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Reaction of Genotypes of Turmeric (*Curcuma longa* L.) To ZN Stress in a Calcareous Soil

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Twenty four genotypes Turmeric (*Curcuma longa* L.) were screened for their relative tolerance to Zn deficiency grown on calcareous soils of North Bihar deficient in available Zn, Genotypes differed in their susceptibility to Zn deficiency. Symptoms were visible within 40 days of seeding. The total Zn concentration in third leaf of the cultivars ranged between 10 and 51.3 mg/kg under the conditions of Zn stress which showed a significant and positive correlation with leaf weight (r=0.988**). By and large genotypes containing Zn concentration less than 18 mg/kg developed severe Zn deficiency symptoms. Further, depression in rhizome yield of the cultivars was observed to be significantly and negatively correlated with Zn concentration of third leaves (r=—0.854**) and showed positive correlations with Fe/Zn and P/Zn concentration ratios (r=0.958**, r=0.931**). About 96% of the variability (R^2=0.958**) in Zn responses under Zn stress bound conditions could be attributed to total Zn concentration, P/Zn and Fe/Zn concentration ratios of the third leaf of the plants. Of the three variables only P/Zn concentration ratio is found to have a significant contribution, and hence it may be used as an indicator of Zn response efficiency of turmeric in calcareous soils.

Key Words : Zn deficiency, *Curcuma longa* L., Genotype differences in Zn nutrition, Calcareous soil, Zn spray, germplasm

Introduction

Turmeric (*Curcuma longa* L.) is one of the principal spices of India. This crop is grown extensively in the calcareous soils of North Bihar differing in available Zn. Different cultivars of turmeric react differently to Zn stress under such soil conditions. About 50 to 80% soils of this region are rated to be deficient in available Zn (ICAR 1980–83). Physiological studies have indicated that differential responses of cultivars is genetically controlled and is a heritable character (Brown

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1972 and Agarwala 1979). Therefore, it was considered to be of interest to screen the germplasm tolerant to Zn deficiency in a calcareous soil. So that, (*i*) they may be grown under conditions of low supply of available Zn, and (*ii*) varieties useful for the Zn deficient soils may be evolved. Twenty four genotypes were collected from the different turmeric growing belts of the country and were evaluated for Zn tolerance in a calcareous soil deficient in Zn under field conditions.

Materials and Methods

Field studies were carried out on a calcareous sandy loam soil deficient in available Zn at Dholi Experimental Station for two consecutive kharif seasons of 1982-83, and 1983-84, respectively. The important characteristics of the soils are presented in table 1. Available Zn, Fe, Cu and Mn were extracted with DTPA (Lindsay & Norvell 1978) and determined with atomic absorption spectrophotometre. Other soil properties were determined as per standard procedures (Jackson 1967). Twenty four germplasm of turmeric were grown in plots of 3×2m following randomized block design with three replications (Expt. 1). Seed rhizomes having 3–4 healthy buds were sown at the depth of 5 cm below the soil at the distance of 30×20 cm between and within the rows. A basal application of 150kg N, 50kg P_2O_5 and 100 kg K_2O ha^{-1} was made using urea, diamonium phosphate and muriate of potash, respectively. Full doses of P_2O_5 and K_2O were applied at the time of field preparation, while N was top dressed in two splits at 45 days and 90 days after sowing. Visual observations were recorded periodically regarding the appearance of Zn deficiency symptoms on the growing crop. To screen the susceptibility of genotypes to Zn deficiency per cent plants affected was determined and the maximum over the three replications was considered for classifying the genotypes as tolerant (completely green),moderately tolerant (5-10% plants showing in deficiency symptoms), susceptible (25–50% plants showing Zn deficiency symptoms) and highly susceptible classes (50–100% plants showing Zn deficiency symptoms). Third leaf from the plants top were collected 75 days after sowing. Dry weight recorded, and composite samples analysed for total Zn content.

Table 1 *Physico chemical properties of the experimental plots at Agricultural Research Institute Farm Dholi, Muzaffarpur (Bihar)*

Sl.No.	Soil characteristic	Values	
		1982-83	1983-84
1.	*p*H	8.72	8.75
2.	EC (m mhos cm^{-1})	0.58	0.44
3.	Organic carbon (%)	0.41	0.48
4.	Free $CaCo_3$ (%)	40.28	38.87
5.	Available P (kg ha^{-1})	8.89	12.44
6.	Available K (kg ha^{-1})	91.28	106.21
7.	DTPA extractable Zn Ug g^{-1}	0.39	0.42
8.	DTPA extractable Cu Ug g^{-1}	0.80	0.80
9.	DTPA extractable Fe Ug g^{-1}	6.80	10.07
10.	DTPA extractable Mn U gg^{-1}	6.56	5.80

