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A New Systematic Technique for Optimum Fertilizer Treatment in Fertilizer Response Experiments

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Experiments were carried out to optimize the nutrients for hybrid maize through nutrient sorption study and green house experiment during 2007- 2008 at Tamil Nadu Agricultural University, Coimbatore. A systematic procedure for optimum nutrient treatment (ONT) as the basis for formulating the treatment structure for field experiments for fertilizer response studies was tested in the present investigation in two soil series belonging to Mayamankuruchi (*Typic* Haplustepts and Madukkur (*Udic* Haplustalfs). Nutrient sorption studies were conducted in these soils for P, K, S, Zn, Fe, Cu, Mn and B. The critical level of nutrients for these soils were fixed prescribed by Portch and Hunter. The sorption curves were used to formulate Optimum Nutrient Treatment (ONT). The validity of these ONTs was verified in a green house experiment using the same soil. The two experimental soils were found to deficient in N, P, K and Zn, and their optimum amounts varied between the soils. The optimum nutrients for hybrid maize *var.* COHM5 were formulated for these two soil series from this study.

Key words: Green house study, Mayamankuruchi, Madukkur, Soil series, Nutrient sorption, Optimum nutrient treatment,

The primary requirement of any successful nutrient management strategy for any crop is the development of realistic fertilizer optima in a systematic way eliminating 'surprise' nutrient deficiencies that may occur in the experimental soil. Obtaining adequate information from the laboratory and green house is immense prior to field trials. The benefits of additional in depth information allows clear interpretation of overall fertility status. By having prior information about a soil from a laboratory and green house fertility status only a limited number of field trials are needed to obtain economic optimum fertilizer recommendation for maize crop. Fertilizer recommendations based on such valid optima and by ensuring balanced nutrition of the test crops help to boost the yield of crops and sustain high crop yields since they become 'rationalized' doses of fertilizers for crops.

A systematic approach to soil fertility evaluation as proposed by Portch and Hunter (2002) envisages the optimization of fertilizer requirement for crop based on the nutrient sorption characteristics of soil. The quantum of nutrients fixed by soil is determined based on the difference between the concentration of nutrients added and extracted with appropriate extractant. The nutrient fixation curve is used to calculate the amount of plant nutrient needed to be added to the soil to arrive at optimum level for growth and yield of crops. The optimal treatment was tested in the present study on two soils belonging to Mayamankuruchi and Madukkur soil series and the findings are presented in this paper.

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Materials and Methods

In the first phase of the study, an incubation experiment was carried out during 2007-08 at Tamil Nadu Agricultural University, Coimbatore to know if any of the applied plant nutrients, *viz.* P, K, S, Zn, Cu, Fe, Mn and B react (fix or complex) abnormally with the soil. The fixation studies are done by adding a specific amount of the plant nutrient in solution to a specific volume of soil. The solution volume added to the soil is sufficient to supersaturate the soil and thereby keeping it under anaerobic condition for a short period of time. After the solution is added, the soil is allowed to incubate at field capacity moisture for 3 days (72 hours) in a dust free atmosphere. After air drying, the soil was analyzed for the respective nutrient element under each treatment.

Using the data of sorption studies, sorption curves were drawn for each nutrient by plotting the amount of nutrient extracted in Y axis against the amount of nutrient added in X axis.

Optimum nutrient treatment (ONT)

From the results of incubation experiments, whether the applied plant nutrients *viz*., P, K, S, Zn, Cu, Mn and B react (fix or complex) abnormally with the experimental soils (Hunter, 1980) was accomplished and an optimum nutrient treatment

