Delineation of Productivity Zones in Mandarin Orchards Using DRIS and GIS

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A survey of seven states in northeast India superimposed the spatial distributions of orchard yield data with leaf analysis data using geographic information system (GIS) technology to delineate important productivity zones within the region.

It is well recognised that crop behavior and soils are not uniform within an orchard (Srivastava et al., 2006). Precision citrus farming involves assessing and managing spatial variability in the supply of nutrients from soil and yield response, thus helping to identify nutrient constraints, rationalise nutrient use, and optimise factor productivity. Advances in software-aided decision support systems (DSS), such as Diagnosis and Recommendation Integrated System (DRIS) and GIS, have led to the development and use of new variability assessment, interpretation, and management tools. These tools have much wider application potential (Schumann and Zaman, 2005; Zaman and Schumann, 2006) when compared with the more empirical approach that growers generally take by improving drainage and fertiliser management.

A survey of 108 'Khasi' mandarin orchards was carried out between 2002 and 2006 covering 590 km² from 50 geo-referenced collection sites in seven states of northeast India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura). Soils of the region are predominantly Entisols (Haplaquent, Ustifluvent, and Udifluvent), Inceptisols (Ustochrept and Haplaquept), Alfisols (Rhodustalf, Paleustalf, Haplustalf, Orchraqualf, and Rhodustalf), and Ultisols (Palehumult, Haplustult, Plinthaqult, and Plinthustult). Climate is characterised by mean annual rainfalls of 180 cm with mean summer and mean winter temperatures of 28 °C and 15 °C, respectively.

Six-to-seven month old leaves at second, third, or fourth leaf positions from non-fruiting terminals and covering 2 to 10% of trees at a height of 1.5 to 1.8 m from the ground were sampled and analysed for macronutrients (N, P, K, Ca, and Mg) and micronutrients (Fe, Mn, Cu, and Zn). DRIS (Srivastava and Singh, 2008) and GIS (Arc 9.3) were used to delineate major productivity zones represented by the sampled mandarin orchards.

Leaf Nutrient Optima

Large variability in leaf macronutrient content (g/kg) exists across northeast India. For example, N in leaves varied from 20.5 to 26.5 (median 24.7), P from 0.9 to 1.3 (median 1.1), K from 11.2 to 21.3 (median 14.3), Ca from 18.2 to 24.2 (median 19.8), and Mg from 2.2 to 4.2 (median 3.4). Similarly, leaf micronutrient content (mg/kg) varied from 133.5 to 281.2 for Fe (median 138.9), 51.6 to 100.3 for Mn (median 60.2), 5.1 to 22.4 for Cu (median 8.5), and 14.5 to 25.6 for Zn (median 25.5). Using this data, leaf nutrient optima for different nutrients were developed using DRIS-based software **(Table 1)**.

Table 1. DRIS-based leaf nutrient optima in relation to fruit yield for 'Khasi' mandarin grown in northeast India.

Nutrients	Deficient	Low	Optimum	High	Excess
			Indices		
N, g/kg	< 16.7	16.7 – 19.6	19.7 – 25.6	25.7 – 28.5	> 28.5
P, g/kg	< 0.6	0.6 – 0.8	0.9 – 1.0	1.1 – 1.3	> 1.3
K, g/kg	< 5.2	5.2 – 9.8	9.9 – 19.3	19.4 – 24.0	> 24.0
Ca, g/kg	< 17.2	17.2 – 19.6	19.7 – 24.9	25.0 – 27.5	> 27.5
Mg, g/kg	< 1.4	1.4 – 23.0	2.4 – 4.8	4.8 – 5.4	> 5.4
Fe, mg/kg	< 23	23 – 84	84 – 249	249 – 331	> 331
Mn , mg/kg	< 19	19 – 42	42 – 88	88 – 111	> 111
Cu, mg/kg	< 2	2	2 – 14	14 – 21	> 21
Zn, mg/kg	< 11	11 – 16	16 – 27	27 – 32	> 32
	Very low	Low	Good	High	Very High
Productivity, kg/tree	< 19	19 – 32	32 – 56	56 – 69	> 69

Precision management techniques are being adapted in citrus production.

