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Critical tissue concentration of zinc in short duration mungbean (*Vigna radiata*)

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In India, about 49% of soils are deficient in zinc (Behera *et al.* 2009) therefore on many crops zinc (Zn) deficiency is the rule rather than exception. Plant analysis (usually leaf analysis) can provide supportive information when diagnosing zinc deficiency. Unfortunately, most Zn levels of plant tissue fall in the gray area between deficient and sufficient zones (between 10 to 25 mg/kg) therefore, critical analysis of tissue Zn concentration or determination of critical Zn level is the need for optimizing the crop productivity. The concentration of Zn in the plant varies considerably during different stages of plant growth, which generally bears positive correlation with the dry matter yield. Concept of critical nutrient concentration (CNC) forms the basis of most methods for using plant analysis for assessing plant nutrient status. As the Zn concentration in different plant parts varies significantly, selection of appropriate plant part at specific growth stage is essential for better Zn diagnostics. Leaves have been considered to be the most appropriate part of the plant to sample for nutrient status for Zn (Bates 1971). On the basis of the plant nutrient curves, ease of sampling, wide range of zinc concentration, sharp transition zone, and other physiological considerations, there is a need to standardise the most effective plant part and appropriate growth stage for determination of CNC which will help in predicting the yield potential and adequacy of nutrient supply. Mungbean (*Vigna radiata* (L.) Wilczek) is an important pulse crop in India. Being a low input, short duration, high value crop, it fits well into rice-wheat and other cereal based cropping systems (Hosain *et al.* 2008). Under such situations, Zn is one of the most limiting micronutrients affecting the yield of mungbean in the system (Prasad 2005). Therefore, understanding the critical tissue Zn concentration at different crop growth stage will help better management of Zn in short duration mungbean through plant diagnostics.

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A pot experiment was conducted at Indian Institute of Pulses Research, Kanpur during 2010 using Zn deficient sandy loam soil to study the effect of Zn nutrition on short duration mungbean (60 days) (cv Samrat) and to determine the critical concentration of Zn in plant tissues at different growth stages. Graded levels of Zn were applied to the crop at the rate 0, 2.5, 5, 7.5, 10, 12.5, 15, 20, 30, and 50 mg $ZnSO_4$/kg soil. The experiment was conducted in completely randomized design with six replications. Dry matter yield was recorded at 30, 45 days after sowing (DAS) and at maturity (60 days) by destructive sampling. All the pots were fertilized with basal dose of 20 kg N, 60 kg P_2O_5 and 20 kg K_2O/ha in the form of urea, single super phosphate and muriate of potash, respectively.

The experimental soil had 8.1 pH, 0.15% organic carbon, 180, 12, and 120 kg/ha available N, P and K, respectively. The initial DTPA extractable available Zn content in the soil was 0.2 mg/kg. Soil moisture in the pots was maintained close to field capacity (12% w/w) by regular watering. Five seeds were sown in each pot and three seedlings were retained after emergence. Each time at day 30, 45 and 60 DAS, leaf samples were collected by separating them into young fully expanded leaf and matured leaves from the plant. The samples were dried in oven at 70±2°C, powdered and digested with di-acid (HNO_3: $HClO_4$:: 10:4) mixture. Total Zn was estimated by using atomic absorption spectrometer-model GBC Avanta. Zinc content at various growth stages and the dry matter yield were plotted to derive polynomial regression equations ($Y=a+bx+cx^2$). Critical concentration of Zn was determined as per the procedure given by Sharma and Arora (1989). In the regression equation ($y=a+bx+cx^2$), dry matter production is the dependent variable (y), zinc concentration in plant tissue is independent variable (x) and a, b, c are the constants. Critical concentration of tissue Zn=b/2c. Likewise, the optimum dose of Zn was quantified based on the correlation between Zn application rate and grain weight/plant. Analysis of variance was performed using the program AGRIS for windows. When ANOVA indicated that there was a significant value, multiple comparisons of mean value were performed using the least significant difference method (LSD). Coefficient of determination (r^2) was worked out as

Table 1 Dry matter and grain weight (g/plant) as affected by different levels of Zn application in mungbean

Growth stage	$ZnSO_4$ applied (mg/kg)										
	0	2.5	5	7.5	10	12.5	15	20	30	50	LSD
	Dry matter (g/plant)										
30 DAS	1.34	1.40	1.48	1.67	1.76	1.91	1.84	1.86	1.80	1.80	0.14
45 DAS	6.14	6.78	7.53	8.03	8.49	8.90	9.57	9.55	9.49	9.46	0.26
60 DAS	10.90	11.61	13.18	13.89	14.35	16.50	13.20	14.00	13.49	12.80	0.79
	Grain weight (g/plant)										
Harvest	2.83	3.17	3.77	3.87	3.97	3.87	3.83	3.77	3.40	3.02	0.23

