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Studies of Micronutrients status in soils of Nagapattinam Taluk of Nagapattinam District, Tamil Nadu, India

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Abstract

Micronutrients, also known as "trace elements" are essential in small quantities for the growth of plants. Fe, Mn, Zn, Cu, B, Mo, Co and Cl_2 are considered as micronutrients. These micronutrients may produce synergetic and antagonistic effects in plants, if they are present in excess or in deficiency level in the soil. In this study an attempt has been made to assess the micronutrient status of Fe, Mn, Zn and Cu in Nagapattinam taluk of Nagapattinam district in Tamilnadu state. Surface soil samples depth (0 – 20 cm) numbering 425 from 85 revenue villages, five samples were collected from each revenue village. The study area covers 30,231 hectares of land. The basic physico –chemical parameters pH, EC and OC were calculated in the study area. Assess the micronutrient status by using Atomic Absorption Spectrophotometer. By using the critical levels fixed by earlier workers for DTPA (Diethylene Triamine Penta Acetic acid) extractable micronutrients in Tamilnadu soils, the percentage deficiencies of individual nutrients were calculated in each revenue village. The results revealed that the order of mean status of available micronutrients was found to be Fe(5.14mg kg^{-1}) > Mn(3.23 mg kg^{-1}) > Cu(1.27 mg kg^{-1}) > Zn(0.91 mg kg^{-1}) on the average basis 65.88, 45.88, 62.22 and 86.98 percent soils were found to be deficient in Fe,Mn,Cu and Zn respectively. From the results of the analysis of soil samples, concrete suggestions can be made to improve the soil quality and crop production.

Key words: Micronutrients, Nagapattinam Taluk, soil, Tamil Nadu

Introduction

In general, most plants grow by absorbing nutrients from the soil. Of the several elements known to be essential for plant growth, eight are required in such small quantities that they are called micronutrients or tracer elements. These are iron, manganese, zinc, copper, boron, molybdenum, cobalt and chlorine. The deficiency or the excess presence of the micronutrients such as Fe, Mn, Zn and Cu may produce synergetic and antagonistic effects in the plants[1]. Even though the special role of micronutrients in plant growth is not well understood, these elements are known to be associated with certain essential process in the plant metabolism.

One common characteristic of all the micronutrients is that they are required in very small amounts and they are all harmful when the available forms are present in the soil in large quantities[2]. Thus, the range of concentration of these elements in which plants will grow satisfactory is considerably small.

Deficiency of micronutrient in soil and plants is a global nutritional problem and is prevalent in many countries with different magnitude of severity. The identification of biological role of Zn by Raulin[3] who observed that common bread mold (Aspergillus) did not grow in the absence of Zn. This observation introduced a new area for research in crops and in 1914 first demonstration of Zn deficiency in plants was made by Maze[4] while the first identification of Zn deficiency in field conditions was reported by [5] in the deciduous orchards of California.

Bioavailability of all four metallic micronutrients is significantly affected by soil pH, decreasing with increasing soil pH. Solubility of Fe decreases a thousand fold for each unit increase in soil pH in the range[6] 4 to 9 and consequently, most Fe deficiencies occur on calcareous soils. The activity (consequent bioavailability) of Mn, Cu and Zn decreases 100 fold for each unit increase in soil pH. Amounts of exchangeable metals in soil are related to their concentrations in soil solutions, so soil pH affects exchangeable Fe, Mn, Cu and zn similarly reactions with soil organic matter (SOM) significantly affect the bioavailability of these metallic micronutrients[7]. Copper reacts with SOM to form very stable complexes with carboxylic and phenolic groups. Due to these stable complexes Cu deficiencies are often associated with organic soils. Reactions of Zn with SOM are also important in providing bio available Zn, but the strength of these bonds is not as strong as with Cu.

Many other factors like calcium carbonate contents, clay contents, concentrations of other nutrients. Salt affected soils and water logging which can affect the bioavailability of micronutrients to plants.

