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Overview of approaches in assessing / mapping micro-nutrients with a case of Ghataprabha command area

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Abstract
The importance of micronutrients and benefits in crop production are being increasingly recognized in modern agriculture. The incidence of micronutrient deficiencies has become more pounced consequent to the adoption of new strategy in agriculture. Although micronutrients are required in small quantity, they are considering to play a vital role in the plant growth and development and therefore to receive a greater attention in modern agriculture. The current paper throws light on various approaches in assessing / mapping micro-nutrients with a case of Ghataprabha command area was discussed. Studies on status of micronutrient cat ions (Fe, Mn, Cu and Zn) in soils of Ghataprabha command area of Belgam district revealed that the soils in different taluks namely Gokak, Raibag, Chikkodi, Athani and Hukkeri, these soils are alkaline in soil reaction and normal in electrical conductivity . The range and mean value of DTPA extractable iron, manganese, copper and zinc in soils of Ghataprabha command area vary from 0.32 to 11.02, 0.37 to 27.73, 0.54 to 8.28 and 0.03 to 3.88 ppm with a mean value of 3.77, 8.00, 2.54 and 0.51 ppm respectively. As per the limits of < 2.5, 2.5 to 4.5 and >4.5 ppm as deficient, marginal and sufficient in available iron, 21.1, 52.0 and 26.9 per cent of samples fall under deficient, marginal and sufficient category respectively. In respect of available manganese majority of the soil samples (97.1%) fall under category of sufficient (>2.0 ppm) and remaining (2.9%) samples fall under deficient category respectively. As per the deficiency (<0.2 ppm) and sufficient (>0.2 ppm) category for available copper, all the command area samples fall under sufficient category respectively. In respect of available manganese, majority of the soil samples (97.1%) fall under category of sufficient (>2.0 ppm) and remaining (2.9%) samples fall under deficient category. As per deficiency (< 0.2 ppm) and sufficiency (> 2.0 ppm) category for available copper, all the soils of command area fall under sufficient category. In case of zinc 76.9, 9.1 and 14.0 per cent of samples fall under deficiency (< 0.6 ppm), marginal (0.6-1.0 ppm) and sufficient (>1.0 ppm) category respectively.

Keywords: Micronutrients, critical limit, deficient, marginal and sufficient

Introduction
The importance of micronutrients and benefits in crop production are being increasing!} recognized in modern agriculture. The incidence of micronutrient deficiencies has become more pounced consequent to the adoption of new strategy in agriculture, namely adoption of employing intensive cropping system with high yielding varieties and use of high analysis straight fertilizer and lesser use of organic manures leading to the imbalance of plant nutrients in soil. Although micronutrients are required in small quantity, they are considering to play a vital role in the plant growth and development and therefore to receive a greater attention in modern agriculture. The current paper throws light on various approaches with a case from mapping of micronutrients in Ghataprabha command area.

Importance of micronutrients
Usually the "importance" is defined as the product of the magnitude of the impacts per unit area and the area of impact. Impact is most commonly measured as crop yield. However, for a range of crops, aspects of crop quality such as oil. protein or fibre content, are equally important in markets. Peanuts sold for human consumption should be free of internal defects such as "hollow heart", caused by boron deficiency. For mung bean, the viability and vigour of germinating seed may be a prime qualitv characteristic that determines market price in those pans of Asia favouring bean sprouts in the diet. For legumes, the main impact of micronutrients may be on amounts of N fixed. Limitations of symbiotic nitrogen fixation decrease current crop production, but may have equally significant impacts on subsequent

crops in the rotation due to lower residual soil nitrogen levels (Wood and Myers 1987) [28]. Another aspect of impact is the effect of micronutrient concentrations in planting seed on the vigour of the next season's crop. This may impose hidden costs in the extra seed needed for crop establishment, or poor, low yielding stands that under perform (Ascher-Fllis *et al*. 2001) [3]. An emerging area of interest is the impact of micronutrient supply on grain quality for human nutrition.

