

Determination of Critical Limit of DTPA-Extractable Copper in Soils by Transition Zones Method

Nagarjuna Vasagiri, D. Muthumanickam

Received 2 May 2016; Accepted 3 June 2016; Published online 30 June 2016

Abstract Field experiments were conducted at eight locations in various farmer fields during *rabi* season (2012-2013) for refinement of copper critical limit in soils. Based on the available status of Cu, the eight farm holdings (L_1 to L_8) 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 randomized 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 fertilizer dosage $60:60:30 \text{ kg N, P}_2\text{O}_5 \text{ and K}_2\text{O kg ha}^{-1}$. The relationship between soil nutrient amounts and group's dependency showed that maximum probability of soil testing groups equal to curve maximum. By considering maximum of the better curve between Cu amounts and probability of group's dependency, exact separation place of Cu sufficient or deficient groups (critical level) was determined as 0.67 mg kg^{-1} . The transition zone was from 0.67 to 0.75 mg kg^{-1} which are minimum and maximum level of this zone indicate confident deficient and excessive of Cu in soil respec-

tively. Based on the significant response and non-response of onion crop to Cu application DTPA-Cu amount was ordered by plant response column order procedure showed that onion bulbs yield has significant response for Cu application to 0.81 mg ka^{-1} .

Keywords Critical limit, DTPA-Extractable Cu, Onion growing soils, Transition zones.

Introduction

Onion belongs to a group of vegetables that have high response to Cu [1] observed that application of Cu recorded significantly higher onion seed yield ($1336.9 \text{ kg ha}^{-1}$) than control ($1008.9 \text{ kg ha}^{-1}$). Using of transition zones method for exact separation of deficient and sufficient groups (Critical level) was determined as 1.38 mg kg^{-1} for copper in (*T. aestivum* L.) in Northwest of Iran. The results for boundary of between soil deficient and sufficient classes or critical levels by plant response column order procedure and interaction chi-square model for Fe, Mn, Zn, and B critical values were determined as 4.7, 11.2, 0.7, and 0.5 mg kg^{-1} soil [2]. Critical level of Fe sufficient and deficient groups would be 4.6 mg kg^{-1} for dry land wheat should be used to determine the exact separation of groups or Fe critical level and distinguish of transition zone [3]. 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

N. Vasagiri*, D. Muthumanickam
Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore, India
e-mail: nagarjunav54@gmail.com

*Correspondence

and determining of critical level of the element is necessary for particular crop. 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. Hence the present investigation was undertaken to study the response of onion to Cu fertilisation in the field conditions and determination of critical limit of DTPA extractable Cu in soils.

Materials 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 critical limit in soils. The soil of the experimental fields were belonging to the soil series Irugur, Manupatti, Vellalur, Palathurai, Athipalayam, Kanjampatti, Sommaiyanur, Puduavadavalli and Annur soil series. The initial analysis of experimental soil was neutral to slightly alkaline in reaction and with free from salts. The organic carbon content of the soil was low. The available nutrient status of the soil was low in available N and P, Medium in available K. The soil was sufficient in DTPA Zn, Mn, Fe and Hot Water Soluble Boron. Based on the available status of Cu, the 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 fertilizer dosage 60:60:30 kg N, P₂O₅ and K₂O kg ha⁻¹. 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 CuSO₄ as per the schedule.

On the basis of soil testing and plant response, the plants were grouped into two categories as sufficient and deficient by plant response column order and interaction Chi-square statistical procedures given earlier [4, 5]. In plant response column order procedure, soil numbers or experimental locations and soil micronutrient amount was drawn in column figure in X and Y axis, respectively. In X axis values were

ordered upon rising order of soil micronutrient amount in Y axis. In this condition, columns in X axis were divided two main parts (5, 6) as given below: First part of columns included the soils which were shown positive and significant response to applied micronutrient at $p < 0.5\%$ and was named as Response or Deficient part as compared to check. Second part, the soils did not show any significant response to applied micronutrient at $p < 0.5\%$ and these soils, the crop did not show any micronutrient deficiency symptom and this was named as Non-response or Sufficient part

To separate the deficient and sufficient plants or determining micronutrient critical level in the soil, a line from end of response (Deficient) part was drawn to Y axis and critical level was detected in cross point of line with X axis. In this study, response and non-response to micronutrient fertilizers was the base on classify them to deficient and sufficient groups. But existing of marginal region between deficient and sufficient groups caused that boundary between these groups was in doubt, thus interaction Chi-square statistical procedure or contingency tables was used to solve this problem [4]. For this purpose, grouping of data and calculation of Chi-square value by contingency table based on observation number related to deficient and sufficient part (fault and trust) was done by using soils of end part of deficient zone which has characteristic of deficient soils (response to applied fertilizer) continually [4].