Micronutrients deficiency can greatly disturb plant yield and quality, and the health of domestic animals and humans[8]. Extensive research on the effects of micronutrient fertilizers on crop yield and quality has been conducted during the past decade[9]. Addition of each micronutrient (Fe, Zn, Cu and B) or a combination of Fe+Zn+Cu+B to NPK fertilizer increased grain yield[10]. Inorganic Fe salts except sequestrene are generally ineffective in soil application. However, repeated foliar

sprays of $FeSO_4$ or chelated Fe cure the chlorosis[11].

Most sand soils (Coarse texture) are deficient in micronutrients. Clay soils (fine texture) are not comparatively to be low in plant available micronutrients. The study indicates that there is a positive correlation of clay contents with Iron, Copper and Zinc[12] studied that available manganese and iron decreased with soil pH and available Copper increased with clay and organic carbon content and available iron decreased with sand content[13] have reported that application of Zn and Fe increased paddy yield, whereas Mn showed negative effect in Punjap Soils. Application of copper sulphate has also been found to increase the yield in India, Portugal and Japan[14].

Manganese is required for enzyme activation in electron transport and disease resistance[15]. Studied the effect of Fe, Mn, Zn and Cu on the yield and yield components of rice; the concluded that Zn alone. Mn alone and combined application of Mn and Cu increased yield by 15, 11 and 10% over NPK respectively.

Micronutrients have become of widespread concern in recent years because of the increased consumption of high analysis NPK fertilizers, intensive cropping and adoption of high yielding varieties of crops.

Their field deficiencies have been noted in many states of our country[15]. In general sandy soils, soils low in organic matter and intensively exploited soils are either deficient or more liable to develop deficiency of micronutrients.

In Tamil Nadu information on micronutrients status at village / taluk level is lacking for the entire state. Hence, a systematic soil analysis was proposed to delineate areas of individual micronutrient deficiencies.

Considering all these above facts an attempt has been made to study the status of micronutrients along with the basic physico-chemical parameters namely pH, EC and OC in the study area.The soil samples were categorized as sufficient and deficient in particular micronutrient according to the criteria laid down.

Soil series of Nagapattinam taluk :

In this taluk, 8 soil series have been identified .The distribution of the various soil series are given mentioned below. Soil series is very important factor to measure the nutrients and fertility level.

1) Kivalur Soil series(Kvr)- Dark yellowish brown (10 YR 4/4 m); silty clay; coarse strong subangular blocky; hard firm sticky and slightly plastic; many fine to medium roots; many very fine tubular pores; slow permeability; deep crack; clear smooth boundary; p^H 6.9.

2) Sikar Soil series(Skr)- Very dark grayish brown (10YR 3/2m); silty clay, coarse strong subangular blocky; very hard firm sticky and plastic; few fine pores; many fine roots; moderately slow permeability; clear smooth boundary; pH 7.8;

3) Sethi Soil series(Sth)- Grey (10YR 6/1m); sand; structure less single grained; loose very fraiable nonsticky nonplastic; very rapid permeability; common fine roots; diffused

smooth boundary; pH7.7;

4) Nagapattinam Soil series(Ngp)- Very dark grey brown (10YR 3/2m); clay; coarse strong angular blocky hard firm sticky and plastic; very slow permeability; deep crack; many fine roots; fine few pores; slightly saline; few fine yellow and brown mottlings; clear irregular boundary; pH7.1;

5) Kohur Soil series (Khr)- Very dark grey brown (10YR 4/3m); silty loam; medium moderate angular blocky; hard firm slightly sticky and plastic; slow permeability; cracks present; common fine brown mottlings; slightly saline; many fine roots; few fine pres; clear smooth boundary; pH7.1;

6) Kalathur Soil series (Klt)- Dark grey (10 YR 4/1 m); clay; strong coarse subangular blocky; very hard firm sticky and plastic; brownish yellow root hair mottings; many fine to medium roots; slow permeability; gradual smooth boundary; pH 7.4.

7) Adhanur Soil series (Adn)- Adhanur series comprises of dark grey brown to dark yellowish brown loamy textured soils from Cauvery alluvium. The soils are very deep non - calcareous, having sand layer within 100 cm.

8) Padugai Soil series(Pdg)- Brown (10 YR 4/3 m); sandy clay loam; moderate subangular blocky; friable slightly sticky and nonplastic; faint common medium black mottlings; many fine to medium roots; common very fine random tubular pores; moderate permeability; abrupt smooth boundary; p^H 6.8.