The second component of importance is the area affected. Traditional approaches to defining the area of impact consider topsoil levels of micronutrients (Takkar *et al*. 1989) [23]. There is emerging evidence that low sub-soii micronutrient status is an under-recognised constraint. Various reports on the area of impact suggest a static nutrient status, and fail to recognise changes in micronutrient status or land use over time. Several examples can be quoted across the world in Australia for example, micronutrient deficiency was first treated 30-50 years ago and depending on the residual value of the added fertiliser, soils'are often still considered adequate for crop yields. Hence areas of southern Australia that were once mapped as almost entirely deficient in Zn, Cu and Mo (Donald and Prescott 1975) [9] are now largely adequate for crop growth. However, changing from cropping with annual species to perennial plants has seen the emergence of deficiencies especially of Cu and Mn in southern Australia in recent years (Dell *et al*. 2003) [8]. This appears to be related to roots having poor access to micronutrients in surface soils during the dry season when most of the plant biomass is being laid down. Changes in genotypes over time may also change the status of an area once considered adequate to deficient. Another example from Nepal where in traditional undertaken in the 1960- 1990's on micronutrients. We will have to find more cost effective ways of updating our knowledge base on micronutrients.

An example of a new approach to assessing the area of impact of micronutrient disorders is based on work we did on B in southwest Australia (Wong 2003) [27]. Boron fertiliser is not currently used in this region on a regular basis but we could see emerging trends that might induce deficiencies during the next decade- new crops, higher yields, soil acidification. Through pot experiments, soil analysis and field trials, we assessed soil properties and correlated them with soil B status: the properties, which we have termed risk factors were soil pH, clay content of soils and geology.

There are various programs that can be used for weight of evidence modelling'. The underlying principle of all is: evidence layers; weighting of evidence, and; categories of evidence. Some weight of evidence models use Bayesian statistics to generate the risk map. The risk map is flexible. It can be updated as new evidence emerges or new research strengthens or weakens evidence. Different crops might have different tolerance to low B and hence a changed species weighting can be used. Whilst it is valuable to have hard data on relationships between soil properties and B status, expert judgement can be used as a proxy. Most parts of the world have simple rules that are used to predict micronutrient deficiencies and these could be used in weight of evidence models also.

This type of risk mapping can be output for fertilizer retailers and manufacturers to estimate market size. Planners might use it to estimate what new infrastructure in roads, grain storage etc are needed to cope with widespread use of micronutrients. Research organisations need this information to design priorities for research and target areas where trials should be carried out.

Boron has different behaviour in soils to zinc because it is more prone to leaching and the risk of toxicity is greater (Shorrocks 1997) [22]. From some of the studies from China the B cycling behaviour in the oilseed rape-rice-rice triple cropping system on three key soils (Wang *et al*. 1997; Wang *et al*. 1999; Yang *et al*. 2000) [26, 26, 29]. Even with repeated annual applications of 3.3 kg B/ha/yr to the oilseed rape for three years, no evidence of B toxicity was found. This was consistent with the extractable B levels that only increased modestly in the 0-20 cm layer. Part of the reason for the small increase in extractable B in the 0-20 cm layer was that B redistributed to greater depths in the soil. However, no leaching loss of B occurred below 80 cm depth even on the sandy alluvial soil. Over 40% of the B added initially was removed over a 3 year period in harvested grain and straw. Hence in this intensive triple cropping system in southeast China, we concluded that B toxicity risk was low, that little B was lost by leaching, but that removal of B in harvested crops and crop straw was a major cause for the decline in residual B over time. We estimated that 1.65 kg B/ha should be re-applied every 3 years in this cropping system. By contrast, on sandy loams derived from sandstone in the uplands of southwest China, repeat applications of B are required to meet the requirements for eucalypt foliage replacement following harvest for essential oils. This is partly because the soil has limited capacity to retain B added as fertilizer, and partly because the B, which is taken up and sequested in the plant is mostly unable to be redistributed to the new shoots as they develop. Hence, steep B gradients develop in these woody plants following fertilizer application and B rundown over time (Dell *et al*. 2001) [7].

