last for one year. Follow label rates and directions. Chelates are more commonly used now than in the past.

Manure

Livestock manure can be a source of micronutrients such as Cu and Zn. Repeated applications of manure have been shown to increase the content of available Cu and Zn.

Other Forms

Carbonates and nitrates and mixtures with elemental forms are examples of other forms, but are seldom used.

Application with Mixed Fertilizers

The most common method of micronutrient application for crops is soil application. Recommended application rates usually are less than 10 lb/acre (on an elemental basis), so uniform application of micronutrient sources separately in the field is difficult. Therefore, both granular and fluid NPK fertilizers are commonly used as carriers of micronutrients. Including micronutrients with mixed fertilizers is a convenient method of application, and it allows more uniform distribution with conventional application equipment. Costs are also reduced by eliminating a separate application. Four methods of applying micronutrients with mixed fertilizers are:

- Incorporation with granular fertilizers: Incorporation during manufacture results in uniform distribution of micronutrients through granular NPK fertilizers.
- Bulk blending with granular fertilizers: Bulk blending produces fertilizer grades that provide the recommended micronutrient rates. Unfortunately, nutrient segregation is common, resulting in uneven nutrient distribution.
- Coating onto granular fertilizers: Coating powdered micronutrients onto granular NPK fertilizers decreases the possibility of segregation.
- Mixing with fluid fertilizers: Mixing micronutrients with fluid fertilizers has become a popular method of application, compatibility tests should be made before tank-mixing operations of micronutrients with fluid fertilizers. Suspension fertilizers are used as micronutrient carriers as well.

Foliar Sprays

Foliar sprays are widely used to apply micronutrients, especially iron and manganese, for many crops. Soluble inorganic salts generally are as effective as synthetic chelates in foliar sprays, so the inorganic salts usually are chosen because of lower costs. Suspected micronutrient deficiencies may be diagnosed with foliar spray trials with one or more micronutrients, but tissue sampling is the most common method to determine deficiencies during the growing season. Correction of deficiency symptoms usually occurs within the first several days, and then the entire field could be sprayed with the appropriate micronutrient source. Inclusion of sticker-spreader agents in the spray is suggested to improve adherence of the micronutrient source to the foliage. Caution should be used because of leaf burn due to high salt concentrations or inclusion of certain compounds in foliar sprays.

Advantages of Foliar Sprays

Application rates are much lower than rates for soil application.

- Uniform application is easily obtained.
- Response to the applied nutrient is almost immediate, so deficiencies can be corrected during the growing season.

Disadvantages of Foliar Sprays

- Leaf burn may result if salt concentrations of the spray are too high.

- Nutrient demand often is high when the plants are small and leaf surface is insufficient for foliar absorption.
- Maximum yields may not be possible if spraying is delayed until deficiency symptoms appear.
- There is little residual effect from foliar sprays.
- Application costs are higher if more than one spray is needed unless they can be combined with pesticide spray applications

Table 10 Optimum Methods and Rates of Micronutrients Application

Zinc	5-6 kg Zn/ha as basal soil application
Iron	3-4 sprays of 0.5-1.0% ferrous sulphate at 10 day intervals
Manganese	3-4 sprays of 0.5-1.0% manganese sulphate is better than its soil application @ 40-50 kg/ha
Boron	0.5-2.5 kg B/ha. Soil application is better than foliar spray or seed- soaking

Since importance of micronutrients is increasing beyond soil and plant system and nutritional security of the people of country is becoming a crucial concern, some systematic studies on micronutrient in soil-plant-animal- human continuum need to be conducted to find out effect of micronutrients deficiencies in soils, on animal and human health.

RESULT AND DISCUSSION

Groundnut

Table 11 Effect of Boroson on Shelling Percentage, Oil Content, Cost of Cultivation, Gross Returns, Net Returns and B: C Ratio of Groundnut

Treatments	Shelling percentage	Oil content (%)	Cost of cultivation	Gross returns	Net returns	B : C Ratio
Borosan 12.5 kg/ha at sowing	67	34.6	19300	51000	31700	2.64
Borosan 25 kg/ha at sowing	67	34.8	19500	56700	37200	2.91
Borosan 37.5 kg/ha at sowing	68	35.1	19700	65400	45700	3.31
Borosan 12.5 kg/ha at sowing and 12.5 kg/ha at 20 DAS	67	35.9	19500	57150	37650	2.93
Borosan 25 kg/ha at sowing and 12.5 kg/ha at 20 DAS	69	35.1	19700	60900	41200	3.10
Borosan 12.5 kg/ ha at sowing and 25 kg/ha at 20 DAS	71	35.0	19700	60150	40450	3.05
Control	65	34.5	19100	43050	23950	2.25
SEm ±	1.2	1.3	-	-	-	-
CD. (5%)	3.3	NS	-	-	-	-

(Source:Yenagi *et.al.*,2015)

The results indicated that different levels of borosan had significant effect on growth, yield parameters and yield of groundnut (Table 11). The crop responded linearly up to 37.5 kg ha^{-1} Application of 37.5 kg borosan along with 100 % recommended NPK at the time of sowing recorded significantly highest pod yield of 2180 kg ha^{-1} and haulm yield of 5200 kg ha^{-1} as compared to control: 100% recommended dose NPK(1435 and 3300 kg ha^{-1} of pod and haulm yield, respectively).

The yield increase was to the tune of 51.92% over control.The positive response to borosan with recommended NPK can be attributed to the availability of sufficient amount of plant nutrients throughout the growth period resulting in better uptake and yield advantage.

The influence of the combined application of $ZnSO_4$ + Borax along with NPK excelled all other treatments in significantly increasing the zinc and boron uptake by groundnut at different stages. Among the various treatments, the highest Zn uptake by pod (322.68 g ha^{-1}) and haulm (224.44 g ha^{-1}) was recorded with the application of 150 per cent NPK + $ZnSO_4$ @ 30 kg ha^{-1} + borax @ 15 kg ha^{-1}. The uptake of B also followed the same trend like Zn by recording a boron uptake of 3.86 g ha^{-1} in pod and 6.68 g ha^{-1} in haulm, respectively at harvest. This was followed by treatment T_5 and T_4. The NPK application alone without micronutrients recorded a lower zinc and boron uptake. The application of $ZnSO_4$ @ 30 kg ha^{-1} + borax @ 15 kg ha^{-1} along with 150 per cent NPK and organic waste *i.e.,* composted coirpith @ 12.5 t ha^{-1} significantly promoted the nutrition of Zn and B by groundnut. The increased nutrient uptake might be due to supply of these nutrients from the applied micronutrient fertilizers. Further the added organics might have increased the nutrient availability through enhanced mineralization and chelation action which facilitated greater absorption and utilization of these nutrients. The earlier reports of Latha *et al.* (2002) and Sumangala (2003) support the present findings.