Interaction Chi-square statistical procedure value for each established contingency table for proposed groupings was calculated by the following formula:

$$\chi^2 = \frac{(N_{11}N_{22} - N_{12}N_{21})^2 N_{..}}{N_{1.} N_{2.} N_{.1} N_{.2}}$$

Where:

χ^2 = Chi-square value

N_{11} = No. of observations deficient which are correctly classified

N_{12} = No. of observations deficient which are incorrectly classified

N_{21} = No. of observations sufficient which are correctly classified

N_{22} = No. of observations sufficient which are incor-

rectly classified

N_{-1} = Sum of observation frequencies for correctly classified

N_{-2} = Sum of observation frequencies for incorrectly classified

N_1 = Total No. of observations in deficient class

N_2 = Total No. of observations in sufficient class

N = Total No. observation frequencies for both sufficient and deficient class

The significance of probability value of calculated Chi-square was determined with one degree of freedom by chi-square table that, values show the dependency of soil testing group (7). Finally, a rela-

tionship was fitted between micronutrient amounts in soils (X-axis) and significant probability of calculated Chi-square for transition zone (in Y-axis), then a line was drawn from maximum amount of curve, which shows maximum dependency of deficient and sufficient groups, to X-axis (amount of soil micronutrient). Cross point of this line with X-axis was defined as boundary line of deficient and sufficient groups or micronutrient critical level. MSTATC, Excel and Curve expert software were used for statistical analysis, column figure drawing and fitting suitable curve between micronutrient amounts and Chi-square probability levels, respectively.

Table 1. Observation frequency, soil Cu and significant probability level of transition zone Chi-square (dependency probability of groups) in groupings.

Sl. No.	Soil DTPA-Cu (mg kg ⁻¹)	Plant position				Total no. of observations	χ^2 value	Dependency probability
		Response (deficient)		Non- response (sufficient)				
		Trust	Fault	Trust	Fault			
1	0.16	26	0	15	9	50	11.890	0.001
2	0.18	25	1	15	9	50	8.834	0.003
3	0.20	26	2	14	8	50	6.575	0.010
4	0.32	26	3	13	8	50	5.466	0.019
5	0.34	27	3	13	7	50	4.688	0.030
6	0.36	27	4	12	7	50	3.934	0.047
7	0.38	28	4	11	7	50	4.675	0.031
8	0.48	28	5	10	7	50	4.166	0.041
9	0.51	28	6	10	6	50	2.351	0.083
10	0.52	29	6	9	6	50	3.008	0.125
11	0.54	29	7	9	5	50	1.463	0.226
12	0.58	31	8	8	3	50	0.228	0.633
13	0.62	31	8	8	2	50	0.128	0.721
14	0.64	32	8	8	1	50	0.088	0.787
15	0.68	32	9	7	1	50	0.003	0.956
16	0.69	33	9	7	1	50	0.335	0.563
17	0.72	35	9	6	0	50	1.497	0.221
18	0.74	35	9	6	0	50	1.497	0.221
19	0.76	35	9	6	0	50	1.497	0.221
20	0.78	35	9	6	0	50	1.497	0.221
21	0.81	35	9	6	0	50	1.497	0.221
22	0.82	35	9	6	0	50	1.497	0.221
23	0.89	35	9	6	0	50	1.497	0.221
24	0.92	35	9	6	0	50	1.497	0.221
25	0.94	35	9	6	0	50	1.497	0.221
26	0.96	35	9	6	0	50	1.497	0.221
27	0.98	35	9	6	0	50	1.497	0.221
28	1.05	35	9	6	0	50	1.497	0.221
29	1.06	35	9	6	0	50	1.497	0.221
30	1.08	35	9	6	0	50	1.497	0.221
31	1.08	35	10	5	0	50	1.389	0.239
32	1.10	35	10	5	0	50	1.389	0.239
33	1.12	35	11	4	0	50	1.226	0.268

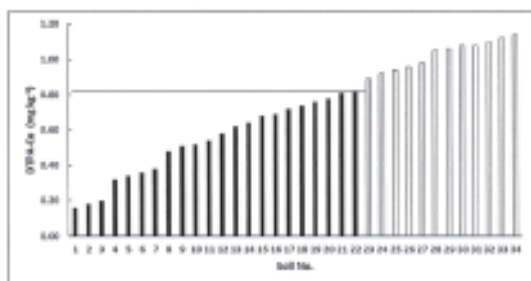


Fig. 1. Relationship between soil Cu amounts and onion crop response to Cu application.

Results and Discussion

The grouping of data and calculation of Chi-square value by contingency table based on observation number related to deficient and sufficient part (fault and trust) was done for identifying transition zones (Table 1). In this method, in each plot 50 onion plants were maintained and identified whether plants are showing any deficiency symptoms under the applied Cu levels. The plants which are showing deficiency symptoms are classified under deficient and plants did not show any deficiency symptoms are classified under non-deficient category. In each category, the trust and fault plants were identified based on the yield of the plants. Based on the significant response and non-response of onion crop to Cu application, DTPA-Cu amount was ordered by plant response column order procedure (Fig. 1). Results showed that onion bulbs yield has significant response for Cu application to 0.81 mg kg^{-1} .

