Performance of Systematic Approach to Nutrient Management to Improve Maize Productivity in Tamil Nadu, India

Satyanarayana Talatam[A], P. Malarvizhi[B] and S.Thiyageshwari[C]

[A]International Plant Nutrition Institute, Hyderabad, Andhra Pradesh, India, Email: tsatya@ipni.net
[B]Soil Science, Tamil Nadu Agricultural University, Coimbatore, India, Email: malarmahes@hotmail.com
[C]Soil Science, Tamil Nadu Agricultural University, Coimbatore, India, Email: *thiyageshwari@gmail.com*

Abstract
Maize and maize-based cropping systems are becoming important for food and nutritional security in Tamil Nadu. However, there are wide yield gaps between different locations mainly due to inadequate and imbalanced fertilizer use. A systematic approach was employed to evaluate inherent fertility and nutrient deficiencies in a wide range of soils with considerable variability and to establish the guidelines for nutrient application rates to optimize crop production and profitability. Nutrient sorption and greenhouse experiments indicated that N, P, K, and Zn were the most limiting nutrients for maize growth in the State. The optimum nutrient treatment (ONT) established through a systematic approach helped in obtaining a 20% yield gain over the State fertilizer recommendation practices with a net benefit-cost ratio of 2.52.

Key words
Systematic approach, Optimum Nutrient Treatment, Fertilizer recommendations, Profitability.

Introduction
Maize is the third most important cereal crop after rice and wheat in India and is cultivated on 8.11 million (M) ha. Total maize production is 19.77 M t, with an average yield of 2,435 kg/ha in 2007-08 (DMR, 2008). Maize is a non-traditional crop in Tamil Nadu, cultivated on 0.18 M ha, with a production of 0.29 M t and an average productivity of 1,552 kg/ha, which is 64% of the national average (Season and Crop Report, 2005). This yield gap is mainly due to inadequate and imbalanced fertilization and lack of distinct fertilizer recommendations for the various varieties and hybrids grown. There is significant opportunity for maximizing maize yields to meet the ever increasing feed grain demand by the growing livestock industry in the state.

The systematic approach to assessing plant nutrient deficiencies involves the determination of prevailing soil nutrient disorders through laboratory sorption studies and greenhouse experiments prior to conducting field experiments (Portch and Hunter 2002). There is flexibility in this approach for repeating relatively inexpensive greenhouse experiments in case there is any need for further clarification of any nutrient disorders detected. Field experiments conducted in the final phase enables confirmation of screening results from the laboratory and greenhouse studies and helps in generating optimum nutrient recommendations for the test crop under various field situations.

Methods
Experiments were conducted in seven different soil series, viz., Irugur (Igr) series (sandy clay loam, Typic Haplustalf), Palaviduthi (Pvd) series (sandy clay loam, Typic Rhodustalf), Palladam (Pld) series (sandy clay loam, Lithic Haplustept), Thulukkanur (Tlk) series (Gravely sandy loam, Typic Haplustept), Mayamankuruchi (Myk) series (Clay, Typic Haplustept), Peelamedu (Plm) series (Clay, Typic Haplustert), and Madhukur (Mdk) series (sandy clay loam, Udic Haplustalf). All series represented dominant soil types where maize is grown. Initial soil analysis data indicated that the Igr, Tlk, Pvd, and Pld soil series had an alkaline pH and were non-saline in nature. Organic C and available N, P, and Zn were low in most of the soil series. But secondary nutrients (Ca, Mg, and S) and micronutrients Cu, Mn, and Fe were in the sufficient range.
We conducted nutrient sorption studies by adding a specific amount of the plant nutrient in solution to a specific volume of soil and allowing it to incubate for 72 hours in a dust-free environment. The air-dried sample was then analyzed for the respective nutrient elements. Sorption curves were drawn for each nutrient by plotting the amount of nutrient extracted on the Y axis against the amount of nutrient added on the X axis. The optimum nutrient treatment for the greenhouse experiment was defined for each experimental soil based on the nutrient fixation characteristics. Then greenhouse experiments were carried out using sorghum (var.

CO 29) as the test crop. The data from the sorption and greenhouse studies were used in subsequent field experiments conducted at different locations representing all seven soil series. The fertilizer rates were calculated to bring the desired level of each nutrient to the optimum level for crop growth (Table 1). Four rates of N, P, and K in selected combinations, along with a single rate of Zn, were tested using three replications in a randomized block design.

Table 1. Fertilization rates for the Optimum (ONT) and State recommendation (SR) treatments used at each experimental site.

Treatments	N-P_2O_5-K_2O-Zn, kg/ha						
	Igr	Tlk	Pvd	Pld	Plm	Myk	Mdk
ONT	200-54-80-8	200-76-75-11	200-76-88-7.4	200-80-85-6	200-60-25-10	200-64-48-4.8	200-70-152-9.6
SR	135-62.5-50-5.5	135-62.5-50-5.5	135-62.5-50-5.5	135-62.5-50-5.5	135-62.5-50-5.5	135-62.5-50-5.5	135-62.5-50-5.5

Results

Nutrient sorption and greenhouse experiments indicated that N, P, K, and Zn were the most limiting nutrients for maize growth. Use of the optimum nutrient treatment resulted in a dry matter yield which varied from 1.94 to 2.51 g/pot, with an average of 2.17 g/pot across the different soil series (Table 2). Relative yields were 57, 63, 71, and 75% of the optimum when N, P, K, and Zn were omitted. No significant yield reductions were noticed with other nutrients, indicating that only N, P, K, and Zn required further investigation to establish the nutrient requirement of maize under field conditions.

