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THE MITSCHERLICH PLANT GROWTH MODEL FOR DETERMINING THE DTPA EXTRACTABLE COPPER IN SOIL

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ABSTRACT

A mathematical model, based on the first order rate equation derived to determine the critical nutrient level in soil and plants. The model has been used to determine the critical level by characterizing plant growth as a function of nutrient concentration in plant tissues or content of the soil. A field experiments was conducted to establish critical limit to DTPA extractable Cu with graded levels of Cu (0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg Cu ha^{-1}) as adopted during 2012-13 for onion growing soils in Tamil Nadu. The curve linear equation was developed based on the Bray's percentage yield (Y) and soil available Cu (x). The extrapolated Bray's per cent yield values at varying definite interval (0.1 mg kg^{-1}) of DTPA extractable Cu in the soil were determined from the equation. The estimated Bray's per cent yield was started to decline after the increasing the DTPA level of 3.00 mg kg^{-1} and upto this extrapolated Bray's percentage yield was considered for estimation of ã. The critical concentration of available Cu in soil worked out to be 0.625 mg kg^{-1} below which appreciable responses to Cu application was expectable.

KEYWORDS: DTPA extractable Cu, Mitscherlich method, Onion growing soils, Onion leaf, Plant growth model.

INTRODUCTION

Copper is an essential micronutrient for normal growth and metabolism of plants (Sharma and Agarwal 2005; Singh *et al*. 2007). Onion belongs to a group of vegetables that have high response to Cu (Swiader and Ware 2002). Micronutrient deficiencies become a major constraint for crop productivity in many Indian soils. The deficiency of micronutrients may either be primary, due to their low total contents or secondary, caused by soil factors that reduce their availability to plants (Sharma and Chaudhary 2007). Knowledge of micronutrient availability in the soil is fundamental for suitable fertilizer recommendations, to avoid deficiency or toxicity problems. Several studies have been conducted to determine the critical nutrient level in soils and plants. The critical levels have been determined by relating available nutrient content of the soil or nutrient concentration in the crop plant with yield. The critical limit in plant refers to a level at or below which plant either develops deficiency symptoms or causes statistically significant or 5 to 10 percent reduction in crop yield as compared to optimum (Debnath and Ghosh 2012).

Clear prediction of deficiencies, critical limits must be refined with reference to nutrient levels both in soil and plant. The suitable fertilizer recommendation can be presented by calibration experiments with crop response results for each crop and determining of critical level of the element is necessary for particular crop (Soltanpour *et al*., 1986). Therefore, it is desirable to precisely know the critical limit of micronutrient in soil and plant is highly useful for providing suitable micronutrient application for crops. It reduces the concentration of micronutrients in soil solution below that required for normal growth. A modified Mistscherlich response equation to quantify critical deficiency levels by characterising plant growth as a function of tissue nutrient concentration (Ware *et al.,* 1982). Critical level of Cu was reported as 1.3 mg kg^{-1} by Mistcherlich-Bray equation for obtaining 80 percent of maximum grain yield in wheat **(**Feiziasl *et al.,* 2009). Sharma (1991) found that the critical N concentration of 3rd leaf from top of the potato for getting optimum tuber yield. Hence the present investigation was undertaken to study the response of onion to Cu fertilisation in the field conditions and to determination of critical limit the DTPA extractable Cu in soils

MATERIAL AND METHODS

Field experiments were conducted at eight locations in various farmer fields at Vadivellampalayam, Panaiyampalli and Pungampalli villages in Tamil Nadu during *Rabi* season (2012-13) for refinement of Copper

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critical limit in soils.The soil of the experimental fields were belonging to the soil series Irugur, Manupatti, Vellalur, Palathurai, Athipalayam, Kanjampatti, Sommaiyanur, Puduvadavalli and Annur soil series (Table 1). The initial analysis of experimental soil was neutral to slightly alkaline in reaction and free from salts. The organic carbon content of the soil was low. The soil was low in available N and P, medium in available K, sufficient in DTPA extractable Zn, Mn, Fe and hot water soluble boron. Based on the available status of Cu, eight farm holdings (L1 to L8) were selected (on the ascending order of Cu status stating from 0.22 mg kg^{-1} at interval of 0.2 mg kg^{-1}). The experiment was laid out in a randomised block design replicated thrice with seven levels of Cu application *viz*., 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg ha^{-1} along with recommended fertiliser dosage 60:60:30 kg N, P_2O_5 and K_2O kg ha^{-1} (Table 2). The fertilizers were applied in the form of urea, super phosphate and muriate of potash to all the treatments. Before sowing of onion bulbs, the required quantity of Cu was applied through $CuSO_4$ as per the schedule. After harvesting of crop weight of bulbs was recorded separately and the collected soil samples were processed and analyzed for DTPA extractable copper with help of atomic absorption spectrophotometer.