Eight genotypes were selected from different groups (Expt. 1) and an experiment was also conducted separately in kharif season of 1983-84, to study their response to Zn application as foliar sprays keeping Zn levels as main plot treatment and genotypes as sub plot treatment (Expt. 2). The samples were washed in acidified solution, distilled water, dried in oven at 67°C and powdered in waring blender having stainless steel knife. Total contents of Zn, Fe and P in leaves were determined by digesting the samples in a mixture of 10 : 4 : 1 of HNO_3 : $HclO_4$: H_2SO_4. Zinc and Fe were determined using atomic absorption spectrophotometer and Pcolorimetrically

Table 2 *Reaction of 24 genotypes of turmeric (Crcuma longa L.) to Zn stress in calcareous soil*

Sl. No.	Genotypes	Origin	Grouping*		Leaf weight (g/s leave)		Zn concentration in leaf (mg/kg)	
			82-83	83-84	82-83	83-84	82-83	83-84
1.	Mannuth Local	Tirchur, Kerela	HS	HS	2.20	2.28	17.0	18.0
2.	Duggirala (Lam) Lam	Andhra Pradesh	HS	HS	1.90	2.00	14.0	15.0
3.	G.L. Puram I	Trichur, Kerela	S	S	3.25	3.40	20.0	23.0
4.	G.L. Puram II	,, ,,	HS	HS	2.25	2.20	18.7	17.3
5.	Kodur type (Lam) Lam	Andhra Pradesh	HS	HS	1.58	2.00	10.7	15.6
6.	Vontimitta	,, ,,	S	S	3.25	3.50	20.5	24.0
7.	Dindigram	Trichur, Kerela	HS	HS	2.09	2.08	15.5	16.3
8.	Amarath Panicapetella—317	,, ,,	HS	HS	1.79	2.20	12.5	18.0
9.	Amarath Panicapetella	,, ,,	HS	HS	1.55	1.85	10.0	13.7
10.	Chayapasupa (Lam) Lam	Andhra Pradesh	HS	HS	1.79	1.99	12.8	14.8
11.	Armoor	,, ,,	S	S	2.00	2.28	15.0	18.6
12.	Amalapuram	Trichur, Kerala	S	S	3.45	3.58	22.0	24.8
13.	Nodyal type	,, ,,	S	S	2.39	2.45	19.0	20.3
14.	Kuchipaddy	,, ,,	S	S	2.29	2.39	18.0	19.5
15.	RH 8-80	Dholi, Bihar	T	T	9.17	10.48	50.6	51.3
16.	RH 9-80	,, ,,	T	T	8.56	8.09	41.2	40.0
17.	RH 10-80	,, ,,	T	T	7.00	6.59	36.5	35.0
18.	RH 13-80	,, ,,	T	T	6.50	6.75	33.5	38.3
19.	RH 17-80	,, ,,	T	T	7.85	8.00	40.0	40.3
20.	RH 26-81	,, ,,	MT	MT	6.55	6.35	33.1	32.5
21.	RH 27-81	,, ,,	MT	MT	6.20	6.35	32.5	33.5
22.	RH 28-82	,, ,,	MT	MT	6.00	5.95	31.9	30.0
23.	RH 25-80	,, ,,	T	MT	6.85	7.00	35.6	38.5
24.	RH 11-80	,, ,,	MT	MT	6.00	6.67	30.0	35.3

* T = Complete green, MT = Moderately tolerant (5 to 10%)
S = Susceptible (25-50%) HS = Highly susceptible (50-100%)

as per procedure given by Jackson (1967). Rhizomes yields were recorded at maturity of the crop.

Results and Discussion

Experiment 1:

Visual observations: The genotypes started to display Zn deficiency symptoms 35–40 days after sowing. The symptoms developed on the third leaf of the plants. It was characterized by a broad band of yellowish white bleached tissues on both sides of the midrib which started at the base of the leaf. Such symptoms were more pronounced on the newer emerging leaf of the whorl and gradually expanded towards the apical portion. Later on, younger leaves turned whitish and plants remained stunted, giving a rosette appearance. The plants showing such symptoms drastically reduced the size of the lamina of the newer leaves and the affected foliage dried up.

Grouping of genotypes: The categorized genotypes are indicated in column 3 of table 2. Only five genotypes, viz., RH 8–80, TH 9–80, RH 10–80 RH 11–80 and RH 13–80 of North Bihar origin were tolerant to Zn stress, showed luxuriant vegetative growth, and contained fairly high Zn concentration in leaves compared to the critical level of any other field crops being grown in calcareous soil (Sakal et al. 1978, 1981, 1982).

Zn in leaves: The genotypes showed greater variability in extracting native Zn and translocating it to the site of the physiological activities i.e., the leaf (table 2). The tolerant genotypes accumulated much higher concentration of Zn in leaves compared to the susceptible ones. Genotypes with less than 18 mg Zn/kg dried leaves were highly susceptible than those with 30 to 38 mg Zn/kg. By and large genotypes with more than 38 mg Zn/kg dried leaves were tolerant to Zn deficiency. The leaf dry weight were greatly reduced due to Zn stress. It was also observed that genotypes of North Bihar origin were in general more tolerant to Zn deficiency than those of the Kerala and Andhra Pradesh origin. This might be due to their adaptability being grown in calcareous soils that are known to have low Zn availability (ICAR 1980–83).