Study Area :

Nagapattinam Taluk is one among the 8 taluks of Nagapattinam District located adjacent to Kilvelur Taluk in Tamil Nadu. The study area covers an extent of 30,231 ha land area with 85 numbers of revenue villages under Nagapattinam Taluk. Soil samples were collected from 85 revenue villages of the study area. Five samples from each village, therefore a total of 425 samples were collected and analyzed for soil parameters. The location map of the Nagapattinam Taluk is given in Fig. 1.

Materials and Methods

Surface soil samples depth (0-20 cm) numbering 425 and representing the 85 revenue villages of Nagapattinam taluk in Nagapattinam District, were collected. Five samples were collected from each village. The air-dried and processed soil samples size (<2mm) were extracted with DTPA-$CaCl_2$-TEA solution[17] and the available Fe, Mn, Zn and Cu content in the extract was determined with the help of an atomic absorption spectrophotometer (ECIL, AAS-4129).

Simple averaging of soil test values for each micronutrient was done to get the average status in the villages.

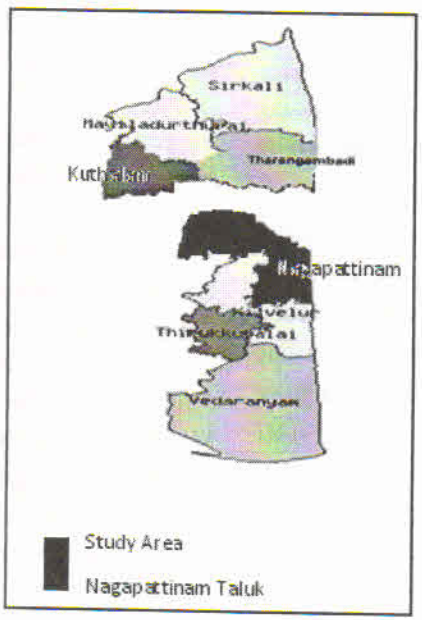
Using the critical levels fixed by earlier workers for DTPA extractable micronutrients in TN soils, the percentage deficiencies of Individual nutrients were calculated in each village. The critical levels for DTPA extractable micronutrients were fixed[16] as follows:

Fe – 3.7 mg Kg^{-1}
Mn – 2.0 mg kg^{-1}
Zn – 1.2 mg kg^{-1}
Cu – 1.2 mg kg^{-1}

FIG.1. LOCATION MAP

Nagapattinam Taluk in Nagapattinam District

Nagapattinam District



Assessment of micronutrients status in Nagapattinam Taluk :

The results of the soil parameters obtained from 85 villages are given in table 1. The soil samples collected from 85 villages from Nagapattinam Taluk. 5 samples were collected from each village and were analyzed. The DTPA extractable micronutrients (Zn, Cu, Fe and Mn), along with pH, EC and OC were studied in each village of Nagapattinam Taluk.

Table 1. Average Mean value of Micronutrients in Nagapattinam Taluk

Nagapattinam Taluk	pH	EC ($ds\ m^{-1}$)	OC %	Available Micronutrients in the soil ($mg\ kg^{-1}$)			
				Zn	Cu	Fe	Mn
MEAN	7.39	0.60	0.29	0.91	1.27	5.14	3.23
RANGE	7.0 - 7.90	0.40 - 0.84	0.16 - 0.49	0.37 - 1.32	0.50 - 2.34	2.30 - 6.92	1.84 - 5.14

The mean Fe, Mn, Zn and Cu content in soils of Nagapattinam taluk ranged from 2.30-6.92, 1.84-5.14, 0.37-1.32, 0.50-2.34 mg kg^{-1} respectively.The mean value of micronutrients status are 5.14 ,3.23, 0.91 and 1.27 mg kg^{-1} are given in Fig. 2 Among 425 samples analysed, soils were reported to be deficient in Fe, Mn, Zn and Cu by 65.88, 45.88, 86.98 and 62.22% respectively are given in Fig .3 The deficiency of Mn (45.88%) was noticed only in 17 villages. In case of Cu, sufficient levels were noticed in 31 villages. Fe was found to be 65.88 % deficient in 17 villages. This may be due to the calcareousness of soils (Kalathur series) coupled with HCO_3 rich groundwater predominant in the area. The available Zn was found to be deficient in almost all the villages of the taluk necessitating immediate attention towards its build up.

