Nutrient Management to Improve Maize Productivity in Tamil Nadu

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Maize and maize-based cropping systems are becoming important for food and nutritional security in Tamil Nadu. A systematic approach to soil fertility evaluation determined common nutrient deficiencies on soils in Tamil Nadu and established guidelines for nutrient application rates to optimise crop production and profitability.

Maize is the third most important cereal crop in India after rice and wheat 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, or only 64% of the national average (Season and Crop Report, 2005). This yield gap is mainly due to inadequate and imbalanced fertilisation and lack of distinct fertiliser recommendations for the various varieties and hybrids grown. There is significant opportunity for maximising maize yields to meet the ever-increasing feed grain demand by the growing livestock industry in the state.

This study's systematic approach to assessing plant nutrient deficiencies involved 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 need for further clarification of nutrient disorders detected. Field experiments conducted in the final phase enable 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.

Nutrient optimisation strategy is needed to increase maize yields.

Greenhouse experiments indicated that N, P, K, and Zn would be the most limiting nutrients.

Experiments were conducted on seven different soil series representing dominant soil types where maize is grown. These included the Irugur (Igr) series in Coimbatore district (sandy clay loam, Typic Haplustalf), Palaviduthi (Pvd) series in Dindigul district (sandy clay loam, Typic Rhodustalf), Palladam (Pld) series in Coimbatore district (sandy clay loam,

Abbreviations: N = nitrogen; P = phosphorus; K = potassium; S = sulphur; C = carbon; Ca = calcium; Mg = magnesium; Zn = zinc; Cu = copper; Mn = manganese; Fe = iron; ONT = Optimum Nutrient Treatment; SR = State Recommendation; CD = Critical Difference, equivalent to Least Significant Difference; SEd = Standard Error of the Difference.

Table 1. Response of CO 29 sorghum in greenhouse nutrient survey.

	------------- Dry matter yield, g/pot -------------							
Treatments	Igr	Tlk	Pvd	Pld	Plm	Myk	Mdk	Mean
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 (p = 0.05)	0.12	0.13	0.12	0.11	0.2	0.19	0.17	

Table 2. Fertilisation rates of the Optimum (ONT) and State recommendation (SR) treatments used at each experimental site.

	---------- $N\text{-}P_2O_5\text{-}K_2O\text{-}Zn$, kg/ha ----------						
Treatments	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

Table 3. Grain yield of maize in different soil series of Tamil Nadu.

	---------- Grain yield, kg/ha ----------							
Treatments	Igr	Tlk	Pvd	Pld	Plm	Myk	Mdk	Mean over locations
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 (p = 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
2.	Urea	1 kg	5
3.	Super phosphate	1 kg	4
4.	Muriate of potash	1 kg	4
5.	Zinc sulphate	1 kg	26
6.	Atrazine	1 kg	240
	---------- Labour Wages ----------		
7.	A type (Man)	8 hrs/day	100
8.	B type (Woman)	8 hrs/day	50
	---------- Produce ----------		
9.	Maize grain	1 quintal	700
10.	Stover	1 tonne	300

Lithic Haplustept), Thulukkanur (Tlk) series in Salem district (Gravely sandy loam, Typic Haplustept), Mayamankuruchi (Myk) series in Tirunelveli district (Clay, Typic Haplustept), Peelamedu (Plm) series in Perambalur district (Clay, Typic Haplustert), and Madhukur (Mdk) series in Perambalur district (sandy clay loam, Udic Haplustalf). The results of the initial soil analyses 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. Secondary nutrients (Ca, Mg, and S) were sufficient and micronutrients like Cu, Mn, and Fe were above the critical limits.

Nutrient sorption studies were carried out 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 analysed 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 or complexation characteristics. The greenhouse experiments were carried out using sorghum (var. CO 29) as the test crop (Portch and Hunter, 2002).

Nutrient sorption and greenhouse experiments indicated that N, P, K, and Zn would be 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 1)**. 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.

The data above were used in subsequent field experiments conducted at different locations representing all seven soil series. The fertiliser rates were calculated to bring the desired level of each nutrient up to the optimum for crop growth **(Table 2)**. Four rates of N, P, and K in selected combinations, along with a single rate of Zn, were tested using three replications in a randomised block design. In this summary, only the optimum rate is shown in the results presented. Maize yields of up to 7.2 t/ha were obtained, averaged over the seven different soil series, 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)**. Skipping any of these nutrients from the optimum dose drastically impacted crop yields, proving that those four nutrients were crucial to maize production at these locations.

The grain yield of maize obtained with the ONT treatment was 7.2 t/ha as compared to 6 t/ha under the SR **(Table 3)**, a yield advantage of 20% or more at 6 out of 7 soil series. Similarly, a grain yield of 7.9 t/ha with the ONT (125% N) treatment provided a 32% yield advantage over the SR **(Table 3)**. This latter result indicates that the maize crops responded to additional levels of N applications over the initial ONT recommendations and there is a need to further study the yield advantage with additional levels of N.

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 Agro Services International (ASI) method (Portch and Hunter, 2002) for hybrid maize proved beneficial to farmers as this approach resulted in a calculated net income of Rs.35,000/ha, versus

Optimum treatments produced maize grain yields of 7.2 t/ha, compared to 6 t/ha with State Recommendation rates.

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.

The outcome of this study on optimising nutrient needs using an established systematic approach in different benchmark soils of Tamil Nadu will help to increase maize production and identify the response of major, secondary, and micronutrients. Further refinement of actual nutrient application rates in field trials ultimately leads to the fertiliser recommendations which farmers of Tamil Nadu can use to achieve maximum economic yield. BC INDIA

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Acknowledgment

The authors greatly appreciate and acknowledge the financial and technical support of the IPNI India Programme.

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