Attempt was made to explain the variability based on the total tissue Zn concentration. Simple correlation studies clearly indicated a highly significant and a positive relation between tissue Zn concentrations and leaf weight ($r=0{\cdot}987^{**}$ and $r10{\cdot}991^{**}$). About 99% of the variability ($r^2=0{\cdot}985^{**}$) in Zn response under Zn stress conditions could be attributed to total Zn concentration of the third leaf from top at 75 d after sowing. Thus, study inferred that it could be used as a simple and reliable tool for screening Zn efficient genotypes from non-efficient ones. The study also suggests that genetic variability of turmeric genotypes in Zn response under stress bound conditions was mainly due to Zn absorption and its translocation to physiological active sites of leaves.

Experiment 2:

Effect of Foliar spray: The yield data are portrayed in table 3. Rhizomes yields increased with 0·5% $ZnSO_4$ solution spray (two) but the magnitude of response varied from one genotypes to another. The maximum response was recorded in highly susceptible genotypes (Mannuty local and Dindigram) while it was minimum in tolerant ones (RH 9–80 and RH 8–80). The per cent depression in yield was calculated and it was minimum in tolerant ones, confirming the earlier observations of several workers in many other cereal crops) Prasad et al. 1982, Singh et al. 1983, Sakal et al. 1984).

Prediction of yield based on mineral analysis: An attempt was made to explain the variability in yield depression based on rhizomes yield. Zn concentration, Fe/Zn, and P/Zn concentration ratios of the leaves. Rhizomes yield was significantly and negatively related with Zn concentration ($r=-0854^{**}$), while P/Zn

Table 3 *Relative performance of 8 genotypes of turmeric* (Curcuma longa *L.*) *to Zn application on a calcareous soil deficient in available Zn*

Sl. No.	Genotypes	Grouping based on per cent plants showing Zn deficiency (table 1)	Mineral composition of 3rd leaf without Zn			Rhizomes yield (g/ha)		Mean	Depression in yield (%)
			Zn conc. (ppm) ratio	Fe/Zn (conc. (ratio)	P/Zn (Conc. ratio)	No zinc	0.5% Zn SO_4 Sol apray (two)		
1.	RH 8-80	Tolerant	53.6	4.1	126	443.2	464.6	453.9	4.5
2.	RH 9-80	,,	43.2	4.0	136	430.3	443.8	437.1	3.1
3.	RH 22-80	,,	42.3	5.5	153	330.3	360.6	345.5	8.4
4.	AP-317	Moderately tolerant	29.5	5.9	321	395.3	447.3	321.3	11.2
5.	G.L. Puram I	Susceptible	22.3	9.9	413	305.1	360.6	332.9	15.4
6.	G.L. Puram II	,,	22.3	3.4	417	366.9	417.5	392.2	12.1
7.	Dindigram	Highly susceptible	17.3	10.3	822	260.4	346.4	303.4	25.0
8.	Mannuthy Local	,,	18.2	10.3	742	149.8	209.7	179.8	28.0
	C.D. for Zn level × Genotypes					9.8			
	Mean					335.2	381.3		

C.D. for main plot treatment = 8.2

C.D. for sub plot treatment = 4.9

and Fe/Zn concentration ratios showed a significant positive relation with rhizomes yields (r=0·969**, r=0·931**). About 96% of the variability (R^2=0·958**) in Zn responses under Zn stress bound conditions could be attributed to total tissue Zn concentration and P/Zn and Fe/Zn concentration ratios of the third leaf. Of the three variables only P/Zn concentration ratio is found to have a significant contribution and hence it may be used as an indicator of Zn response efficiency of turmeric in calcareous soils.

Conclusions

Marked genotypic differences to Zn deficiency in turmeric was noticed. Only five genotypes viz., RH 8-80, RH 10-80, RH 11-80 and RH 13-80 of North Bihar origin were tolerant to Zn stress, exhibited luxuriant vegetative growth. The genotypes showed greater variability in extracting native Zn and translocating it to the site of the physiological activities i.e., the leaf. It is also inferred from the study that Zn concentration or P/Zn concentration ratio of the 3rd leaf from the top at 75 day after seeding may be used a reckoner of Zn response efficiency of turmeric in calcareous soils. Rhizomes yields increased with 0·5% $ZnSO_4$ solution spray (two) but the magnitude of response varied from one genotype to another. Since efficiency of nutrient use is genetically controlled and heritable an

integrated approach by the genetists, plant breeders and plant nutritionists can help in identifying specific gene-controlled lesions determining nutrient use efficiency. Such studies need careful consideration to evolve varieties useful for Zn deficient soils.

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