The relative high pH of the soils might be due to the presence of high degree of base saturation. The electrical conductivity, pH and organic carbon of the soils varied from 0.40 to 0.84 dsm^{-1}, 7.0 to 7.90 and 0.16 to 0.49% with a mean value of 0.60dsm^{-1}, 7.39and 0.29% respectively. On the basis of the limits suggested by Muhr *et al.*[18] for judging salt problems of soils, all samples (100%) were found (EC<1.0). The organic carbon content was low (<0.50%) in 100% soil samples. High temperature and good aeration in the soil increases the rate of oxidation of organic matter resulting reduction of organic carbon content.The Deficiency percentage of Micronutrients in Nagapattinam Taluk is given in table 2. The micronutrients status of Zn, Cu, Fe and Mn in the surface soil of Nagapattinam Taluk is given in figures 4, 5, 6 and 7 respectively.

Table 2. Deficiency Percentage of Micronutrients in Nagapattinam Taluk

Nagapattinam Taluk	Deficiency of Micronutrients (%)			
	Zn	Cu	Fe	Mn
Deficiency of Micronutrients (%)	86.98	62.22	65.88	45.88
Total number of villages Deficient	83	54	17	17
Total number of villages Sufficient	2	31	68	68

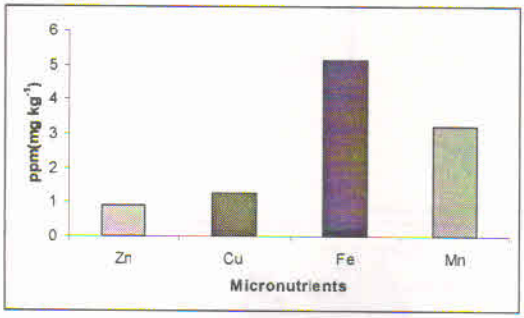


Fig. 2. Mean value of Micronutrients status in Nagapattinam taluk

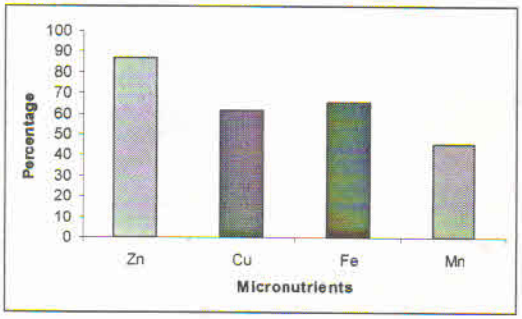