Another case from Karnataka the status of micronutrients of irrigated soils of Ghataprabha command which are being intensively cultivated with high yielding crops like sugarcane, maize and cotton. The study involved five hundred surface soils samples collected from different the farmer fields in the command based on the extent of area under irrigation and representative soil types. The available micronutrient content in the soils are categorized into deficient, marginal and sufficient as outlined by Katyal and Randhawa (1983) [12]. The soil DTPA extractable micronutrient, categorized as shown under (table 2).

Table 1: The initial Physico-chemical properties of soils

Texture	Sandy clay loam
PH (1:2.5)	7.1-9.3
EC (1:2.5)	0.13-2.6
OM (%)	0.45-0.62
CEC (C mol/kg)	20.25
Available Nitrogen kg/ha	120
Available P_2O_5	16
Available K_2O	160

Table 2: Available micronutrients in soils categorised as outlined by Katyal and Randhaw (1983) [12]

Micronutrients (ppm)	Deficient	Marginal	Sufficient
Available iron	<2.5	2.5-4.5	>4.5
Available zinc	<0.6	0.6-1.0	>1.0
Available Manganese	<2.0		>2.0
Avaiiabie copper	<0.2;		>0.2

The available iron content in Gokak, Raibag, chikkodi, Athani and Hukkeri taluk soils varied from 0.45 to 8.91, 1.49, to 10.06, 0.96 to 6.19, 1.28 to 4.24 and 0.32 to 11.02 ppmwith a mean of 5.04, 4.32,3.54, 2.90 and 3.07 ppm respectively (table 3 and fig 1). A major portion of Gokak taluk soils (56.5% of soils) are sufficient in available iron is probably due to high amount of native iron. These soils are derived from calcic gneiss which are rich in Fe (Anon 1993) [1]. Similar results were also reported by Fordham (1969) in case of soils derived from calcic gneiss. Only 6.5% of Gokak taluk soils are deficient and 37% soils are marginal in available iron, it may be due to variation in management practices and cropping pattern. Out of 200 soil samples analysed, 58.5 per cent of Raibag taluk soils fall under marginal category (range from 2.5 to 4.5 ppm). Thirty four per cent of samples fall under sufficient category and only 7 per cent of sample fall under deficient category (<2.5 ppm). The available iron fall under marginal category was observed in Chikkodi (48%) Athani (72%) and Hukkeri (44%) taluk soils. This type of variation may be due to the soil management practices and-cropping pattern adopted by different farmers.

A perusal of data on available zinc revealed that, out of 200 soil samples analysed in Gokak taluk, 101 samples (50.5%) were categorised as deficient, 13.5 per cent as marginal and 36 per cent samples fall under sufficient category. Eighty per soils analysed from Raibag taluk fall under deficient category, where as in Chikkodi 86 per cent, in Athani, 88 per cent and in Hukkeri taluk, 80 per cent samples fall under deficient category. Only 2 to 16 per cent of samples fall under marginal and sufficient category. Such a type variation in available zinc may be due to differences in management practices like variation in zinc application and intensive cropping pattern which exhaust native nutrient. Gopichand *et al*., (1985) observed very low Zn in black soils of Guntur district. Noticed the majority of the TBP black soils studied were deficient in available zinc.

Available manganese content in Gokak, Raibag, Chikkodi, Athani and Hukkeri taluk soils varied from 0.37 to 27.73, 1.03 to 22.67, 2.72 to21.92, 1.46 to 12.49 and 1.20 to 19.00 ppm with a mean value of 11.74, 9.35, 7.76, 4.16 and 6.00 ppm respectively (table 3 and figure 2). Majority of soils (97.1%) of Command area are sufficient in available manganese. These soils are derived from granite parent rock (Anon 1993) [1] had the highest available manganese and also may be due to higher exchangeable manganese in water logged condition. A very small per cent of soils showing deficient in DTPA extractable manganese, it may be due to the variation in management practices and cropping pattern adopted.