(ONT) for greenhouse experiment was defined for each experimental soil.Critical levels of nutrients required for the soil with CEC more than 5 c mol (p_+) kg_{-1} (60, 196, and 6 mg L_{-1} for P,K and Zn, respectively) were used in formulating the ONT as prescribed by Portch and Hunter (2002). In whichever case, if the extracted amount of nutrients at the initial level was higher than the critical level, this nutrient was considered as not limiting in the soil. If the extracted amount of a nutrient at the initial level was less than the critical level, then this nutrient was considered as limiting in the soil. Such of these limiting nutrients were included in the ONT. A positive growth response is expected for almost all soils when nitrogen is added. Since, every soil is deficient in N and requires its application, N was also included in the ONT at 100 mg kg_{-1} level as prescribed by Portch and Hunter (2002). The optimum nutrients treatment as 100, 32, 24 and 2.4 mg kg_{-1} of NPK and Zn, respectively were fixed for Mayamankuruchi soil series. Similarly, the optimum nutrients treatment as 100, 35, 75 and 4.8 mg kg_{-1} of NPK and Zn, respectively were fixed for Madukkur soil series.

In the second phase of study, testing of the ONT by means of green house nutrient survey experiment was accomplished by following the fundamental was the ONT. Treatments 2-13 (Table 3) received the same amount of each nutrient as that of optimum except for the one under study. If the nutrient was added in the optimum then it was excluded in the particular treatment and vice versa. Treatment 14 was the check.

The greenhouse experiment was set up for experimental soils using plastic cups (250- 300 ml). In each plastic cup, 4 holes (0.5 cm diameter) were made at the bottom and cotton was placed at the bottom of the cup to prevent the soil passing from the cup. The plastic cups were filled with 200 g of air dried soil. The cups were placed in a plastic tray. Fodder sorghum (*Sorghum vulgare) var.* CO 29 was sown as the test crop. After seed germination, capillary irrigation was started.The irrigating solution, prepared by dissolving of 1.5 g NH_4NO_3 in 5 litres of water was added to the plastic tray to a depth of about 1.5 cm and constantly maintained at that depth for the entire growth period. For irrigation, a reservoir bottle of one litre capacity was used. The reservoir bottles filled with the irrigation solutions were inverted to sit inside a plastic pipe placed at the bottom of the plastic tray. Two slits of about one cm depth were cut into both the ends of the pipe for the entry of air and liquid. All the plastic cups representing treatments in all the four replications. After few days of germination, the plants were thinned and maintained seven plants per cup.

Sorghum plants were harvested on twenty fifth day after sowing. They were dried in an oven at 60-70_o C until a constant dry weight was reached and the dry matter yield in each plastic cup recorded.

The relative yield (RY) was worked out separately for each treatment using the formula.

$$RY = \frac{DMYt}{DMY_{ONT}} \times 100$$

Where, DMY represents drymatter yield, t represents the treatment and ONT represent the optimum nutrient treatment.

Results and Discussion

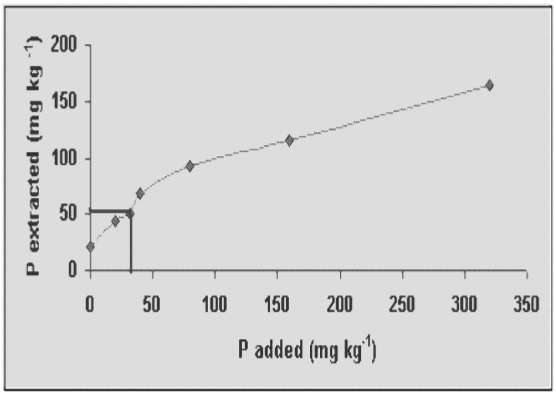
The results of nutrient sorption study revealed that P,K and Zn were found to limit yield in both the experimental soils. The level of extracted nutrients by the soil were below the critical level on the basis of CEC (above 5 c mol (p_+) kg_{-1}) as prescribed by Portch and Hunter (2002).