Fig. 3. Deficiency percentage of Micronutrients status in Nagapattinam Taluk

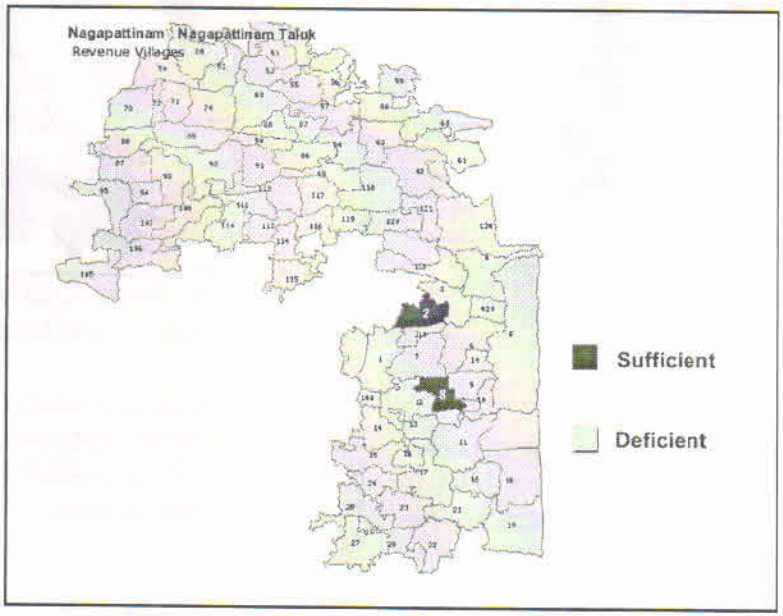


Fig .4 Zn-Status of surface soil in Nagapattinam Taluk

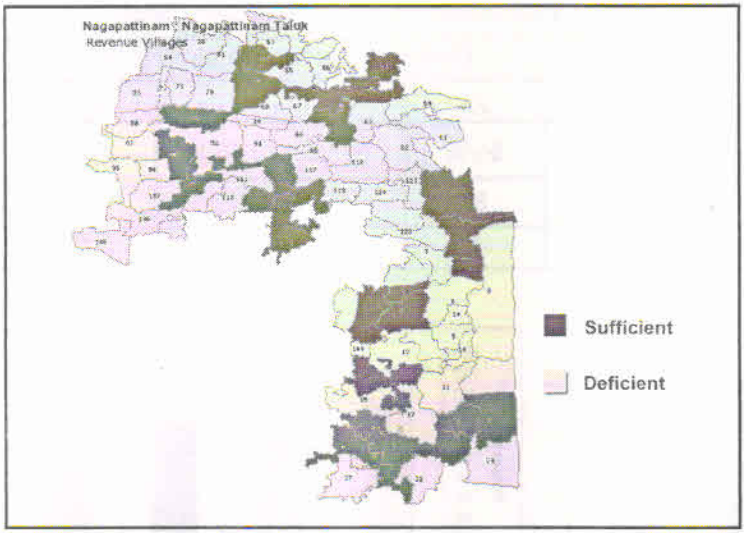


Fig. 5. Cu-Status of surface soil in Nagapattinam Taluk

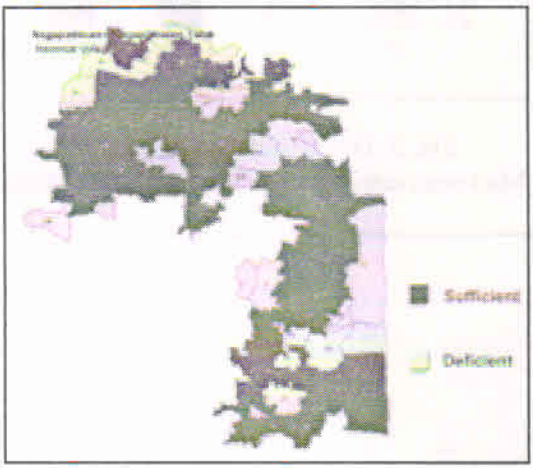


Fig. 6. Fe- Status of surface soil in Nagapattinam Taluk

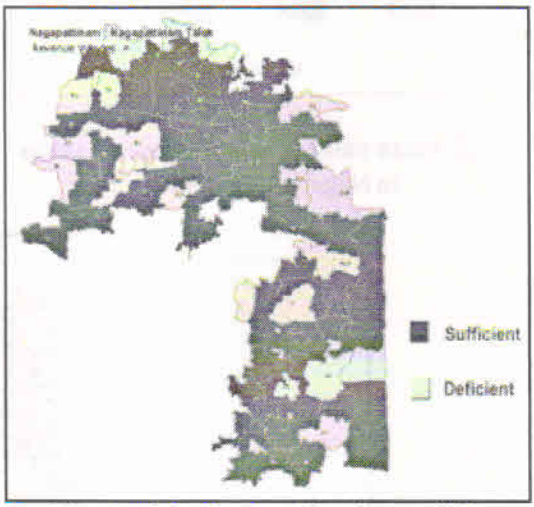


Fig. 7. Mn- Status of surface soil in Nagapattinam Taluk

Conclusions

The deficiency percentage of micronutrient status in the Nagapattinam Taluk is given. From the Research data were evident that Zn deficiency is widespread in the district followed by Fe, Cu, and Mn and the order of deficiency can be given as follows:

Zn > Fe> Cu > Mn

The systematic study undertaken to assess the micronutrients status of soils of Nagapattinam Taluk revealed that they have become an imperative problem (yield limiting factor) in the taluk. The mean status of Fe, Mn, Zn and Cu were 5.14, 3.23, 0.91 and 1.27 mg kg^{-1} respectively in the Taluk. On the average basis 65.88, 45.88, 86.98 and 62.22

percent soils were found to be deficient in Fe, Mn, Zn and Cu respectively in the Taluk. Soil test based Zn application is essential for sustainable production of crops. Deficiency of more than one micronutrient was noticed in most of the villages.