A mathematical model, based on the first order rate equation was derived to determine the critical nutrient levels in soil and plants. The model has been used to determine nutrient levels by characterizing plant growth as a function of nutrient concentration in plants or nutrient available in soil or nutrient applied. The critical nutrient level can be determined by the equation $x = -\text{In}\,(0.1/Y) / K$,where

$$K=\sum_{k=1}^{1-n}\left(\frac{2.303}{x}\ \log10\ \frac{a}{a-y}\right)n-1 \quad \text{and} \quad Y=\left(\frac{a-y_0}{a}\right)$$

where,

a = maximum estimated yield;

y_0 = minimum estimated yield (Sharma 1991).

RESULT AND DISCUSSION

A mathematical model, based on the first order rate equation derived to determine the critical nutrient level in soil and plants. The model has been used to determine the critical level by characterizing plant growth as a function of nutrient concentration in plant tissues or content of the soil. The model determines the critical soil nutrient level for which a large body of data is desired in order to get accurate critical values. The curve linear equation was developed based on the Bray's percentage yield (Y) and soil available Cu status (x). The extrapolated Bray's per cent yield values at varying definite interval of DTPA extractable Cu in the soil were determined from the equation.

$$Y = 34.07 + 14.39\,x - 2.419\,x^2.$$

The extrapolated Bray's per cent yield values at varying definite interval (0.1 mg kg^{-1}) of DTPA extractable Cu in the soil was determined from the equation (Table 3).The estimated Bray's per cent yield was start to decline after the increasing the DTPA level of 3.00 mg kg^{-1} and up to this the extrapolated Bray's percentage yield was considered for estimation of γ, *i.e*. ratio of difference between maximum and minimum extrapolated yield divided by maximum yield.

$$\gamma = (55.50-34.07) / 55.50$$

$$\gamma = 0.3860$$

The average K value is 2.160.

$$\text{Critical limit } (x) = -\text{In}\,(0.1/\gamma) / K$$

$$x = 0.6253$$

The critical limit of DTPA extractable soil Cu value obtained from this study is 0.625 mg kg^{-1}. Using the Mathematical method 0.625 mg kg^{-1} is the critical limit of DTPA extractable Cu in onion growing soils. Sharma (1991) reported the critical limit of 0.75 mg kg^{-1} DTPA-Zn for potato grown soil and also found that the critical N concentration of 3rd leaf from top of the Potato for getting optimum tuber yield. Similarly, Ware *et al*., (1982) used a modified Mitscherlich response equation to quantify critical deficiency levels characterizing plant growth as a function of tissue nutrient concentration.

CONCLUSIONS

A mathematical model, based on the first order rate equation derived to determine the critical nutrient level in soil and plants. The model has been used to determine the critical level by characterizing plant growth as a function of nutrient concentration in plant tissues or content of the soil. The curve linear equation was developed based on the Bray's percentage yield (Y) and

Table 1. Physical and chemical properties of the experimental site

S. No.	Particulars	Values							
		Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8
I.	**Physical properties**								
1	Sand (%)	78.13	68.3	73.36	52.4	70.52	67.69	45.1	57.8
2	Silt (%)	2.55	13.9	8.12	22.2	7.60	8.11	16.2	15.5
3	Clay (%)	19.32	17.8	18.52	25.4	21.88	24.20	38.70	26.70
4	Textural Class (%)	Sandy loam	Sandy loam	Sandy loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam
	Soil Series	Manupatti	Kanjampatti	Annur	Irugur	Puduvadavalli	Kuppandampalayam	Palathurai	Vellalur
II.	**Physico-Chemical properties**								
1	Soil pH	7.65	7.53	7.32	7.43	7.72	7.31	7.71	7.74
2	EC (d S m^{-1})	0.28	0.41	0.32	0.52	0.43	0.27	0.53	0.37
3	Organic carbon (g kg^{-1})	0.47	0.45	0.4	0.43	0.24	0.33	0.43	0.33
4	CEC (c mol(p+)kg^{-1})	15.2	17.8	19.4	22.3	17.0	28.8	22.9	24.5
III.	**Chemical properties**								
1.	Available N (kg ha^{-1})	268	252	261	236	262	268	270	267
2	Available P (kg ha^{-1})	9.4	8.8	9.9	14.4	10.8	9.8	11.0	11.1
3	Available K (kg ha^{-1})	359	291	273	257	432	261	379	206
4	Available Fe (mg kg^{-1})	8.89	10.94	5.41	7.81	5.59	6.55	8.96	9.99
5	Available Zn (mg kg^{-1})	1.38	1.38	1.40	1.44	1.25	1.36	1.38	1.33
6	Available Mn (mg kg^{-1})	5.15	7.50	3.56	4.22	4.94	3.55	6.33	5.33
7	Available Cu (mg kg^{-1})	0.22	0.42	0.62	0.82	1.04	1.23	1.42	1.63