Table 12 Effect of ZINC and Boron on the Growth and Yield of Groundnut

Treatments	Plant height (cm)			Dry matter production (kg ha^{-1})			Yield (kg ha^{-1})	
	FS	PFS	HS	FS	PFS	HS	Pod	Haulm
Ti-Control	19.78	30.25	42.74	1212	1819	3473	1463	2232
T_2-100% NPK	23.63	34.90	48.6	1350	2073	4017	1878	2663
T_3-150% NPK	26.34	37.95	52.6	1549	2301	4374	2080	2854
T_4-150% NPK + Zn @ 30 kg ha^{-1}	28.68	40.69	57.0	1676	2490	4695	2213	3032
T_5-150% NPK + B @ 15 kg ha^{-1}	30.84	43.30	61.1	1788	2637	5012	2345	3187
-150% NPK + Zn @ 30 kg ha^{-1} + B @ 15 kg ha^{-1}	32.95	45.88	65.1	1884	2768	5296	2466	3354
SEd	0.91	1.15	1.65	40.7	57.54	126.49	52.50	72.00
CD (p=0.05)	1.87	2.35	3.40	83.8	118.54	260.56	108.16	148.32

*fs- flowering stage; pfs- peg formation stage; hs- harvest stage (Source: Elayaraja and Singaravel, 2012),

Table 13 Effect of Zinc and Boron on The Major Nutrients Uptake (Kg ha^{-1}) By Groundnut

Treatments	Nitrogen				Phosphorus				Potassium			
	FS	PFS	HS Pod	HS Haulm	FS	PFS	HS Pod	HS Haulm	FS	PFS	HS Pod	HS Haulm
T_1-Control	25.03	36.85	39.29	31.89	4.91	5.83	5.65	7.09	31.53	42.32	14.15	36.94
T_2-100% NPK	34.87	46.96	54.85	44.38	5.13	7.51	7.50	9.39	36.10	52.83	21.93	48.29
T3-150% NPK	38.65	55.85	63.21	51.86	7.86	8.36	8.69	10.10	44.92	59.84	24.06	54.08
T4-150% NPK + Zn @ 30 kg ha^{-1}	44.12	61.23	71.20	56.79	8.08	10.54	9.84	11.12	48.09	65.30	28.15	59.30
T_5-150% NPK + B @ 15 kg ha^{-1}	48.17	65.39	79.12	62.23	9.29	11.01	10.60	13.63	54.38	72.81	31.38	65.16
T_6-150% NPK + Zn @ 30 kg ha^{-1} + B @ 15 kg ha^{-1}	54.02	72.55	85.05	68.85	10.04	12.39	11.89	14.23	59.78	79.61	36.83	73.65
SE +	1.37	1.82	2.50	1.74	0.30	0.36	0.28	0.40	1.48	2.00	0.96	1.97
CD (p=0.05)	2.83	3.75	5.14	3.59	0.61	0.75	0.58	0.82	3.05	4.12	1.97	4.06

*fs- flowering stage; pfs- peg formation stage; hs- harvest stage (source: Elayaraja and Singaravel 2012),

Table 14 Effect of FYM, iron and zinc on yield attributes and economics of groundnut

Treatments	Number of pods plant^{-1}	Pod weight (g plant^{-1})	100 Kernels weight(g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Gross Net realization (^ha^{-1})	BCR realization (^ha^{-1})	
[A] FYM levels:									
F_0 : 0 t ha^{-1}	15.8	11.3	40.4	2335	3741	38.4	112598	83795	1:2.90
F° : 5 t ha^{-1}	17.3	12.5	43.0	2709	4127	39.5	130182	85899	1:1.93
S.Em ±	0.4	0.2	0.5	51.9	65.6	0.4			
C.D. (0.05)	1.1	0.7	1.6	150.9	190.5	NS			
[B] Fe-Zn level:									
M_1 : No Application	15.2	10.1	39.0	2226	3638	37.8	107479	78676	1:2.73
M_2 : 2.5 kg Fe ha^{-1}	16.5	12.4	41.5	2556	3941	39.3	122902	93453	1:3.17
M_3 : 2 kg Zn ha^{-1}	15.5	10.8	39.3	2321	3674	38.7	111793	82509	1:2.81
M_4 : 2.5 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	16.7	12.6	42.3	2569	3981	39.2	123604	93674	1:3.12
M_5 : 5 kg Fe ha^{-1}	17.7	12.7	44.2	2633	4091	39.1	126668	96705	1:3.22
M_6 : 4 kg Zn ha^{-1}	15.7	11.0	41.3	2453	3864	38.8	118123	88478	1:2.98
M_7 : 5 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	18.8	13.9	44.3	2899	4350	39.8	139155	108350	1:3.51
S.Em ±	0.7	0.4	1.0	97.1	112.6	0.8			
C.D. (0.05)	2.0	1.3	2.9	282.3	356.5	NS			
Interaction:									
F x M	NS	NS	NS	NS	NS	NS			
C.V.%	10.3	9.0	5.9	9.4	7.6	4.8			
(source: Rahevar *et.al.*,2015)									

The results of the present investigation clearly indicated that for increasing the growth, yield and nutrient uptake by groundnut, application of 150 per cent NPK + $ZnSO_4$ @ 30 kg ha^{-1} + borax @ 15 kg ha^{-1} + composted coirpith @ 12.5 t ha^{-1} would be beneficial effect of micronutrient on groundnut.

The remarkable increase in mean values of dry matter and yield attributes of groundnut was noted due to application of iron and zinc. Dry matter production was significantly influenced due to application of 5 kg Fe ha^{-1} + 4 kg Zn ha^{-1} along with recommended dose of N and P (Table 14).Enhanced dry matter production might be due to improvement in nutrient uptake particularly iron and zinc along with NP that have favorably influenced on carbohydrate metabolism and favorable sustained availability of nutrients that increased transformation of photosynthetic activity towards growing plant parts. Similar findings were observed by Thomas *et al.* (2010).