Table 1. Characteristics of the experimental soil

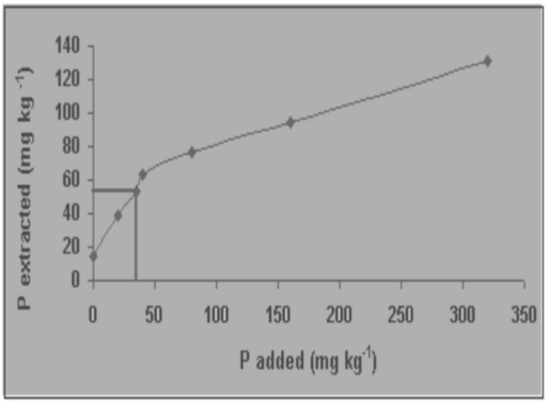
Parameter	Measured values	
	Myk series	Mdk series
Texture	Cl	Scl
Soil pH (1:2.5)	8.07	6.75
Electrical conductivity (dSm_{-1})	0.26	0.03
Cation exchange capacity (c mol (p_+) kg_{-1})	31.2	14.3
Organic carbon (per cent)	0.57	0.33
Available nitrogen (kg ha_{-1})	230.3	148
Available phosphorus (kg ha_{-1})	18.4	14.0
Available potassium (kg ha_{-1})	292	242
Exchangeable calcium (c mol (p_+) kg_{-1})	31.5	10.0
Exchangeable magnesium (c mol (p_+) kg_{-1})	6.7	2.87
$CaCl_2$ - S (mg kg_{-1})	73.2	68.5
DTPA- Zn (mg kg_{-1})	2.91	2.6
DTPA- Cu (mg kg_{-1})	4.26	4.4
DTPA- Mn (mg kg_{-1})	20.4	15.3
DTPA- Fe (mg kg_{-1})	42.5	41.1
Hot water soluble B (mg kg_{-1})	6.2	6.1

The results of the experimental soils revealed that the CEC of Maymankuruchi and Madukkur soil series were 31.2 and 14.3 c mol (p_+) kg_{-1} respectively which were greater than 5 c mol (p_+) kg_{-1}. The extracted amount of S, Mn, B, Fe and Cu were higher than the critical level as prescribed by Portch and Hunter (2002). Hence, the above nutrients were not included in ONT. The extracted amounts of other nutrients such as P, K and Zn were found to be below the critical level, so these nutrients were included in ONT. The quantum of P, K and Zn required to be added to meet the optimum nutrient requirement for maize is given in Table 3 and Fig. 1. Since N is universally limiting crop yield, a standard dose of 100 mg kg_{-1} was fixed as optimum nutrient requirement to the greenhouse experiment. Therefore, N was also included along with P, K and Zn in the ONT of the experimental soils. The test crop sorghum CO 29 was used for the above study.

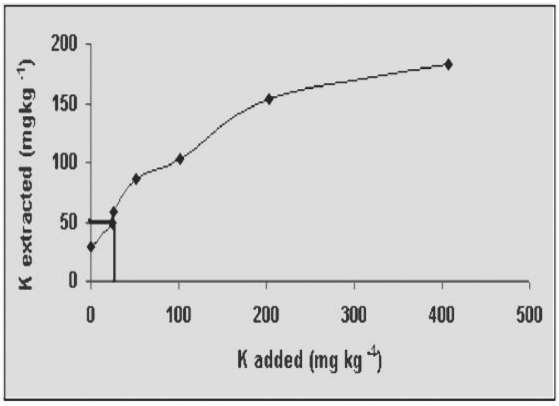
The nutrient requirements of the ONT varied between the two experimental soils (Table 2). The Madukkur soil series required high amount of P, K and Zn as compared to the Mayamankuruchi soil series.The predominant clay mineral in Mayamankuruchi soil series was of 2:1 expanding