Table 3: Range, mean and different category of micronutrients in soils of Ghataprabha command area of Belgam district, North Karnataka

Taluk	Range	Mean	Percent samples		
Available iron in ppm			Deficient	Marginal	Sufficient
Gokak	0.45-8.91	5.4	6.8	37.0	56.5
Raibag	1.49-10.06	4.32	7.0	58.5	34.0
Chikkodi	0.96-6.19	3.54	24.0	45.0	28.0
Athani	1.28-4.24	2.90	28.0	72.0	-
Hukkeri	0.32-11.02	3.07	40.0	44.0	16.7
Available Zinc in ppm					
Gokak	0.03-1.46	0.87	50.05	13.5	36.0
Raibag	0.11-1.91	0.41	80.0	14.0	6.0
Chikkodi	0.12-3.88	0.45	86.0	2.0	12.0
Athani	0.11-0.93	0.28	88.0	12.0	-
Hukkeri	0.12-1.79	0.52	80.0	4.0	16.5
Available manganese in ppm					
Gokak	0.37-27.73	11.74	1.5	-	98.5
Raibag	1.03-22.67	9.35	1.0	-	99.0
Chikkodi	2.72-21.92	7.76	-	-	100
Athani	1.46-12.49	4.14	8.0	-	92.0
Hukkeri	1.20-19.0	6.00	4.0	-	96.0
Available Copper in ppm					
Gokak	0.56-5.83	2.52	-	-	100
Raibag	0.54-8.28	2.16	-	-	100
Chikkodi	1.00-3.24	2.27	-	-	100
Athani	1.04-3.72	3.07	-	-	100
Hukkeri	1.30-4.60	2.70	-	-	100

The available copper content in Gokak, Raibag, Chikkodi, Athani and Hukkeri taluk soils varied from 0.56 to 5.83, 0.54 to 8.28, 1.00 to 3.24, 1.04 to 3.72 and 1.30 to 4.60 ppm with a mean value of 2.52, 2.16, 2.27, 3.07 and 2.70 ppm respectively. The higher level of available copper in soils of command area may be due to the granite gneiss. Considering the 0.2 ppm critical limit of available copper, almost all the command area soils fall under sufficient category. Murthy (1988) [16] reported that the *Vertisol* of India derived from granite have higher amounts of available copper, next to soil derived from basalt. Katyal and Sharma (1991) [13] found that the *Vertiso* exhibited higher content of DTPA copper than *Entisols.*

Stakeholder partnerships in addressing micronutrient deficiencies

Nutrient management formerly was considered to be largely a matter for the individual farmer taking advice perhaps from government extension services. In recent years, it has become obvious that there are many more stakeholders in sustainable nutrient management, and the roles of farmers and government extension services are changing. The notion ot' the government as the provider of a nationwide extension service is in transition (Wall 2001) [24]. In developed countries, most governments have withdrawn substantially from the provision of a comprehensive national extcnsion service. This has been driven by: concerns about the growing cost; a questioning of the necessity or the desirability of such government-provided services; and the emergence of a private sector that supplies many of these services. Meanwhile extension-related work has had to dcal » ith new issues from increased regulations, environmental factors, market pressures and chatlged societal perceptions about agriculture. By contrast, many developing countries are still striving to create a comprehensive national extension network (Lathvilayvong et at. 1995) [14]. In many cases, the ratio of extension officers to farmers in developing countrics is so small that alternative ways of delivering information such as the mass media have to be examined. Non-governmental organisations often provide advice on nutrient management in developing countries, generally based on a particular set of belief systems that are sometimes at variance with mainstream science. Many of these NGO's promote practices such compost, permaculture, and discourage the use of inorganic fertilizers. Farmers' grassroots organisations are also emerging with a voice on nutrient management. The local "farmer wisdom groups" in NE Thailand are a case where small community groups are seeking self-reliance and apply this thinking to nutrient management as well as other facets of agriculture and community development (S. Ruaysoongnern, personal communication). The Farmer Training Schools set up in Cambodia to promote integrated pest management are having spillover effects on nutrient management by encouraging groups of farmers to experiment with nutrient management practices (Robinson and Nugent 2002) [20].

International aid projects have in many countries in SE Asia played a leading role in the development of national fertilizer recommendations. In Thailand, a FAO project developed fertilizer recommendations for field crops based on on-farm experiments (Ho and Sittibusaya 1984) [10]. In Cambodia and Laos, IRRI-led projects have developed rice fertilizer recommendations Seng *et al*. 2001) [21]. Such inputs will tend to be once-off contributions using resources and trained personnel that may not be available to the national agencies responsible for updating and adding to the sets of recommendations.