Data indicated in Table showed that there was a significant increase in yield attributes such as number of pods per plant, pod weight per plant, 100 kernel yields, pod and haulm yield due to application of 5 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. Pod and haulm yield may be increased due to increase in the yielding attributes such as number of pods per plant, pod weight per plant and 100 kernel weight in these treatments.

These increases in the yield components and yield may be attributed to the balanced nutrition of crop with the application of Fe and Zn supplementation along with recommended dose of N and P might be due to low content of Fe (3.30 mg kg^{-1}) and Zn (0.48 kg ha^{-1}) in the experimental plot. Iron is a structural component of porphyrin molecules: cytochromes, hemes, hematin, ferrichrome and leghemoglobin. These substances are involved in oxidation reductions in respiration and photosynthesis. It performs an essential role in nucleic acid acidmetabolism. It is essential, for many of the enzymatic transformations. Thus iron helps indirectly in crop production. Likewise zinc is also involved in many enzymatic activities. It is important in the synthesis of tryptophan, a component of some proteins and a compound needed for the production of growth hormones like indole acetic acid.

The maximum net realization of 1,08,350 ha^{1} with BCR of 3.51 was secured due to application of 5 kg Fe ha^{-1} + 4 kg Zn ha^{-1} (M_7) which was closely followed by application of 5 kg Fe ha^{1} (M_5) 96,705 ha^{1} with BCR of 3.22. The lowest net realization of ^ 78,676 ha^{1} with BCR of 2.73 was obtained under no application of iron and zinc (M_1) (Table 14).

The higher monetary return under treatment M_7 is mainly on account of more yield and favorable response of groundnut to the Fe and Zn level.

Table 15 Nitrogen (N), Phosphorous (P) and potassium (K) content in haulm and kernels of groundnut as influenced by zinc and boron application

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel
T_1- Control (RDF)	1.02	3.40	0.27	0.46	1.31	2.21
T_2- (T_1 + $ZnSO_4$ @ 5 Kg ha-`-^{1}) -	1.04	3.49	0.28	0.51	1.33	2.29
T_3- (T_1 + $ZnSO_4$ @ 10 Kg ha-"-^{1})	1.05	3.51	0.29	0.53	1.36	2.41
T_4- (T^1 + $ZnSO_4$ @ 20 Kg ha-`-^{1})	1.06	3.59	0.30	0.59	1.38	2.50
T_5- (T_1 + Borax @ 5 Kg ha-`-^{1})-	1.03	3.45	0.28	0.48	1.33	2.28
T_6- (T + ZnSO4 @ 5 Kg ha-`-$^{1\text{`}}$) -	1.04	3.53	0.32	0.54	1.36	2.41
T_7- (T_5 + $ZnSO_4$ @ 10 Kg ha-`-^{1})	1.06	3.56	0.34	0.59	1.39	2.49
T_8- (T_5 + $ZnSO_4$ @ 20 Kg ha-`-^{1})	1.07	3.66	0.39	0.63	1.42	2.60
S.Em ±	0.02	0.02	0.01	0.01	0.01	0.03
CD@ 5%	NS	0.07	0.03	0.03	0.04	0.11

(Source: Nadaf and Chidanandappa, 2014)

Table 16 Total uptake of primary and secondary nutrients by groundnut as influenced by zinc and boron application Treatments Uptake of nutrients by groundnut (kg ha^{-1})

Treatments	(N)	(P)	(K)	(Ca)	(Mg)	(S)
T_1- Control (RDF)	70.56	13.65	67.11	27.61	18.09	12.96
T_2- (T_1 + $ZnSO_4$ @ 5 Kg ha-$^{-1}$) -	78.50	15.94	74.09	31.07	18.58	20.54
T_3- (T_1 + $ZnSO_4$ @ 10 Kg ha-$^{-1}$)	82.60	17.96	78.49	32.88	19.80	22.48
T_4- (T^1 + $ZnSO_4$ @ 20 Kg ha-$^{-1}$)	91.14	20.92	87.61	36.37	20.31	26.27
T_5- (T_1 + Borax @ 5 Kg ha-$^{-1}$)	76.73	15.31	72.37	30.32	18.43	14.55
T_6- (T + ZnSO4 @ 5 Kg ha-$^{-1}$)	83.01	18.29	79.65	33.53	19.95	22.39
T_7- (T_5 + $ZnSO_4$ @ 10 Kg ha-$^{-1}$)	89.14	20.80	86.27	35.98	20.54	25.48
T_8- (T_5 + $ZnSO_4$ @ 20 Kg ha-$^{-1}$)	95.72	23.50	92.68	38.34	20.87	28.16
S.Em ±	1.41	0.65	1.47	0.57	0.94	0.55
CD@ 5%	4.27	1.97	4.47			

(Source: Nadaf and Chidanandappa, 2014)

Among the secondary nutrients uptake Mg uptake was not affected by the imposed treatments. While, Ca uptake was significantly increased due to the application of borax and zinc sulphate either separately or in combination (Table 16). This is probably because of increase in the haulm and kernel yields of groundnut.

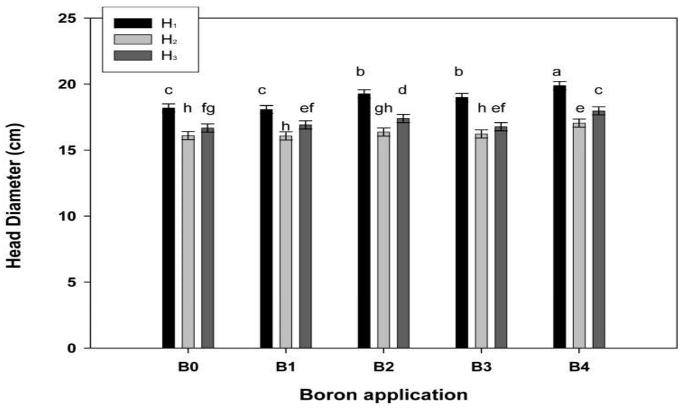
Sunflower

It was obvious from the results that sunflower hybrid Patron 551 and foliar application of B (200 mgL^{-1}) at ray floret stage brought maximal results. So farming community should prefer sunflower hybrid Patron 551 over other Patron 851 and S-278 hybrids and foliar application of B (200 mgL^{-1}) at ray floret stage should be practiced under semi-arid conditions of Faisalabad for robust and healthy crop.

Table 17 Effect of Different Methods of Boron Application on Growth and Yield of sunflower hybrids.