In the field experiments averaged over the seven different soil series , maize yields of 7.2 t/ha were obtained with the application of N, P_2O_5, K_2O, and Zn at the rates of 200, 69, 79, and 8 kg/ha, respectively (Table 3). Omitting any of these nutrients from the optimum dose adversely affected crop yield indicating that N, P, K, and Zn were crucial to maize production at the experimental sites.

The grain yield of maize obtained with the optimum nutrient treatment (ONT) treatment was 7.2 t/ha as compared to 6 t/ha under the State recommendation (SR), a yield advantage of 20% or more for 6 out of 7 soil series (Table 3). Economic comparisons were calculated based on the cost of crop inputs, labour, and the value of harvested grain and stover (Table 4). The optimum nutrient levels developed using the ASI method for hybrid maize proved beneficial to farmers as this approach resulted in a calculated net income of Rs.35,000/ha, versus Rs.23,200/ha with the SR. This approach further resulted in a benefit-to-cost ratio of 2.52 with ONT, versus 2.11 obtained with the adoption of the SR.

Table 2. Response of CO 29 sorghum in a greenhouse nutrient survey

Treatments	Dry matter yield, g/pot							Mean
	Igr	Tlk	Pvd	Pld	Plm	Myk	Mdk	
ONT	1.94 (100)	2.48 (100)	1.98 (100)	1.99 (100)	2.51 (100)	2.24 (100)	2.03 (100)	2.17 (100)
ONT-N	1.23 (63)	1.32 (53)	1.13 (57)	1.13 (57)	1.36 (54)	1.33 (59)	1.12 (55)	1.23 (57)
ONT-P	1.46 (75)	1.47 (59)	1.22 (62)	1.23 (62)	1.43 (57)	1.45 (65)	1.2 (59)	1.35 (63)
ONT-K	1.62 (84)	1.76 (71)	1.38 (70)	1.33 (67)	1.74 (69)	1.64 (73)	1.31 (65)	1.54 (72)
ONT-Zn	1.25 (64)	1.85 (75)	1.52 (77)	1.54 (77)	1.88 (75)	1.75 (78)	1.58 (78)	1.62 (75)
Control	0.52 (27)	1.02 (41)	0.59 (30)	0.68 (34)	1.99 (43)	0.92 (41)	0.75 (37)	0.92 (36)
SEd	0.06	0.07	0.06	0.06	0.1	0.09	0.08	
CD (0.05)	0.12	0.13	0.12	0.11	0.2	0.19	0.17	

Data in parenthesis represents relative yield (%)

CD denotes the critical difference

Table 3. Grain yield of maize for several soil series of Tamil Nadu

Treatments	Grain yield, kg/ha							Mean over locations
	Igr	Tlk	Pvd	Pld	Plm	Myk	Mdk	
ONT	7,120	7,247	7,182	7,284	7,209	7,265	7,210	7,217
ONT-N	3,125	3,200	3,150	3,252	3,498	3,218	3,163	3,229
ONT-P	3,640	3,764	3,720	3,822	4,085	3,782	3,740	3,793
ONT-K	3,887	3,930	3,873	3,975	3,546	3,948	3,926	3,869
ONT-Zn	5,675	5,840	5,748	5,850	5,952	5,858	5,785	5,815
ONT (125% N)	7,805	7,987	7,712	7,814	8,147	8,005	7,908	7,911
SR	5,895	6,058	5,920	6,022	6,110	6,076	5,975	6,008
Control	2,598	2,786	2,667	2,769	2,886	2,804	2,698	2,744
SEd	321	328	109	329	96	118	115	
CD (0.05)	664	677	224	679	197	244	237	

Table 4. Unit cost of inputs and produce

S. No.	Particulars	Units	Cost (Rupees)
	Inputs		
1.	Maize seed (COHM -5)	1 kg	70.00
2.	Urea	1 kg	5.00
3.	Super phosphate	1 kg	4.00
4.	Muriate of potash	1 kg	4.50
5.	Zinc sulphate	1 kg	26.00
6.	Atrazine	1 kg	240.00
	Labour Wages		
7.	A type (Man)	8 hrs/day	100.00
8.	B type Female (Woman)	8 hrs/day	50.00
	Produce		
9.	Maize grain	1 quintal	700.00
10.	Stover	1 tonne	300.00

Conclusion

This study on optimising nutrient needs using an established systematic approach for several bench mark soils of Tamil Nadu showed improvement in maize yield and helped to identify the response of major, secondary, and micronutrients. Simplification of the approach in the future through developing models for different soil series can improve maize production, productivity, and profitability in Tamil Nadu.

References

DMR (2008) Salient achievements of AICRP maize, Directorate of Maize Research, New Delhi, India.

Portch S, Hunter A (2002) Special Publication No. 5, PPI/PPIC China Program. pp. 1-62.

Seasons and Crop Report (2005) Directorate of Economics and Statistics. Government of Tamil Nadu.