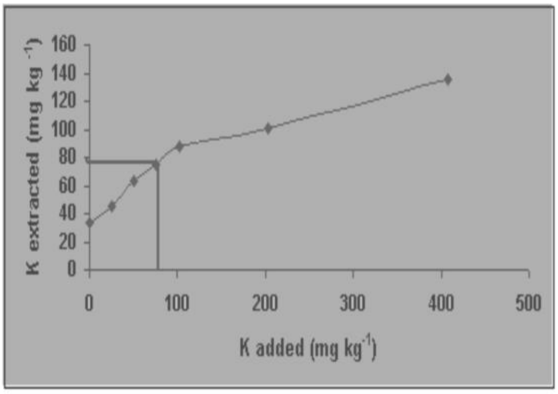
P sorption curves (Mky)



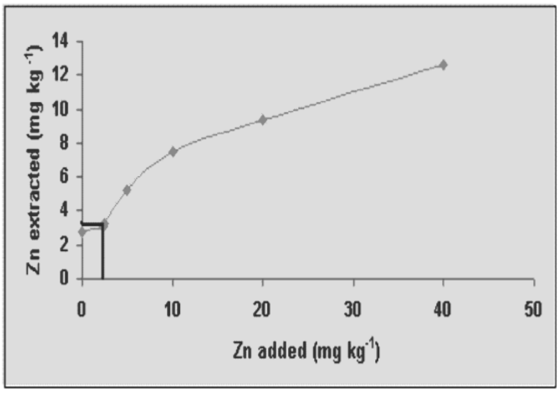
P sorption curves (Mdk)



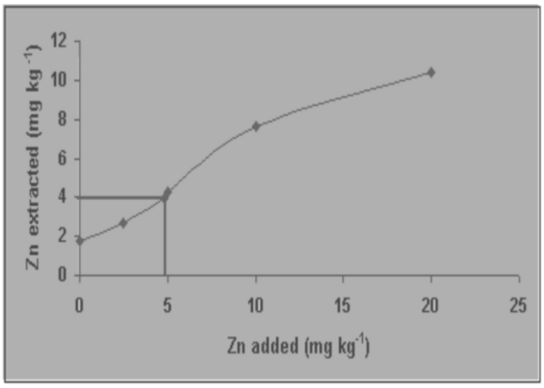
K sorption curves (Myk)



K sorption curves (Mdk)



Zn sorption curves (Myk)



Zn sorption curves (Mdk)

Fig.1. Nutrient sorption curve

type. Besides, this soil also contained higher amount of available potassium and its CEC was also higher as compared to Madukkur soil series (Table 1). This might be due to the role of exchangeable cations in releasing the soil nutrients in the available pool. Similar observations were made by Latha and Murugappan (2005) and Balaji (2005). The Mayamankuruchi soil series belonged to clay loam and Madukkur soil series was sandy clay loam. By virtue of these properties, the Mayamankuruchi soil series inherently maintained high level of K in exchangeable form and therefore the K requirement in ONT of Mayamankuruchi soil series was lower than that of Madukkur soil series. Similar finding was reported by Murugappan *et al.* (2002).

In green house study, the dry matter yield was significantly reduced in the treatments in which N, P, K and Zn were excluded from the ONT (Table 2). In the case of Mayamankuruchi series, the yield reduction was 41 per cent when N was excluded and 43 per cent when P was excluded from ONT. The yield reduction was 35 per cent with K and 27 per cent with Zn exclusion from ONT. For Madukkur series, these reductions were 45, 41, 35, and 22 percentages, respectively for N, P, K and Zn exclusion from ONT. The addition of other nutrients, *viz.,* Ca,

