Optimising Crop Nutrient Needs Using a Systematic Approach to Soil Fertility Evaluation and Improvement

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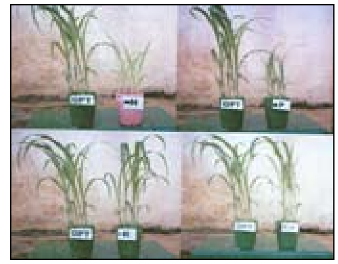

Model greenhouse experiments show variations in growing between + and – treatments (sorghum as indicator plant).

Field experimentation on crops grown in soils with multiple nutrient limiting situations is a challenge in terms of cost and time. Soil testing programs are evolving towards more realistic decision support systems for nutrient recommendations. Examples of research are described here showing how a systematic approach (SA) to soil fertility evaluation and improvement is helpful in establishing nutrient needs for crops grown in various soil types.

The soil resource base is constantly under pressure as food, feed, fuel, and fiber demands are ever increasing, while per capita availability of cultivated land is declining. Annual loss of plant nutrients from Indian soils continues to be large at 5.4 to 8.4 M t, thus the spread of multiple nutrient deficiencies is commonly reported throughout India. Under these circumstances, monitoring soil fertility is a real challenge demanding rapid, reliable, and inexpensive techniques.

The SA method of evaluating soil fertility actually dates back to the mid 1960s, but modified procedures of the SA as outlined by Hunter (1980) and Portch and Hunter (2002) have been found to be useful to facilitate simultaneous evaluation of all essential mineral nutrients under rapidly changing and dynamic soil fertility environments.

The SA concept necessitates pre-screening of the prevailing soil nutrient disorders through laboratory sorption studies and greenhouse experiments prior to conducting any field study. This process allows for the flexibility of repeated use of relatively inexpensive greenhouse experiments in case there is any need for further clarification. When satisfied, this knowledge is extended to related field experiments for the confirmation of screening results and quick assessment of the nutrient requirements of various crops under field conditions.

Our experience has allowed the adoption of such research programs in South India and Sri Lanka in collaboration with State Agricultural Universities to quickly diagnose multiple nutrient disorders in soils and efficiently optimise nutrient application for a variety of crops grown under various field situations. This paper presents results of experiments conducted on three soil series, including the Kalathur (clay loams, a member of soil order Vertisols – Typic Haplusterts) and Palaviduthi (sandy clay loams of the order Ultisols – Typic Kandiustults) series from Tamil Nadu where rice and sugarcane were field tested, and the Vellayani series (sandy clay loams of the order Alfisols – Typic Haplustalfs) of Kerala where banana was the test crop.

The sorption and greenhouse experiments performed on the Kalathur series indicated that N, P, K, and Zn were the most limiting for crop growth. Relative yields were 61, 66, 75, and 75% of that of the optimum when N, P, K, and Zn were omitted, respectively (**Figure 1**). Relative yields were not affected drastically with other nutrients, indicating that those four nutrients need further investigation to establish nutrient requirement of crops under a field situation. Ultimately, by utilising soil sorption information for P, K, and Zn along with greenhouse experiments and field experiments with rice, researchers established the application of 170-55-42-6.5 kg N-P_2O_5-K_2O-Zn/ha which produced yields close to 7 t/ha (Murugappan et al., 2001). Skipping any of these nutrients from the optimum dose drastically impacted crop yields (**Figure 2**) proving that those four nutrients are crucial to crop production. Here the researchers have used target yield equations and indigenous N supply to determine N rates in these conditions.