Treatments	No. of leaves per plant	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	No. of achenes per head	1000-achene weight (g)	Achene yield (kgha^{1})	Biological yield (kgha^{1})	Harvest index (%)
H_1	26.13 A	175.67 A	1.81 A	18.88 A	1283.40 A	44.55 A	2019.93 A	9401.07 A	21.48 A
H_2	20.80 B	134.40 B	1.58 B	16.37 C	1153.67 B	36.87 C	1854.20 C	9049.20 B	20.48 C
H_3	20.93 B	135.07 B	1.50 C	17.14 B	1119.76 C	41.51 B	1911.53 B	9072.47 B	21.08 B
LSD ($p < 0.05$)	0.69	5.93	0.047	0.07	23.166	1.409	24.197	27.451	0.236
B_1	21.89 B	140.67 C	1.61 B	16.99 D	1142.22 C	39.82 B	1866.56 D	9117.33 C	20.49 D
B_2	22.67 AB	144.22 BC	1.61 B	17.02 D	1152.96 C	40.07 B	1876.44 D	9129.78 C	20.54 CD
B_3	23.33 A	156.78 A	1.70 A	17.67 B	1199.11 B	41.37 AB	1948.56 B	9223.11 A	21.12 B
B_4	22.56 AB	149.44 AB	1.60 B	17.33 C	1167.30 C	40.46 B	1911.89 C	9180.33 B	20.81 BC
B_5	22.67 AB	150.78 AB	1.62 B	18.30 A	1266.44 A	43.17 A	2039.33 A	9220.67 A	22.10 A
LSD ($p < 0.05$)	0.89	7.65	0.060	0.138	29.908	1.819	31.238	35.439	0.305
H x B interaction	Ns	Ns	Ns	See Figure 2	Ns	Ns	Ns	Ns	Ns

Source: Imran Khan *et al*., 2015



(Source: Imran Khan *et al*., 2015)

Figure 3 Effect of different methods of boron application on Head diameter (cm) of sunflower hybrids. H = Patron 551, H_2 = 851, H_3 = S-278, B_0 = No B application, B_1 = Seed priming with B (0.05%), B_2 = Soil B application (2 kg-ha^{-1}) at sowing, B_3 = Soil B application (2 kg-ha^{-1}) at ray floret stage, B_4 = Foliar application of B (200 mg-L^{-1}) at ray floret stage. The head diameter of ten plants for all the treatments was measured with the help of measuring tape at crop maturity stage and then statistically analyzed. The bars indicate the interaction between sunflower hybrids and boron application methods.

In the present study, foliar spray of zinc sulphate (0.1 %) at ray floret stage recorded significantly maxirnum capitulum diameter (12.34 cm), total number of seeds (582.3), number of filled seeds (434.3) and filled seed weight (14.4 g) per capitulum and followed by soil application of zinc sulphate (20 kg/ha). Foliar spray of $ZnS0_4$ at the rate of 0.1 % significantly increased the components of sunflower cultivars as influenced by seasons.

Seed Yield and Physiological Traits

The data on physiological traits of sunflower during flowering phase revealed that the application of Zn and B micronutrients significantly increased the values of DM, LAI, LAD, CGR and NAR at flowering. The optimal response was noted with the application of 15-1.5 Zn-B kg ha^{-1}. Beyond this dose, there were no further significant increases were detected. This micronutrient treatment showed maximum response in dry matter (1150.12 g m^{-2}), leaf area index (5.26), leaf area duration (51.34 days), crop growth rate (7.39 g day^{-1} m^{-2}), net assimilation rate (22.11 gday^{-1} m^{-2}) and superior seed yield at harvest (2251.03 kg ha^{-1}) were observed with application of 15 kg Zn and 1.5 kg B ha^{-1} respectively. The results of the experiment are fully supported by (Patil *et al.,* 2006) that soil application of $ZnSO_4$ (10 and 20 kg ha^{-1}) and borax (2 kg ha^{-1}) were the best treatments in increasing seed yield and quality of sunflower. Further, significant effect of micronutrients were reported in several studies, found increases in plant growth and yield in response to micronutrient application reported that addition of 20 kg Zn ha^{-1} significantly increased seed production and shoot dry-matter yield of sunflower. The application of micronutrients on growth of sunflower, in terms of seed yield, dry matter, leaf area index, leaf area duration, crop growth rate and net assimilation rate can be interpreted in terms of the metabolic function of micronutrients in the plant observed that the combined application of Zn (5.25 kg ha^{-1}) and B (6.3 kg ha^{-1}) exhibited yield increases over unfertilized controls.

The results of the study are also supported by Neena and Chatterjee (2001) who reported that biomass, capitulum size, seed number, seed weight, concentration of chlorophylls a, b and soluble proteins were higher at 0.065 mg Zn L^{-1} and significantly low under deficiency and excess of zinc. For the seed oil content in sunflower, they observed that it was highest (23.4%) at 0.65 mg Zn L^{-1}. Mirzapour and Khoshgoftar (2006) found the concentration of Zn in sunflower leaves increased with an increase in soil added Zn of from 0 to 60 kg Zn ha^{-1} and highest leaf Zn concentrations was achieved by the foliar application of $ZnSO_4$.

Table 18 Effect of Boron and ZINC on Seed Yield and Its Attributes of Restorer Line Sunflower RHA-857

					No. of	Filled			Valume	108	Seed	
Treatments	**Dosage (kg/ha)**	**Method of application**	**Capitulum diameter (cm)**	**No. of seeds capitulum**	**Filled seeds / capitulum**	**seed weight / cap. (g.**	**Seed set (%)**	**Seed recovery (%)**	**weight of seed (g)**	**seed weight (g)**	**yield /plant (g)**	**Seed yield (kg/ha)**
T, -Borax	2kg	Dusting	12.81	602.8	452.3	15.8	74.2	91.5	28.4	4.25	18.57	722.3
T, - Borax	0.1%	Foliar	13.74	638.8	488.5	17.1	75.5	92.9	28.5	4.30	20.12	784.1
T, -ZnSO4	10	spray Soil	11.91	542.2	393.6	13.4	71.3	89.6	26.4	4.08	15.72	612.3
T_4 - ZnSO4	20	Soil	12.17	569.1	416.6	13.1	72.3	90.3	27.1	4.14	16.82	652.4
T,-ZnSO4	0.1%	Folfiar	12.34	582.3	434.3	14.4	73.1	90.9	27.1	4.17	17.36	674.8
T„-Control		spray	11.48	510.4	362.6	12.4	69.8	88.3	25.5	3.73	14.59	567.4
Mean			12.41	574.3	424.6	14.4	72.7	90.6	27.1	4.11	17.20	668.9
S.Em±			0.44	9.23	7.6	0.89	1.1	0.6	0.41	0.12	0.41	13.1
C.D (P=0.05)			1.26	26.2	21.9	2.55	3.1	1.8	1.17	0.35	1.18	37.5