Table 2. Response of CO 29 sorghum for nutrients in green house survey study

Treatment	Nutrient doses with ONT	Mayamankuruchi		Madukkur	
		Dry matter yield (g pot^{-1})	Relative yield (%)	Dry matter yield (g pot^{-1})	Relative yield (%)
ONT	100, 60, 190 and 6 mg kg^{-1} N,P,K and Zn	2.24	100.0	2.03	100.0
ONT-N	N not added	1.33	59.4	1.12	55.2
ONT-P	P not added	1.45	64.7	1.20	59.1
ONT-K	K not added	1.64	73.2	1.31	64.5
ONT - Zn	Zn not added	1.75	78.1	1.58	77.8
ONT + Ca	400 mg kg^{-1}Ca	2.15	95.9	2.08	100.5
ONT + Mg	121 mg kg^{-1} Mg	2.11	94.2	2.09	102.9
ONT+S	60 mg kg^{-1} S	2.26	100.8	2.02	99.5
ONT + Fe	20 mg kg^{-1} Fe	2.32	103.5	2.11	103.9
ONT + Cu	4 mg kg^{-1} Cu	2.01	89.7	1.95	96.0
ONT + Mn	30 mg kg^{-1} Mn	2.28	101.7	1.91	94.1
ONT+B	2 mg kg^{-1} B	1.96	87.5	1.79	88.2
ONT + Mo	2 mg kg^{-1} Mo	2.01	89.7	1.74	85.7
Control	Nothing was added	0.92	41.1	0.75	36.9
SEd	-	0.09	—	0.08	—
CD (0.05)	-	0.19	—	0.17	—

Mg, S, Cu, Fe, Mn and Mo, which were not part of ONT, did not significantly influence the dry matter yield. Keeping the ONT as the central treatment, other treatments for field experiments can be formulated by varying the level of each nutrient. The treatment structure formulated on this basis to evaluate maize response to the deficient nutrients in the two bench mark soils used in the present study are presented in Table 3. Thus, the ONT for the two experimental soils defined on the basis of soil analysis and nutrient sorption studies were valid and considered as fundamental for the field experiments, which are mean to define fertilizer optima.

Table 3. Treatments for the field trial

Treatment	Mayamankuruchi series				Madukkur series			
	N	P	K	Zn	N	P	K	Zn
	Nutrient doses (kg ha^{-1})							
$N_0P_2K_2Zn$	0	64	48	4.8	0	70	150	9.6
$N_1P_2K_2Zn$	150	64	48	4.8	150	70	150	9.6
$N_2P_2K_2Zn$ (ONT)	200	64	48	4.8	200	70	150	9.6
$N_3P_2K_2Zn$	250	64	48	4.8	250	70	150	9.6
$N_2P_0K_2Zn$	200	0	48	4.8	200	0	150	9.6
$N_2P_1K_2Zn$	200	48	48	4.8	200	52.5	150	9.6
$N_2P_3K_2Zn$	200	80	48	4.8	200	87.5	150	9.6
$N_2P_2K_0Zn$	200	64	0	4.8	200	70	0	9.6
$N_2P_2K_1Zn$	200	64	36	4.8	200	70	112.5	9.6
$N_2P_2K_3Zn$	200	64	60	4.8	200	70	187.5	9.6
$N_2P_2K_2$ -Zn	200	64	48	4.8	200	70	150	9.6
Blanket (state recommendation)	135	62.5	50	5.5	135	62.5	50	5.5
Control	0	0	0	0	0	0	0	0

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References

Balaji, T. 2005. Evaluation of balanced fertilization for maximizing the yield and quality of sugarcane in Theni district. Ph.D. Thesis. Tamil Nadu Agricultural University, Coimbatore.

Hunter, A. H. 1980. Laboratory and green house techniques for nutrient survey studies to determine the soil amendments required for optimum plant growth, Agro Services International Inc., Orange city, Florida, USA.

Latha, M.R. and Murugappan, V. 2005. Fertilizer optimization in rice by eliminating hidden nutrient deficiencies. Inst. *Rice Res. Newsl.*, 29.2: 63-65.

Murugappan, V., Latha, M.R, Jagadeeswaran, R and Sheeba, S. 2002. Nutrient sorption as the basis for identifying nutrient deficiencies in soils. *J. Agric Resource Management* **1**: 70-76.

Portch and Hunter, A. 2002. A Systematic Approach to Soil Fertility Evaluation and Improvement, Modern Agriculture and Fertilizers, *Spl. Publication No. 5*, PPI/PPIC China Program.

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