Table 3. Estimation of rate of constant (K) in the onion crop experiments

S. No.	$Y = 34.07 + 14.39 x - 2.419 x^2$		
	DTPA-Cu (mg kg^{-1})	Estimated Bray's Per cent yield	K value
1	0.00	34.07	0.00
2	0.10	35.49	9.52
3	0.20	36.86	5.10
4	0.30	38.18	3.64
5	0.40	39.45	2.91
6	0.50	40.67	2.48
7	0.60	41.84	2.20
8	0.70	42.97	2.00
9	0.80	44.05	1.86
10	0.90	45.07	1.75
11	1.00	46.06	1.67
12	1.10	46.99	1.61
13	1.20	47.87	1.56
14	1.30	48.71	1.53
15	1.40	49.49	1.50
16	1.50	50.23	1.48
17	1.60	50.92	1.47
18	1.70	51.56	1.47
19	1.80	52.16	1.47
20	1.90	52.70	1.48
21	2.00	53.20	1.49
22	2.10	53.65	1.52
23	2.20	54.04	1.54
24	2.30	54.40	1.58
25	2.40	54.70	1.63
26	2.50	54.95	1.70
27	2.60	55.16	1.78
28	2.70	55.32	1.89
29	2.80	55.43	2.04
30	2.90	55.49	2.28
31	3.00	55.50	2.80
32	3.10	55.47	
33	3.20	55.38	

Table 2. Treatment details

T. No.	Treatments
1.	Control (Recommended dose of NPK fertiliser alone)
2.	T1 + 0.5 kg Cu ha^{-1}
3.	T1 + 1.0 kg Cu ha^{-1}
4.	T1 + 1.5 kg Cu ha^{-1}
5.	T1 + 2.0 kg Cu ha^{-1}
6.	T1 + 2.5 kg Cu ha^{-1}
7.	T1 + 3.0 kg Cu ha^{-1}

soil available Cu (x). The extrapolated Bray's per cent yield values at varying definite interval (0.1 mg kg^{-1}) of DTPA extractable Cu in the soil were determined from the equation. The estimated Bray's per cent yield was started to decline after the increasing the DTPA level of 3.00 mg kg^{-1} and upto this extrapolated Bray's percentage yield was considered for estimation of ã. The critical concentration of available Cu in soil worked out to be 0.625 mg kg^{-1} below which appreciable responses to Cu application was expectable.

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REFERENCES

Debnath and Ghosh. 2011. Determination of critical limit of available boron for rice in Terai Zone Soils of West Bengal. *Journal of the Indian Society of Soil Science.* 59 (1): 82-86.

Feiziasl, V., Jafarzadeh, J., Pala, M and Mosavi, S.B. 2009. Determination of critical levels of micronutrients by plant response column order procedure for Dryland wheat (*T. aestivum* L.) in Northwest Iran. *International Journal of Soil Science.* 4 (1): 14-26.

Sharma, J.C and Chaudhary, S. K. 2007. Vertical distribution of micronutrient cations in relation to soil characteristics in lower shiwaliks of solan district in north –west Himalayas. *Journal of the Soil Society of Soil Science.* 55 (1): 40-44.

Sharma, R.K. and Agarwal, M. 2005. Biological effects of heavy metals: An overview. *Journal of Environmental Biology.* 26(2): 301-313.

Sharma, U. C. 1991. Response of soybean to micronutrients in acidic soils of Nagaland. *Indian Journal of Hill Farm.* 5(1): 75-76.

Singh, D., Nath, K and Sharma, Y.K. 2007. Response of wheat seed germination and seedling growth under copper stress. *Journal of Environmental Biology*. 28(2): 409-414.

Soltanpour, P.N., Gharous, M. El and Azzaoui, A. 1986. Nitrogen and phosphorus soil test calibration studies in Morocco. Proceeding of the 1st soil Test Calibration Workshop, June 23-25, 1986, ICARDA, Aleppo, Syria, pp: 85-95.

Swiader, J.M and Ware G.W. 2002. Producing Vegetable Crops, 5th *edn*. Danville, IL: Interstate Publishers, Inc. pp: 658.

Ware, G. O., Ohki K and Moon L. C. 1982. The Mitscherlich plant growth model for determining critical nutrient deficiency levels. *Agronomy Journal.* 74 (1): 40-44.

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