(Source: Patil *et al*., 2006)

Nutrient Content in Plant

The incorporation of varying levels of Zn and B showed significant response for nutrient content in plant. The increased application of micronutrients increased the plant nutrient concentration. The nitrogen content in plant was increased from 0.43% to 0.48% being minimum in control and maximum in treatments receiving Zn and B at the rate 10 and 1.5 kg ha^{-1} and above. Similarly the phosphorus accumulation in plant was increased from 0.151 to 0.154% in all the treatments and slightly decreased with the incorporation of Zn and B. The potassium concentration in plants ranged between 0.758 to 0.760% showing no response of Zn and B treatments. Plant analytical results revealed that Zn increased from 15.03 mg kg^{-1} (control) to 29.38 mg kg^{-1} (20-2.0 kg ha^{-1} Zn-B treatment). Increasing rates of B increased the accumulation of B in plant which ranged from 12.38 mg kg^{-1} (control) to 14.88 mg kg^{-} under 20- 2.0 kg ha^{-1} Zn -B (Table 20).

Sesame

This experiment concluded that, application of*Azospirillum* as seed treatment, recommended dose of NPK, soil application of $MnSO_4$ @ 5 kg ha^{-1}, clipping at 0 + 2 leaf stage and planofix spraying of 30 ppm at 45 DAS and at 55 DAS found to be the best production technologies to improve yield.

The sandy soil of Onattukara region is beset with severe production constraints. Proper management practices in terms of addition of fertilizers and manures and following the most suitable cropping sequence is absolutely essential to ensure a sustained crop production in the locality. It has been found that the synergism between these S and B ensured the availability of nutrients like P, K, Mg, S, B, Fe, Mn and Zn. There was a slight improvement of soil pH also Further the key to soil fertility lies with the improvement in organic matter status of the soil which was also found to be positively correlated with the addition of S and B.

Table 19 Sunflower Plant Nutrient Content As Affected By Different Zinc And Boron Levels (Mean of two years)

Zinc and Boron (kg ha^{-1})	**N (%)**	**P (%)**	**K (%)**	**Zn (mg kg^{-1})**	**B (mg kg^{-1})**	**DM At harvest (kg ha^{-1})**
0-0	0.43	0.16	0.76	15.03	12.37	8761.94
10-1.5	0.44	0.15	0.75	22.87	12.96	9236.85
10-2.0	0.45	0.15	0.75	22.98	13.37	9752.56
15-1.5	0.48	0.14	0.76	28.66	14.61	10279.09
15-2.0	0.48	0.14	0.76	28.90	14.66	10289.91
20-1.5	0.48	0.13	0.76	29.04	14.79	10293.15
20-2.0	0.48	0.13	0.76	29.05	14.88	10305.37

Table 20 Effect of Different Treatments on Seed Yield, Stover Yield and Harvest Index Percentage Sesame

Treatment	Treatment details	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T0	Control - No treatment	541.23	1907.63	22.1
T1	Recommended dose of NPK + O.M (RD)	611.13	2008.85	23.32
T2	*Azospirillum* seed treatment + RD of NPK	669.59	2147.33	23.77
T3	T_2 + Soil applicati on of $MnSO_4$ @ 5 kg ha^{-1}	729.31	2277.62	24.25
T4	T_1 + Clipping at 0 + 2 leaf stage	787.95	2371.74	24.93
T5	T_2 + Clipping at 0 +2 leaf stage	903.03	2632.09	25.54
T6	T_3 + Clipping at 0 + 2 leaf stage	957.88	2734.21	25.94
T7	T_1 + Planofix spraying of 30 ppm at 45 and 55DAS	675.05	2168.22	23.74
T8	T_2 + Planofix spraying of 30 ppm at 45 and 55 DAS	733.87	2286.31	24.29
T9	T_3 + Planofix spraying of 30 ppm at 45 and 55 DAS	825.69	2468.73	25.06
T10	T_4 + Planofix spraying of 30 ppm at 45 and 55 DAS	1016.62	2854.44	26.26
T11	T_5 + Planofix spraying of 30 ppm at 45 and 55 DAS	1080.74	2978.49	26.62
T12	T_6 + Planofix spraying of 30 ppm at 45 and 55 DAS	1160.75	3133.61	27.02
	SED	24.57	58.14	0.1
	CD (p = 0.05)	47.7	97.97	0.2

Table 21 Pre Treatment Analysis of Soil Quality Indicators at The Experiment Site

Name of indicator	Value	Class
Organic carbon(%)	0.3	Low
Available P(kg ha^{-1})	6.5	Low
Available K(kg ha^{-1})	62	Low
Exch Ca(cmol kg^{-1})	0.48	Low
Exch Mg(cmol kg^{-}1)	0.03	Low
Available S(kg ha^{-1})	10.2	Low
Available B(ppm)	0.18	Low
Ph	5.1	Acidic
EC(d Sm^{-1})	0.3	Non-saline
CEC(cmol kg^{-1})	3.2	
Bulk density Mg m^{-3}	1.58	
Water holding capacity	23.00%	
Mechanical composition		
Coarse sand Fine sand	68.55% 17.00 % 5.55	Loamy sand 8.35%
Silt Clay Texture	%	Loamy sand

(Source: Jeena mathew and Sumam George, 2012)

Table 22 Effect of S And B on The Grain Yield of Economics of Its Cultivation

Treatments	Grain yield (kg ha^{-1}) First crop	Grain yield (kg ha^{-1}) Second crop	B:C ratio
S0 B0	585.94	537.50	2.05
S0 B1	1104.17	1113.17	3.68
S0 B2	1057.29	1055.73	3.36
S0 B3	940.11	1020.56	2.86
S1 B0	734.38	732.81	2.36
S1 B1	1010.38	1041.40	2.38
S1 B2	968.75	938.54	2.64
S1 B3	1091.15	1084.38	2.88
S2 B0	953.12	1063.54	2.56
S2 B1	979.17	1055.72	3.24
S2 B2	1127.61	1128.65	3.55
S2 B3	1028.65	1034.89	3.11
S3 B0	953.12	948.95	3.28
S3 B1	1377.61	1172.94	4.52
S3 B2	895.83	894.27	2.81
S3 B3	1460.94	1407.30	4.38
CD(SXB)	156.255	91.938	0.49

Source: Jeena mathew and Sumam George 2012

From the field trials it could be observed that S@30 kg ha^{-1} and B@2.5 kg ha^{-1} has been found to be the optimum dose to ensure a sustained production of sesame in the Onattukara sandy soil of Kerala.