Hence the new approach that has emerged to influence sustainable nutrient management is based on partnerships amongst the different stakeholders. Improved decision making and improved sustainability depends on accessing a much broader range of information than in the past and from many more sources. Partnerships amongst stakeholders facilitate information sharing, and collective action for sustainable nutrient management. The quality of leadership in the key stakeholder bodies is critical since partnership requires a collective will amongst stakeholders and involves many changes in traditional roles and attitudes of the individual stakeholders and their representatives. The role of extension officers in a partnership will be characterised by group facilitation, motivation and activation, rather than direction or simply dispensing advice. The technical skills of the extension officer may be less in demand in their new role.

The emergence of the private sector in developing technologies and products, and disseminating information is a potentially beneficial one for micronutrient management. Agents of fertilizer companies can increase the access of farmers to information and expert advice either by direct visits to farms or through the mass media. Fertilizer companies have a real interest in understanding blockages to the adoption of micronutrient fertilizer including markets, supply chains, product labeling and price sensitivity. But there are risks for sustainable micronutrient management. - Fertilizer manufacturers and sellers in general have shown less rigorous standards of proof when promoting the benefits of their products than scientists. Hence there is a risk of many ineffectual products being sold leading to economic hardship for farmers and loss of confidence in the use of fertilizers of all sorts. Fertilizer salespersons may also have less concern about environmental protection than is prudent. Scientists can either enter the relationship between farmers and the private sector as antagonists towards the private sector, or seek a more conciliatory role. Defending the farmers against unscrupulous claims and practices has to be one of the roles of public sector scientists. However, if scientists fail to develop a constructive relationship with the private sector, many useful products and services may fail to reach farmers. Other products will be used by farmers despite their poor quality or ineffectiveness. Scientists can seek to engage inlentil varieties tended to be B efficient and so the prevalence of reported B deficiency for this crop was low. Improved varieties have higher yield potential but are also more prone to B deficiency (Kataki *et al*. 2001) [11]. Finally, as yield output from farming systems rise, areas that were previously adequate are now declining in micronutrient reserves in soils, and hence deficiency is reported with increased frequency.

Boron is essential for plants, but was not previously considered essential for animal and humans. Recent research in the US is gradually changing that perception (Nielsen 2002) [17]. This workshop comes at the time as emphasis on micronutrient levels in staple grains because of their critical importance for the supply of micronutrients in the human diet.

Classical approach for assessing micronutrient deficiencies

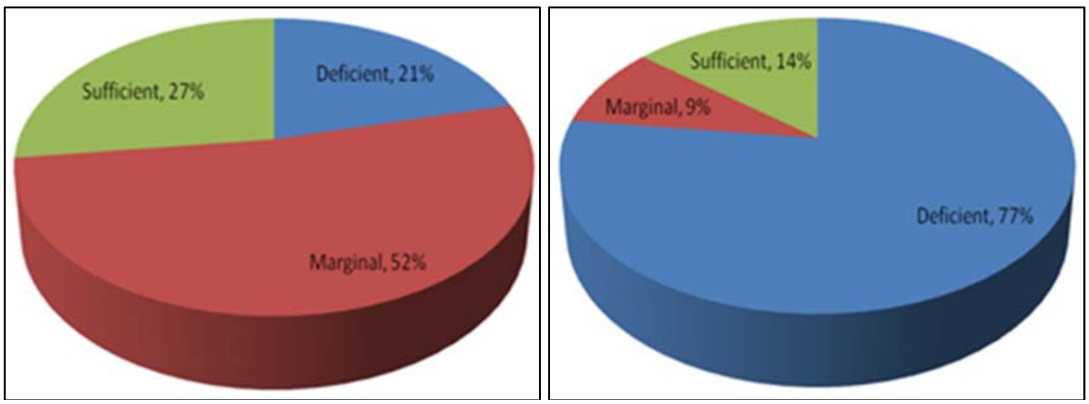
The classical approach to assessing micronutrient limitations is based on the law of limiting factors (This was also referred to as Liebig's law of the minimum. Black 1993) [5]. It has been applied in most countries over the last 50 years (e.g. Anderson 1970) [2]. The approach involves extensive soil analysis, either as part of a soil survey or for the purposes of assessing nutrient status. This body of soil analysis data provides a benchmark for the range of values to be expected in soils, and the proportion of sites that might be deficient. The pioneering work of Prof Liu Zheng in China for example produced a set of national maps for the average levels of each micronutrient (Liu 1992) [15].