Interaction Chi-square statistical procedure or contingency table was used to determine exact separation of Cu sufficient and deficient groups. The dependency probability from true or fault of distinguish method by proposed grouping to determine exact separation of marginal zone (Table 1). The soil nutrient amount has maximum significant probability of Chi-square in the boundary line between two groups. Accordingly critical level of Cu sufficient and deficient groups will be 0.67 mg kg^{-1} with 95.0% probability dependency ($p \leq 0.95$). But maximum estimated dependency probability will not always confirm to maximum soil nutrient curve and groups dependency

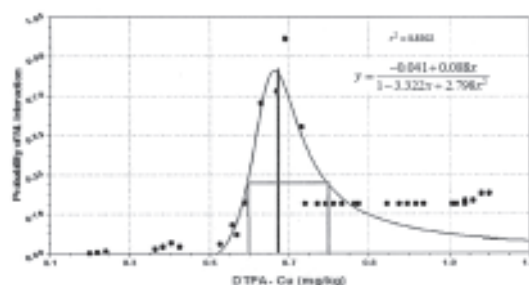


Fig. 2. The DTPA extractable Cu critical level in soil determined by transition zones method.

probability. Therefore the relationship between nutrient amount and group's dependency probability should be (Fig. 2) used to determine the exact separation of groups or Cu critical level and distinguish of transition zone.

The significance of probability value of calculated Chi-square was determined with one degree of freedom by Chi-square table that, values show the dependency of soil testing groups. Finally, a relationship was fitted between micronutrient amounts in soils (X-axis) and significant probability of calculated Chi-square for transition zone (in Y-axis), then a line was drawn from maximum amount of curve, which shows maximum dependency of deficient and sufficient groups, to X-axis (amount of soil micronutrient). Excel and Curve expert software were used for statistical analysis; column figure drawing and fitting suitable curve between micronutrient amounts and Chi-square probability levels respectively.

The relationship between soil nutrient amounts and group's dependency showed that maximum probability of soil testing groups equal to curve maximum. By considering maximum of the better curve between Cu amounts and probability of group's dependency,

$$y = \frac{-0.041 + 0.088x}{1 - 3.322x + 2.798x^3}$$

exact separation place of Cu sufficient or deficient groups (critical level) was determined as 0.67 mg kg^{-1} . The transition zone was from 0.67 to 0.75 mg kg^{-1} which are minimum and maximum level of this zone indicate confident deficient and ex-

cessive of CU in soil respectively. The results of present investigation are in concordance with the earlier findings [2], 1.38 mg kg⁻¹ for copper in (*T.aestivum* L.) in Northwest of Iran and [3] 4.6 mg kg⁻¹ for dry land wheat

Conclusion

By considering maximum of the better curve between Cu amounts and probability of group's dependency, exact separation place of Cu sufficient or deficient groups (Critical level) was determined as 0.67 mg kg⁻¹ with 95.0 % probability dependency ($p \leq 0.95$). The transition zone was from 0.67 to 0.75 mg kg⁻¹ which are minimum and maximum level of this zone indicate confident deficient and excessive of Cu in soil respectively. Based on the significant response and non-response of onion crop to Cu application, DTPA-Cu amount was ordered by plant response column order procedure showed that onion bulbs yield has significant response for Cu applications to 0.81 mg kg⁻¹.

References

1. Khalate SP, Sanghavi KU, Kadam JR (2002) Effect of some micronutrients on seed yield and seed quality of onion (Cv Baswant-780). *Sou Ind Hor J* 50 : 248—250.
2. Feiziasl V, Jafarzadeh J, Pala M, Mosavi SB (2009) Determination of critical levels of micronutrients by plant response, Column order procedure for dryland Wheat (*T. aestivum* L.) in Northwest of Iran. *Int J Soil Sci* 4 : 14—26.
3. Feiziasl V (2007) Soil testing : Interpretation of calibration experiments by Mistcherlich-bray, plant response column order procedure (Interaction Chi-square) and integrated system. *Dryland Agric Res Inst Bull No.* 208, pp 120.
4. Keisling TC, Mullinix Ben (1979) Statistical considerations for evaluating micronutrient tests. *Soil Sci Soc Am J* 43 : 1181—1184.
5. Halving JL, Sollarpour PN (1981) Evaluation of NH₄HCO₃-DRPA soil test for iron zinc. *Soil Sci Am J* 45 : 70—75.
6. Sing GH, Takkar PN (1981) Evaluation of efficient soil test methods for Zn and their critical values in salt-affected soils for rice. *Commun Soil Sci Pl Anal* 12 : 383—406.
7. Feiziasl V (2006) Determination of Fe, Mn, Zn and Cu critical levels and classification by Cate-Nelson ANOVA methods for dryland wheat (*T. aestivum* L.) in North Western of Iran. *Iran J Agric Sci* 37 : 389—401.