The deficiency of Zn was noticed in Nagapattinam taluk 86.98 percent. Zn deficiency leads to widespread nutritional disorder in various crops. The mean available Zn content was also below the critical level (0.91 mg kg^{-1}). In case of field crops, soil application of $ZnSO_4$ @ 15-25 kg/ha can be done before sowing or transplanting. Foliar sprays of 0.5% $ZnSO_4$ 2-3 times at 10-15 days interval can be effective in correcting Zn deficiency in standing crops. Crops like rice, maize, groundnut, sugarcane, banana, citrus, and other fruit crops may respond well to Zn fertilization especially in case of calcareous, ill drained P rich soils. In such cases, foliar nutrition of Zn (0.2 -0.05% $ZnSO_4$ sprayed at 2-3 times) may be a viable option. Application of Zn along with organic manures may enhance the availability and efficiency of native Zn through chelation.

Bio-Inoculants like rhizobium and mycorrhizae (VAM) applied in combination with Zn were found to improve yield on Zn uptake by crops. In case of maize grown on alkali soils, Zn may play an ameliorative role in suppressing Na^{-} absorption. So in the maize growing area of Nagapattinam Taluk where high pH was noticed application of $ZnSO_4$ is essential. Though the soils are supposed to be rich in total Fe, the DTPA extractable Fe was relatively low in many villages of the district due to the influence of many inherent factors.

In Nagapattinam taluk where rice is the major crop, Fe deficiency was 65.88 percent. For rice in case of Fe deficient calcareous soils, application of 25 kg $FeSO_4$ along with 10t/ha of coir pith (or) 20 t/ha of FYM may be done. The foliar spraying of 0.2% $FeSO_4$ before flowering and fruit set will alleviate Fe deficiency in the standing crop. In case of sodic soil as common in many villages (mainly due to NaCl water area) application of green manure and FYM in conjunction with gypsum may improve the availability of Fe in these soils. According to the degree of Fe deficiency, application of 50-100 kgs $FeSO_4$ /ha as basal dose to Sugarcane (especially in calcareous soils with bicarbonate rich ground water) may be done. In standing crop it may be supplemented with 2-3 foliar sprays of 2% $FeSO_4$ at weekly intervals.

However, in the present study, in the Nagapattinam taluk showed sufficient levels of Mn (45.88 percent only deficient). In some cases, its deficiency may arise due to excessive levels of Fe and Calcareousness. Corrective measures may be done through foliar application of $MnSO_4$. Spraying of $MnSO_4$ before first irrigation is preferable for most crops (0.5– 1% $MnSO_4$ spraying repeated 2 to 3 times at weekly intervals). In Mn deficient areas, crops like rice, sorghum, groundnut, onion, sugarcane, finger millet and sesame may respond well to its application. So, in standing crops where Mn deficiency is a problem in coarse textured, calcareous and alkaline soils of the district, repeated (2-3 times) foliar sprays of 0.5-1.0% $MnSO_4$ can alleviate the problem.

In the taluk, 62.22 percent deficiency of Cu was recorded. Considerable villages showed deficiency of Cu. These variations in the available Cu content in the whole district may be attributed to differences in the topography, texture and organic matter content of soils. In case of coarse textured red sandy soils, soil breeding with clayed. Vertisol may improve the available Cu content by preventing

excessive leaching of this micronutrient. High levels of Cu are toxic to the plants as it may produce synergetic and antagonistic effects. Further, the germination percentage of seeds gradually decreases with the increase of Cu concentration. High levels of Cu revealed that indiscriminate use of Bordeaux mixture and other Cu containing fungicides (to grapes and other horticultural crops) over the years might have led to high Cu buildup in soils. Wherever Cu deficiency is noticed in standing crops, 2 to 3 foliar sprays of 0.025% $CuSO_4$ either singly or in combination with other micronutrients may enhance yield as well as quality of the produce.

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