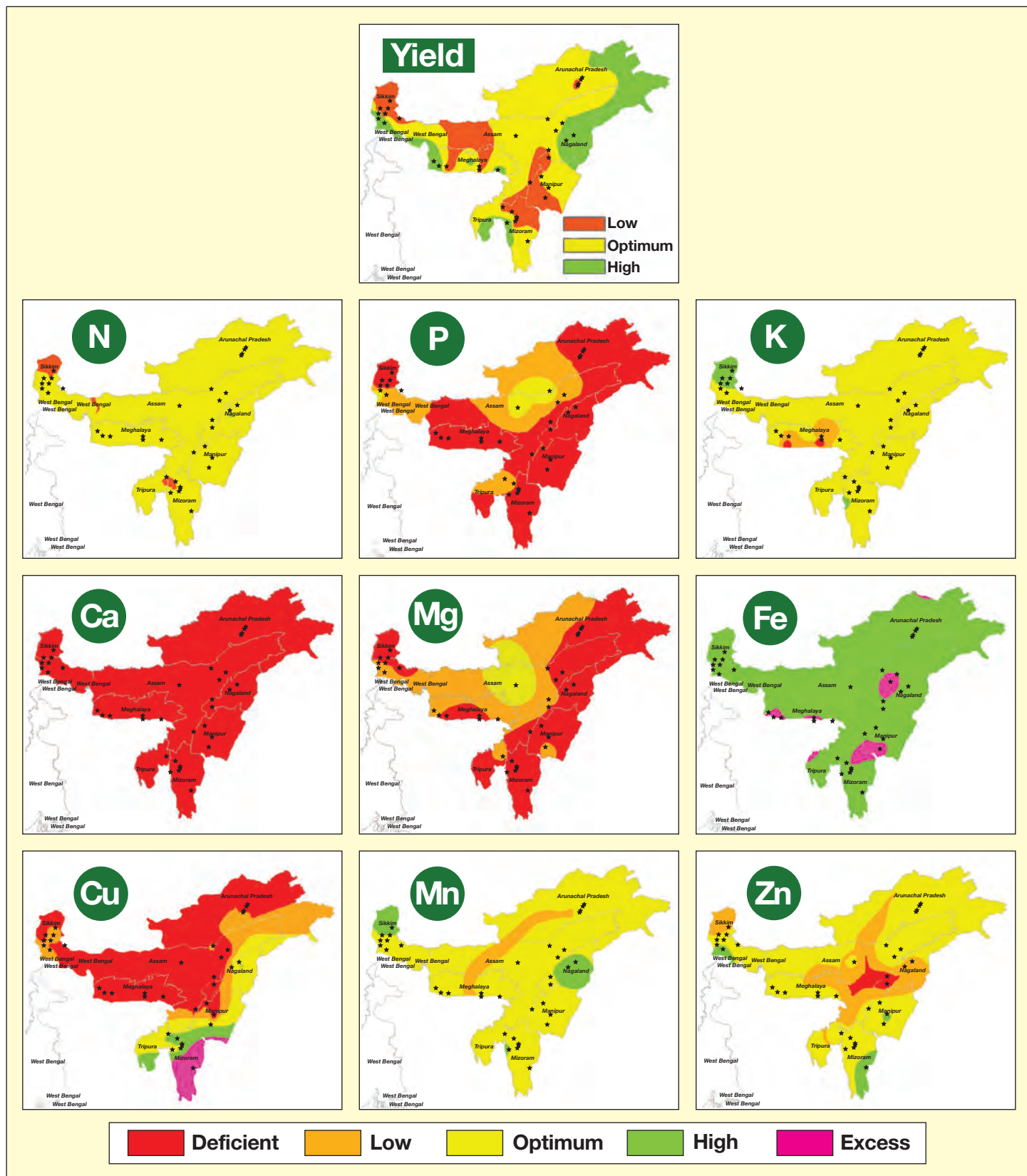Abbreviations and notes: N = nitrogen; P = phosphorus.

Figure 1. Spatial distribution of 'Khasi' Mandarin yield (productivity) and several leaf nutrients across seven states in northeast India.

Spatial Distribution of Nutrient Constraints

Leaf nutrient optima values were used to develop GIS-based nutrient distribution maps **(Figure 1)**. These maps showed that most orchards in northeast India were optimum in N nutrition, low to deficient in P, and optimum to high in K. Calcium and Mg were largely deficient in the acidic soils. On the other hand, Fe was mostly high, Cu was mostly deficient, and Mn and Zn were mostly optimum.