However, to confirm a deficiency a yield response in the field is necessary evidence (Craswell *et al*. 1987) [6]. Such trials would then normally be followed by other experiments to establish minimum fertilizer rates, fertilizer types, and may also be used to generate critical levels in plants and soils. Finally, the varied requirements of different plant species on the same low micronutrient soils need to be assessed.India has a. most impressive database of such information from its All-India Coordinated Micronutrients study (Takkar *et al*. 1989) [23].

This approach continues to be relevant and in use. In the past years several studies of this type have been published from Pakistan (e.g. Rashid *et al*. 2002) [18]. The principle of limiting factors remains valid and will continue to play a useful role in identifying nutrient constraints. Another case where the principle of limiting factors will continue to be useful is when yields progressively increase over time in a farming system, causing nutrient levels to decline in the soil. Whilst the classical approach is very powerful, and has been very useful, it has to be recognised as a relatively costly approach. Ideally for each soil or group of similar soils, a set of soil and plant test calibrations needs to be developed for the diagnosis and prediction of mineral disorders and to determine fertilizer requirements (Craswell *et al*. 1987) [6].

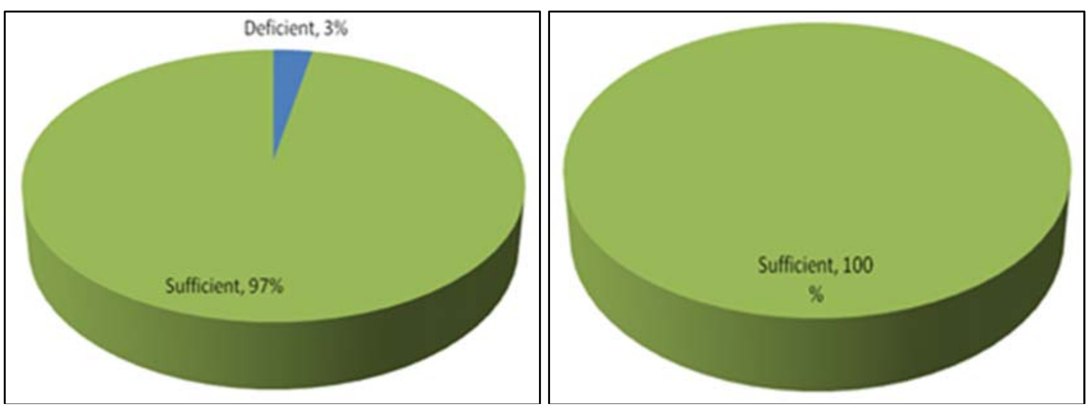
New approach for mapping micronutrient deficiency:

As discussed above, the present approach to mapping impact areas presumes a static pattern of micronutrient status in soils. However, cropping systems and farming systems are dynamic. Even in traditional farming communities substantial changes in farming practices (e.g. new varieties, fertilizer use, changed weeding regimes) and systems (e.g. double cropping) have occurred. Each of these changes can have significant implications for micronutrients. So the critical question is how our assessment can be continually updated. One thing is obvious- that it will not be possible to repeat the vast body of research partnerships with the private sector to provide independent evaluation of products under controlled conditions, and to review, audit, and edit information provided to farmers. The challenge for scientists in this partnership is to maintain their independence whilst not alienating either farmers or fertilizer companies, the community, or government. It should be possible to convince all groups of their mutual benefits when scientists provide an independent review of products, services and information that reaches farmers.



Available Iron status Available Zinc status

Fig 1: Available Iron and Zinc status in soils of command area



Available Manganese Available Copper

Fig 2: Available manganese and copper status in soils of command area

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