In the Palaviduthi series, sorption and greenhouse experiments established that in addition to N, P, K, and Zn, Fe was also an important nutrient. Omission of these nutrients from the optimum resulted in yields which were 62 to 84% of the optimum (**Figure 3**). This information was used in subsequent

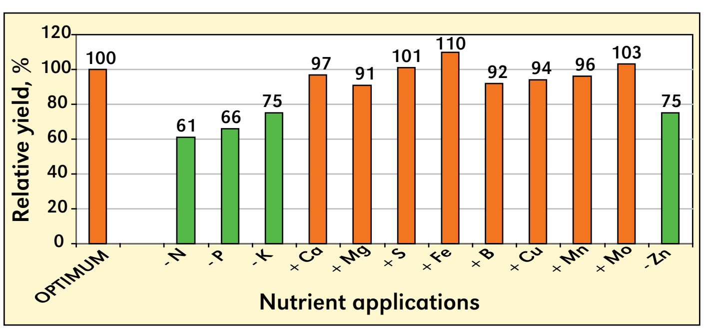

Figure 1. Results of greenhouse studies used to identify most limiting nutrients for rice prior to field experiments (Kalathur Series, Tamil Nadu).

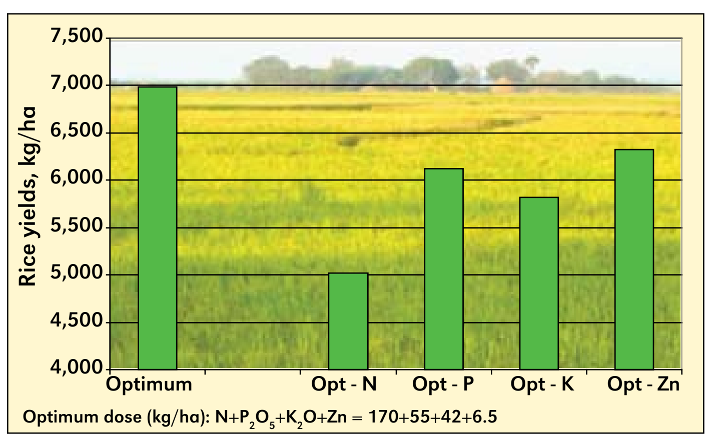

Figure 2. Results of field studies establishing nutrient needs for rice (Kalathur Series, Tamil Nadu).

Abbreviations and notes for this article: N = nitrogen; P = phosphorus; K = potassium; Mg = magnesium; Ca = calcium; Fe = iron; Zn = zinc; M t = million metric tons.

field experiments conducted on sugarcane (Balaji et al., 2005). All five nutrients are needed to obtain good cane yields of up to 126 t/ha with the applications of N, P_2O_5, K_2O, Zn, and Fe at the rates of 310, 160, 250, 31, and 72 kg/ha, respectively (**Figure 4**). Previous data collected from multi-locations with variable rates were used as the basis for N and sorption curves developed based on added levels of nutrients vs. levels extracted for the other nutrients. The doses were calculated to bring a desired level of each nutrient decided optimum for crop growth. Four levels each of N, P, and K in selected combinations along with two levels each for Fe and Zn were tested with three replications in randomized block design (complete data not shown here). This is a usual protocol established for selecting treatments and conducting field experiments to fine tune optimum nutrient doses.

For the Vellayani series, results were unusual since sorption and greenhouse values were not significantly affected by P addition. However, addition of N, K, Ca, and Mg were considered crucial for obtaining good yields in those series (**Figure 5**). Since Mg is not a common nutrient considered under banana production, the investigator was interested in establishing the Mg needs of the crop. The corresponding field experiments found that a nutrient application of 180-240-380-120 kg N-K_2O-Ca-Mg/ha resulted in optimum productivity (Prakashmany, 2002), a significantly higher response compared to the yield result from addition of N, K, and Ca (**Figure 6**).

Conclusion

Developing an inventory of soil fertility information at the soil series level using the SA has proven useful. Information obtained from sorption and greenhouse studies have predicted fairly well nutrient requirements, which were ultimately confirmed through field studies. Fertility information at the soil series level could in most cases where past farmer management was relatively similar, be safely extrapolated to large areas, providing information which is applicable to a wide range of crops and cropping systems, and saving time and costs within soil fertility evaluation programs. BC-INDIA