Soybean

Biswas *et al*. (2003) observed that soil application of molybdenum @ 2 kg ha-^{1} has recorded significantly higher 100 seed weight (11.49 g^{-1}), grain yield (1773 kg ha -^{1}), Stover yield (2767 kg ha $^{-1)}$ an harvest index (39.05 %) of soybeans compared to control (10.92g^{-1}, 1575 kg ha^{-1} , 2581 kg ha-^{1} and 37.78 %, respectively). This was mainly due to optimum application of molybdenum helps in improve the uptake of phosphorus and fixes atmospheric nitrogen resulted in increasing the productivity of soybean.

Kobraee *et al.* (2011) reported that soil application of manganese @ 40 kg ha-^{1} has recorded significantly higher number of seeds per plant (62.67), 100 seed weight (17.81 g-$^{1)}$ and seed yield (3493 kgha^{-1}) of soybean as compared to control (49.67 plant-^{1,} 17.12 g-^{1} and 2627 kg $ha^{-1,}$ respectively). This was mainly due to manganese helps in chlorophyll and carotenoids synthesis and improving plant photosynthesis resulted in increasing the productivity of soybean.

Nandini *et al.* (2012) reported that soil application of boron @ 1.5 kg ha^{-1} recorded significantly higher pods per plant (61), 100 seed weight (13.26 g-$^{1)}$, seed yield (1831 kg ha-^{1}) and harvest index(46.34 %) of soybean as compared to control 38, 12.66 g,931 kg ha^{-1} and 44.21 % , respectively). This was mainly due to optimum application of boron helps in improving the productivity of soybean and lower yield in control plot due to boron deficiency in soil.

Table 23 Effect of Sulphur and Boron on Boron, Sulphur, Protein and Oil Content of the Grain of Soybean. (Average for Three Years).

Treatment	Concentration in seed		Uptake by seed		Oil content	Protein content
	Boron (ug/g)	Sulphur (%)	Boron (g/ha)	Sulphur (kg/ha)	(%)	(%)
S-level (kg/ha)						
0	47.24	0.409	41.62	3.60	20.13	40.13
10	47.39	0.412	57.72	5.02	20.16	40.17
20	48.19	0.413	74.75	6.44	20.23	40.22
30	48.98	0.418	96.77	8.28	20.27	40.58
40	49.95	0.416	96.53	8.22	20.32	40.52
CD (P=0.05)	0.13	0.002	4.17	0.36	0.02	0.04
B-level (kg/ha)						
0.0	47.88	0.402	44.67	3.74	20.21	40.26
0.5	48.05	0.411	71.99	6.14	20.21	40.32
1.0	48.22	0.415	78.22	6.69	20.23	40.35

1.5	48.32	0.421	88.89	7.74	20.23	40.36
2.0	48.28	0.420	83.61	7.25	20.24	40.34
CD (P=0.05)	0.13	0.002	4.17	0.36	0.02	0.04
S x B (P=0.05)	0.29	0.005	9.29	0.81	NS	0.10

(Source: KonthoujamNandini Devi *et.al.,* 2012)

From the above investigation, it may be concluded that application of sulphur @ 30kg per ha and 1.5 kg of boron per ha along with the recommended dose of NPK is found to be best for producing high yield of good quality grain and profitability of soybean variety JS 335. Some of the contradictory results on the optimum doses of P, S and Co fertilization, as reported in foregoing discussion, indicates the differential nutritional requirement of soybean for different soils of the region. Thus nutritional requirement of the crop must be assessed on site specific basis for recommendation of optimum fertilizer doses for soybean. However, in light of the results reported here, we conclude that the concomitant application of P, S and Co (P60 S15 Co1) is advisable for the best growth, yield and quality of soybean on acid alfisols of the study area.

Mustard

Sharma and Jain (2003) registered that foliar application of zinc @ 0.5 % at flower initiation and 50 % flowering stage in Indian mustard has recorded significantly higher plant height (166.2 cm) and primary branches (7.17 plant) as compared to control (154.6 cm and 5.00 plant $^{-1,}$ respectively). This was mainly due to application of zinc helps in activation of many enzymes and helps in utilization of nitrogen.

Tejeswara Rao and Subbaiah (2006)) concluded that combined (Zn, B and Mo) foliar application of micronutrient recorded significantly higher plant height (176 cm), primary branches (7.0 plant-^{1}) and dry matter production at different stages of Indian mustard as compared to control (144 cm, 5 plant $^{-1}$ and dry matter production at different stages, respectively). Verma and Baigh (2012) observed that application of molybdenum @ 4.0 kg ha-^{1} has recorded significantly higher plant height (158.5 cm), primary branches (8.23 plant $^{-1}$) secondary branches (12.25 plant) and tertiary branches (1.17 plant) of Indian mustard as compared to control (152.7 cm, 6.57, 11.20 and 0.50 plant^{-1}, respectively).

Table 24 Mustard Yield And Yield Components As Affected By Different Zinc And Iron Levels During 2005 And 2006

Treatments Zn and Fe (kg ha-1)	Days to flowering	Days to Maturity	Plant height (cm)	Pods Per Plant	Seeds per pod	1000-Seed weight (g)	Seed Yield (kg ha^{-1})	Oil content (%)
2005 0.0-0.0	53	185	212	299	9	1.92	573	40
0.0-1.5	52	184	214	305	12	2.01	637	40
0.0-3.0	54	183	224	328	11	2.16	740	41
2.5-0.0	51	183	230	317	12	2.15	880	40
2.5-1.5	51	182	236	331	11	2.35	897	40
2.5-3.0	50	183	225	286	11	2.32	1013	41
5.0-0.0	50	179	227	344	12	2.31	1081	41
5.0-1.5	51	178	244	362	13	2.37	1272	42
5.0-3.0	52	182	227	356	12	2.36	1148	41
L.S.D (0.05)	1.56	2.16	18.31	56	1.60	0.10	171	
2006 0.0-0.0	54	182	224	324	14	2.12	1165	40
0.0-1.5	55	184	224	330	13	2.13	1088	41
2.5-0.0	53	182	231	290	11	2.17	1164	40
2.5-1.5	52	182	222	336	12	2.61	1277	41
2.5-3.0	53	183	230	366	13	2.64	1316	41
5.0-0.0	52	182	225	328	11	2.62	1398	40
5.0-1.5	52	181	233	385	15	2.69	1526	41
5.0-3.0	53	182	226	359	13	2.65	1477	40
L.S.D (0.05)	1.56	2.14	17.95	73	1.56	0.11	205	