Delineation of Productivity Zones

Using GIS again, the spatial distribution of selected macro- and micro-nutrient constraints were superimposed and, when combined with fruit yield data, delineated orchard productivity

zones of interest **(Figure 2)** including Zone I: 26°8' 13" E & 27°25' 43" E latitude and 92°23' 82" N and 92°59'43" N longitude showing no constraint of Zn, Mg, P, and N and having very high average productivity of 84 kg/tree (areas identified as Navgaon, and Rangpara of Assam state); Zone II: 26°31'35"-27°2'35" E latitude and 88°3'49"-88° 23' 56" N longitude; 26°35'56"-27° 27'3" E latitude and 93° 23' 5"-93° 58' 26" N longitude showing no constraint of Zn, P, and N and having an good productivity of 54 kg/tree (areas identified as Golpara of Assam state and Mirik, and Lisa Hills of West Bengal state); and Zone III: 26°4' 55"-27°47'43" E latitude and 91°32'8"-93°0' 47" N longitude showing no constraint of Zn and P and having low productivity of 30 kg/tree (areas identified as Shergaon, Dirang, and Tangla & Mangaladai (Assam).

In summary, the integrated use of two diverse software-based DSS helped in identifying potential sites for the purposes of land use planning and monitoring trends in productivity and orchard fertility. Future evaluation of these productivity zones/sites with respect to maximising productivity and improving sustainability will help to improve the efficacy of this delineation process. BC-SA

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References

Schumann, A.W. and Q.U. Zaman. 2005. Precision Agric. 6:467-480.

Srivastava, A.K. and S. Singh. 2008. J. Plant Nutr. 31:1091-1107.

Srivastava, A.K., Shyam Singh, and K.N. Tiwari. 2006. Better Crops with Plant Food 88:22-25.

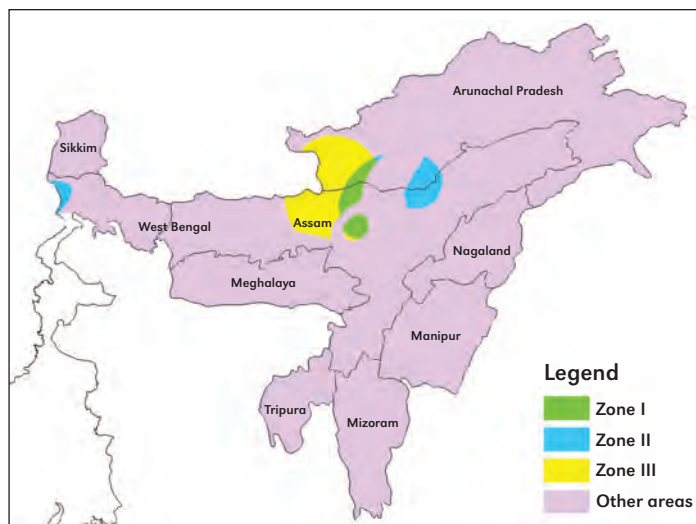Zaman, Q.U. and A.W. Schumann. 2006. Precision Agric. 7:45-63.

Figure 2. Three selected zones of mandarin orchard production in northeast India differentiated by selected leaf nutrient and yield survey data.

Software-aided decision support systems are adaptable to mandarin orchard management in Northeast India.

International Certified Crop Adviser Program Now in India

The International Certified Crop Adviser (ICCA) program of the American Society of Agronomy (ASA) was launched in India during 2010. This proactive certification program was established in 1991 in the United States of America (USA) and later extended to Canada. India is the first country outside North America to provide the ICCA program, along with "continuing education" as a major, significant, and attractive feature for renewing the certification. The India ICCA program is one of the objectives of the Cereal System Initiative for South Asia (CSISA). The program is being adapted in India through collaboration of ASA with the International Rice Research Institute (IRRI) and Indian Society of Agribusiness Professionals (ISAP).

The India ICCA certificate will be issued by ASA and will be recognized in the USA, Canada, and India. The program is open for all agri-professionals and agri-graduates who are engaged in farm advisory activity, whether in private or public sectors. The certification program includes af a comprehensive exam based on the Performance Objective document (syllabus) covering four major competency areas: Nutrient Management, Soil and Water Management, Integrated Pest Management, and Crop Management.

The main objective of this program is to educate the frontline agriculturists employed by private companies, non-government organizations (NGOs), and public sectors to guide farmers on the latest technologies. With this objective, the India ICCA program aims at improvement in the quality of farm advisory across all sectors of agriculture. The exam will be offered twice every year, in June and December. The basic requirement for the certification is either a degree in Agriculture, B.Sc. (Agri.) with a minimum of 2 years of crop advising experience or a higher secondary (10 +2) with a minimum of 4 years of active crop advising experience.

Detailed information for prospective candidates regarding the India ICCA exam is available at the website: www.certifiedcropadviser.org/india. Candidates may also contact the Manager, India Certified Crop Adviser Program, through e-mail at k.yadav@cgiar.org or phone at + 91 – 9654456005. Or contact the Indian Society of Agribusiness Professionals by phone at +91-11-43154100 or e-mail at indiacca@isapindia.org. BC-SA