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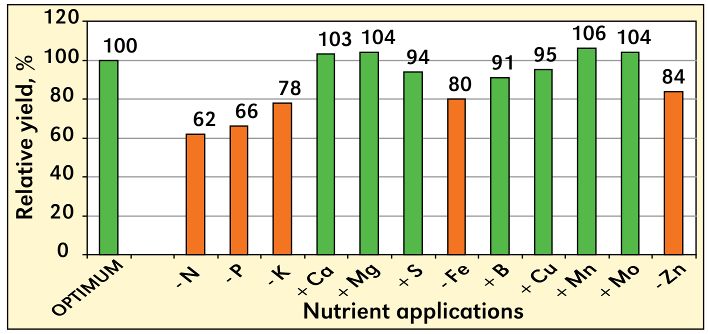

Figure 3. Results of greenhouse studies used to identify most limiting nutrients for sugarcane prior to field experiments (Palaviduthi Series, Tamil Nadu).

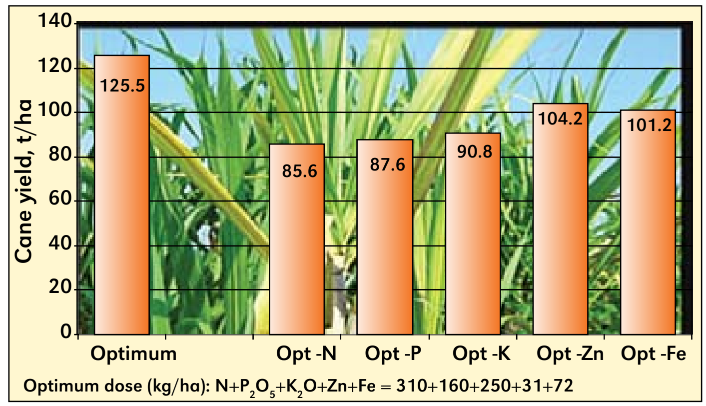

Figure 4. Results of field studies establishing nutrient needs for sugarcane (Palaviduthi Series, Tamil Nadu).

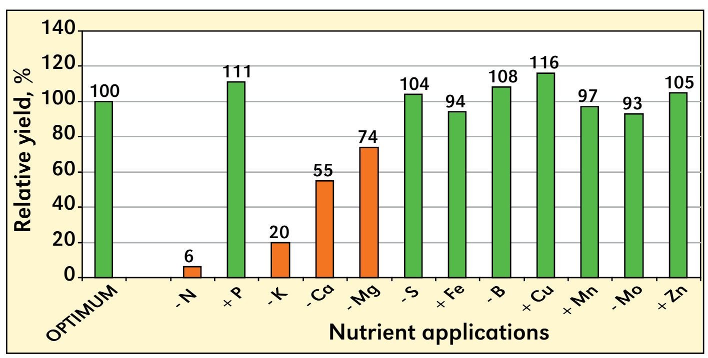

Figure 5. Results of greenhouse studies used to identify most limiting nutrients for banana prior to field experiments (Vellayani Series, Kerala).

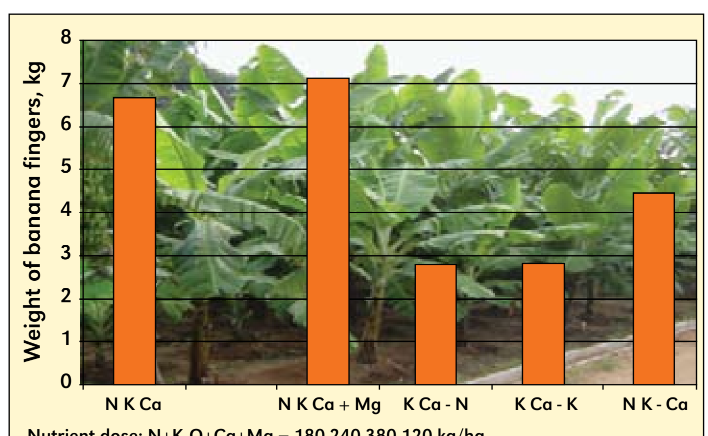

Figure 6. Results of field studies establishing nutrient needs for banana (Vellayani Series, Kerala).