(source: Nazakat Nawaz *et.al*., 2012)

It is concluded that application of 5 kg/ha zinc and 1.5 kg/ ha iron in addition to 90-60 kg ha NP fertilizer was optimal treatment for 100 % increase in seed yield in mustard variety BARD-1 under climatic conditions of National Agricultural Research Centre, Islamabad. Further increase in zinc and iron levels have no significant effect on yield and yield components of mustard variety BARD-1. Further experimentation is needed in different agro-ecological zones of the country to optimize zinc and iron deficiency in the soils.

Safflower

Ravi *et al*. (2008) concluded that combined foliar application of iron @ 0.5 % + zinc 0.5 % at 30 and 65 DAS of safflower has recorded significantly higher growth parameters like plant height (97.5 cm), no. of leaves (81.5 plant-^{1}), primary (10.8 plant-^{1}), secondary (17.3 plant^{-1})and dry matter production (2440.7 kg ha $^{-1}$) as compared to control (80.4 cm, 65.4 plant-^{1}, 7.6 plant-^{1}, 13.7 plant-^{1} and 2029.6 kg ha-^{1} respectively).

Table 25 Physical and Chemical Properties of Studied Soil

Depth of soil(cm)	Soil texture	K(ppm)	P(ppm)	N(%)	Oc(%)	pH	Ec(dc/m)
0-30	Sandy loam	180	24	0.04	0.41	7.8	1.8

Table 26 Analysis of Variance

S.O.V	Df	Plant height	Thousand seed weight	Seed yield	Biological seed	Protein(%)	Oil(%)
Replication	3	6.3	0.56	6055.7	533044.1	0.901	8.82
Treatment	3	81.655	4.55	589827**	344523.4**	13851.607**	10.23**
Error	29	1.16	0.55	9704	306198	0.28	5.83
C.V(%)		1.3	0.66	3.14	6.5	1.96	2.53

Table 27 Comparison of Means

Treatment	Plant height (cm)	Thousand seed weight(g)	Seed yield (kg/ha)	Biological seed (kg/ha)	Protein (%)	Oil(%)
Control	79.88	35.20	1345.71	4019.53	25.42	16.45
Fe	92.41	38.88	1758.33	5374	31.43	18.5
Zn	85.75	36.82	1640.83	4971.66	29.67	18.02
Fe+Zn	98	39.2	1950	6291	35.03	20

(Source: Ghavami *et al.*,2015)

The results showed that the effect of micronutrients on plant height, seed weight, protein content, oil content and seed and biological yield were highly significant(table 26). Comparison of means (Table 27) show that the features listed among treatments was significantly different from the control Micronutrients. The highest was plant height and oil content and protein was treated zinc with the iron. The positive effects have been reported of zinc on the production of growth hormones, photosynthesis, and increases in wheat grain weight . The lowest mean of plant height, seed weight and oil content belonged to the control (Table 27). Iron through increased photosynthetic activity of protein and carbohydrates in plant, its increased grain weight. In another experiment reported Zinc application increased dry matter production, number of pods per plant, soybean is increasing seeds per pod and 100 seed weight grain yield, protein and oil seed was significantly. So far the importance of micronutrients in improving crop performance and environmental protection, This study aimed to evaluate foliar micronutrient elements iron entrance and compounds combining the qualitative and quantitative were carried out characteristics of safflower.

Castor

Table 28 Effect of Subsoiling, Land Configuration and Zinc Fertilization on Growth, Yield And Quality of Castor

Treatments	Plant height (cm)	Inter-nodes	Length of main spike (cm)	Capsules / main spike	Spikes /plant	Seed weight /plant (g)	100-seed weight (g)	shelling (%)	Oil (%)	Seed yield (q ha1)	Stalk yield (q ha-'
Moisture conservation practices											
M_1-FB	83.67	14.22	35.63	39.43	4.02	34.89	31.62	68.74	46.03	12.70	17.09
M_2- ABRS	89.80	16.57	37.57	44.15	4.87	36.08	31.95	69.51	46.26	13.24	17.85
M_3- BRS	92.35	17.83	39.55	47.82	5.02	37.61	32.59	70.37	46.50	13.61	18.15
M_4- IRS	94.45	18.13	41.28	55.32	5.68	40.91	33.09	74.16	47.12	14.97	19.85
M_5- BBF	99.82	19.50	42.15	60.77	5.77	43.34	33.32	75.05	47.28	15.29	20.20
C.D. (P=0.05)	9.38	1.21	1.55	5.52	0.63	4.84	0.95	4.85	0.85	1.52	1.53
Zinc (kg ha^{-1})											
z_roZ_1 - 0	85.80	17.09	37.85	45.99	4.97	35.43	32.00	69.74	46.36	12.92	17.40
Z_2-5Z_2 – 5	94.58	17.11	39.84	50.62	5.05	39.46	32.72	72.44	46.74	14.40	19.19
Z_3- 10	95.67	17.55	40.04	51.88	5.19	40.82	32.83	72.52	46.81	14.57	19.31
C.D. (P=0.05)	5.53	ns	0.61	2.13	Ns	3.29	0.52	2.50	0.36	0.66	0.63

(Source: Mathukia and Khanpara,2006)

Application of zinc @ 10 kg ha^{-1} (Z_3) and 5 kg ha^{-1} (Z_2), being statistically at par, significantly excelled plant height, length of main spike, capsules/main spike, seed weight/plant, test weight, shelling, oil content, seed yield and stalk yield over control (Z_1), while zinc levels could not cause their significance impact on number of internodes and spikes/plant (Table, 30). Zinc fertilization @ 10 kg ha^{-1} (Z_3) and 5 kg ha^{-1} (Z_2) increased seed yield by 12.8 and 11.5% and stalk yield by 11.0 and 10.3% over control (Z_1), respectively. By virtue of involvement in various enzyme systems, carbohydrate metabolism and redox processes, zinc might have promoted growth, yield and quality of the crop.

