Background Information

Mango (*Mangifera indica)* in peninsular India is known for low productivity (6.5 t/ha) and low profitability. Since mango is perceived by the farmers as a 'hardy' crop capable of growing in varying climates and soil types at low external inputs (water, nutrients), adequate attention has not been paid to its nutrient management. Irregular bearing is still a major problem in India and poor nutrition is one of the reasons for this phenomenon. Zinc deficiency in visible and hidden form is widespread in mango (Anonymous 2004) and is suspected to be one of the reasons for low productivity. A survey on zinc deficiency in mango orchards indicated that this problem was widespread in all four agro-climatic zones in peninsular India; in acid, neutral and high pH alfisols of Konkan, Karnataka and Andhra Pradesh, respectively. The survey of these orchards, based on soil analysis of the 0 – 15 and 15 – 30 cm layers indicated 0.75 to 2.2 mg/kg of DTPA zinc (Lindsay and Norvel, 1978), which is considered adequate even for field crops such as maize which are sensitive to zinc deficiency.

Earlier observations in peninsular India have indicated that maize, beans and onions, which are zinc sensitive crops, did not show any zinc deficiency symptoms, when grown in adjacent fields to Mango in the same soil type, whereas Mango was exhibiting visible zinc deficiency. The average spacing adopted for mango is 10m x 10m in India and 100 trees/ha is the planting density. Zinc removal by mango is only 140 mg/tree/year accounting for only 14 g of zinc/ha/year, whereas considering the active root system of mango (Kotur, et al 1997) available zinc is around 800 g/ha. These numbers indicate the inability of mango to absorb adequate amounts of zinc in a soil where other crops like maize, which are zinc sensitive are able to mobilize zinc, confirming Graham's (1984) observation that 'there is a genetic deficiency in the plant rather than deficiency in the soil'. Hence a study was initiated to establish the inherent inability of mango to mobilize zinc from soil so that farmers may be awakened from the mindset that mango is a "hardy" crop.

Experimental details

Two experiments, one in the field and another in the greenhouse, were conducted during the years 2004 – 2006. In the first experiment was conducted in the field, in a mango orchard with the four cultivars Alphonso, Totapuri, Neelum and Mallika (an alfisol of pH 7.3 with a total zinc of 6.2 mg/kg and DTPA of 0.78 mg/kg) with a tree age of 15 years. An intercrop of maize was grown during the monsoon season (June – September 2005). The seeds of four composites, (Ganga, Deccan and 60A UAS and Pusa composite) were sown as intercrop. Both mango and maize were provided the needed macro and micronutrients except zinc. A randomized block statistical design with 4 replications with a plot size of $200m^2$ was adopted. At three intervals, samples of both maize and mango leaves (at 30, 45 and 60 days) were collected and analyzed for zinc and other nutrients. Results are presented in Table 1. A greenhouse experiment to investigate the cause for Zn deficiency in a soil adequate in zinc was also conducted. In cement pots of 0.6m x 0.6m x 0.6m, one banana plant and one mango graft of one year age of cv. Alphonso were planted in a soil of pH 7.3 with DTPA Zn of 0.78 mg/kg. One pot wa sown with 10 seeds of Maize Ganga. This was replicated in 10 pots for each crop. The crop was given adequate major and micronutrients and watered to field capacity once a week.

Results and Discussion

The results of the experiment (Table 1) to study comparative efficiency of mango and maize on zinc mobilization indicated that maize is able to mobilize more zinc from a soil of same available zinc status (0.78 mg Zn /kg) in spite of the fact that maize has a faster growth rate and dry matter accumulation and higher Zn removal/ha than mango and is considered sensitive to zinc. At 30 days, the Zn in mango was only 16 mg/kg whereas the mean for maize was at 33 mg/kg significantly higher. Likewise after 45 and 60 days, maize had significantly higher zinc than mango. Screening for visual zinc deficiency indicated that except for one cultivar (Ganga), none of the maize cultivars showed visible symptoms, whereas in Mango all cultivars except Mallika showed deficiency symptoms. This study revealed that mango is not as efficient as Maize in mobilizing zinc for its need. Among the four cultivars Mallika is most efficient in zinc uptake.

Table 1: Comparative efficiency of mango and maize on zinc uptake

Mango	**Leaf Zn mg/kg**			**Maize**	**Leaf Zn mg/kg**		
cultivars	**30 days**	**45 days**	**60 days**	**cultivars**	**30 days**	**45 days**	**60 days**
Alphonso	12	14	18	Ganga	25	35	40
Totapuri	16	17	20	Deccan	30	30	44
Neelum	17	18	22	UAS 60 A	40	38	32
Mallika	20	24	28	Pusa Composite	38	40	46
Mean	16.3	18.0	22	Mean	33.0	36	41
CD at 5%	3.2	4.2	4.6		4.2	-0	-
	Mean (Mango) = 18.8			Mean (Maize) = 36.6 CD 5% = 8.4			

The results of the second experiment on the causes for the inherent or genetic susceptibility of mango to zinc (Table 2) indicated that the inability of mango to solubilize enough soil zinc from zinc reserve by rhizosphere acidification (Nye, 1981) may be one of the causes, since in the same soil banana and maize are able to mobilize adequate zinc in spite of the fast growth rate and dry matter accumulation capacity of these two crops. Based on these two studies, mango is inherently (genetically) inefficient in taking up adequate zinc for its metabolic zinc need in a situation where adequate zinc is available. The inability of mango to extract adequate zinc from soil is because of the inefficiency of its root to modify the environment at the interface with soil by releasing protons. Among the three crops compared, banana is the most efficient in acidifying the rhizosphere and mobilizing not only zinc but also iron and manganese, maize is next best and mango is poorest in this adaptive mechanism to a nutrient stress situation (Graham, 1984). Hence farmers have been advised to correct zinc regularly by foliar spray. As a future research programme, the development of nutrient efficient cultivars to be used as a rootstock has been initiated.

Table 2: Studies on causes of susceptibility of Mango to Zinc deficiency.

Sampling date (Days after sowing of Maize)	Leaf nutrient content (Mg/kg)			Rhizosphere soil pH	Non-Rhizosphere soil pH
	Mn	Zn	Fe		
		Mango Cv. Alphonso			
30 days	32	16	32	7.2	7.1
60 days	38	16	48	7.1	7.0
90 days	38	18	52	7.2	7.0
		Banana Cv. Robusta			
30 days	110	25	73	7.1	6.4
60 days	140	28	84	7.0	5.8
90 days	230	33	102	7.1	5.2
		Maize Cv. Ganga			
30 days	36	25	42	7.2	6.8
60 days	52	35	502	7.1	6.4
90 days	68	38	52	7.2	6.0

Acknowledgements

The author is grateful to Mr. Mazhar Jameel for technical assistance and the Director of IIHR for facilities provided.

References

Anonymous (2004), Predominant micronutrient disorders of mango in T. Nadu, Karnataka. Annual report of IIHR, Bangalore. P 124-28, 2004

Graham, RD (1984). Breeding for nutritional characteristics in cereals. Adv. Plant Nutri 1: 57-102.

Kotur, SC, BRV Iyengar and TN Shivaanada (1977). Distribution of root activity in young 'Alphonso' mango (*Mangifera indica)* trees as influenced by season and growth. Ind. J. Agl. Sci 67(3): 113-6.

Lindsay WL and Norvel WA (1978). Development opf DTPA soil test for zinc, iron, Manganese and Copper. Soil Science Soc. Am. J. 42: 421-428

Nye, Ph (1981). Changes of pH across the rhizosphere induced by roots. Plant soil 61: 7-26.