Application of zinc @ 10 kg ha·1 (Z3) and 5 kg ha·1 (Zz), being statistically equivalent, significantly increased seed and stalk yields as well as oil content and oil yield over control (Zl)' Zinc fertilization was found to depress the P content in seed and stalk and enhance the K content in stalk and Zn content in seed and stalk. Whereas, N content in seed and stalk and K content in seed remained virtually unaffected under different levels of zinc. Owing to higher seed and stalk yields with zinc application, uptake of N, K and Zn were also higher than control. By virtue of reduced P content with Zn application, P uptake was almost equal under different levels of zinc.

Table 29 Effect of sub soiling, BBF and zinc fertilization on yield, quality and nutrient composition of castor

Treatments	Yield (kg ha1)		Oil (%)	Oil yield (kg ha1)	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (ppm)	
	Seed	Stalk			Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk
M_1 –FB	1270	1709	46.03	584	2.015	0.874	0.353	0.088	0.626	0.682	51.69	30.58
M_2- ABRS	1324	1785'	46.26	613	2.093	0.871	0.345	0.088	0.616	0.669	51.42	30.37
M_3-BRS	1361	1815	46.50	633	2.123	0.857	0.340	0.086	0.607	0.641	50.85	30.18
M_4-IRS	1497	1985	47.12	705	2.011	0.839	0.338	0.082	0.601	0.612	50.03	29.68
M_5- BBF	1529	2020	47.28	723	2.000	0.787	0.322	0.079	0.599	0.597	49.52	29.87
CD (P=0.05)	152	153	0.85-	72	NS	NS	0.011	0.005	NS	0.037	NS	NS
Zinc (kg ha1)												
Z,-0	1292	1740	46.36	599	2.018	0.848	0.363	0.088	0.597	0.618	49.29	29.20
Z_2- 5	1440	1919	46.74	673	2.062	0.846	0.336	0.084	0.617	0.649	51.04	30.45
Z_3- 10	1457	1931	46.81	683	2.067	0.843	0.320	0.082	0.615	0.654	51.78	30.76
CD (P=0.05)	66	63	0.31	30	NS	NS	0.015	0.003	NS	0.016	1.43	0.71

(Source: Mathukia and Khanpara, 2006)

Table 30 Effect of subsoiling, BBF and zinc fertilization on nutrient uptake by castor

Treatments	Nitrogen uptake (kg ha1)			Phosphorus uptake (kg ha1)			Potassium uptake (kg ha1)			Zinc uptake(kg ha1)		
	Seed	Stalk	total	Seed	Stalk	total	Seed	Stalk	total	Seed	Stalk	Total
M,-FB	25.59	14.91	40.50	4.45	1.51	5.96	7.96	11.67	11.63	65.85	52.30	118.15
M_2- ABRS	27.74	15.55	43.30	4.55	1.56	6.11	8.16	11.96	20.12	68.08	54.32	122.39
M_3- BRS	28.88	15.54	44.42	4.61	1.56	6.16	8.28	11.66	19.93	69.35	54.81	124.16
M_4- IRS	30.12	16.64	46.76	5.06	1.63	6.69	9.00	12.16	21.16	74.89	59.01	133.90
M_5- BBF	30.58	15.88	46.46	4.91	1.59	6.50	9.16	12.06	21.22	75.78	60.37	136.15
CD (P=0.05)	3.27	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.39	12.70
Zinc (kg ha1)												
Z_1 – 0	26.02	14.69	40.72	4.67	1.53	6.21	7.72	10.73	18.45	63.61	50.80	114.41
Z_2 - 5	29.66	16.23	45.88	4.82	1.60	6.42	8.86	12.42	21.28	73.43	58.39	131.81
Z_3-10	30.07	16.20	46.26	4.64	1.58	6.22	8.95	12.56	21.51	75.34	59.29	134.63
CD (P=0.05)	1.64	0.92	2.21	NS	NS	NS	0.42	0.47	0.87	3.81	2.16	5.56

(Source: Mathukia and Khanpara, 2006)

CONCLUSION

- High yielding varieties, intensive cropping with high analysis NPK fertilizers, limited use of organic manures and less recycling of crop residues led to the depletion of secondary and micronutrient from the soil reserves.
- Application of micronutrients through foliar application increase crop yield.
- Application of Integrated micronutrient management .Increasing micronutrient use efficiency.
- Fustigation provides opportunity for efficient use of compound and ready-mix nutrient solutions containing small concentrations of micronutrients, which are otherwise very difficult to apply accurately to the soil when applied alone. There is need to develop recommendations for the most suitable fertilizer formulations including the basic nutrients (NPK) and microelements according to the local soil type, climate, crops and their physiological stages, and other factors like nutrient mobility in the soil and salinity.
- Further, there is need to work on reducing the initial cost of establishment through continuous research and development in technology which suits best to Indian conditions.

Future Challenges in Micronutrient Research in India

- Micronutrient fertilization programmes for nutrients other than Zn and B has not picked up at all. Even in case of Zn where its inclusion in fertilization schedule for cropping systems is more or less established, some aspects need to be immediately probed.
- Delineation and reassessment of micronutrient status in soils should strictly be carried out based on geographical positioning system (GPS) and state-wise and district-wise micronutrient fertility maps should be prepared using geographical information system (GIS) software especially in uncovered areas.
- Development of integrated micronutrient management technology, using available organic materials, in important crop sequences is vital for increasing micronutrient use efficiency. Inclusion of inoculation of vesicular arbuscularmycorrhizal (VAM) fungi in the integrated nutrient supply systems has potential of mitigating deficiencies on not-so-severely deficient soils.
- Monitoring micronutrient deficiencies in different cropping systems in various agro-ecological regions is essential for forecasting potential micronutrient problems.
- Case studies have shown that sewage and industrial effluents and sludges have enriched the soils with heavy metals including micronutrients. Monitoring of both micronutrient and toxic metal concentrations in the edible parts of crops grown on such soils will have important practical significance from animal and human health points of view. Wherever possible, integrated packages including application of these wastes as a component of balanced fertilization should be developed.

Since importance of micronutrients is increasing beyond soil and plant system and nutritional security of the people of country is becoming a crucial concern, some systematic studies on micronutrient in soil-plant-animal- human continuum need to be conducted to find out effect of micronutrients deficiencies in soils, on animal and human health.

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