Table 2 Leaf zinc concentration (mg/kg) as affected by different levels of soil Zn in mungbean

Growth stage	Leaf type	$ZnSO_4$ applied (mg/kg)											
		0	2.5	5	7.5	10	12.5	15	20	30	50	±Sd	LSD
		Zinc concentration in plant parts (mg/kg)											
30 DAS	YFEL	18.6	24.3	27.9	29.9	31.8	33.6	33.4	29.6	29.5	27.3	4.50	3.27
	ML	16.9	22.1	24.6	26.4	24.8	32.8	26.4	27.4	25.4	27.8	4.09	4.01
45 DAS	YFEL	16.5	17.9	17.6	18.6	19.1	19.4	22.6	20.1	19.2	19.7	1.65	1.53
	ML	16.8	17.9	18.3	18.8	19.2	20.6	21.4	19.8	19.2	19.2	1.31	1.93
60 DAS	YFEL	12.0	14.5	19.2	19	20.6	21.7	22.9	20.2	20.8	16.8	3.39	2.33
	ML	13.5	15.9	17.4	18.4	17.6	19.3	17.5	20.3	23.1	17.8	2.55	2.57
Harvesting	Grain	18.6	19.7	21.0	21.3	24.2	24.0	22.6	22.9	21.3	22.6	1.79	0.91
	Straw	12.5	14.5	14.3	14.6	13.2	13.6	14.7	15.7	14.4	14.7	0.90	1.89

YFEL, Young fully matured leaf; ML, matured leaf; ±Sd, standard deviation; LSD, least significant difference (P=0.05)

per the method outlined by Gomez and Gomez (1984).

Pulses are responsive to Zn application and a positive correlation exists between soil Zn level and plant tissue Zn concentration. Pulses are generally considered sensitive to Zn deficiency although there are differences among varieties (Khan *et al*. 1998). In neutral to alkaline soils where pulses are usually grown, Zn deficiency can often be encountered (Roy *et al*. 2006). The growth pattern of short duration mungbean cv. Samrat had an initial lag phase followed by log phase or fast growing phase. The crop growth upto 30 DAS was very slow and acquired only 1.7 g/plant, i e almost less than 20 percent of the final dry weight at the time of harvest (9.64 g/plant). The dry matter accumulation was increased at the rate of 447 mg/plant from 30 to 45 DAS and attained an average plant dry weight of 8.39 g. At 60 DAS, maximum dry matter (16.5 g/plant) was attained with 12.5 mg $ZnSO_4$/kg soil. Whereas, 20 and 15 mg $ZnSO_4$/kg soil was required to produce maximum dry weight at 30 and 45 DAS, respectively.

Mean plant tissue Zn concentration at 30 DAS was 27.0 mg/kg which was reduced to 19.0 mg/kg at 45 DAS and the concentration was almost maintained up to the harvesting stage. Increase in level of Zn resulted in significant increase of Zn content in plants and the trend was moderate to highly positive (Table 2). Zinc concentration in plant tissues of mungbean ranged between 12 to 33.6 mg/kg with varying dose of soil applied Zn. Correlation between plant tissue Zn concentrations with dry matter production was found variable at different sampling period throughout the growth stages. At the early stage of crop growth moderate values of coefficient of determination (r^2) were observed (0.716 to 0.740) and it was found maximum at 45 DAS (0.826 to 0.882) and r^2 values again reduced at harvesting stage.

Leaf position selected for sampling exhibited moderate to high degree of variability in the tissue Zn concentration in the study samples with increase in soil Zn concentration. Higher variability in the mineral concentration of study tissue is prime feature for selecting sampling zone in plants. At early stage (30 DAS), there was relatively higher variability of tissue Zn concentration (±Sd 4.09 to 4.50) and at 45 DAS (±Sd 1.31 to 1.65) the variability was relatively lower for both the sampling position. At harvesting stage (60 DAS), the variability in the tissue Zn concentration at varying level of soil Zn was also higher and significant deviation was observed in different leaf position at graded level of soil Zn. Ohki (1976) reported that there was less variation between different leaf positions in soybean at low level of soil Zn concentration but with increase in soil Zn concentration, the variation within different leaf position was widened. It is apparent from Fig 1 that at early stage (30 DAS) the relationship between Zn concentration and dry matter was almost linear. However at 45 DAS, the relationship followed the typical "C" shape as also observed by the previous workers (Ohki 1977, Berry and Wallace 1981). This variation in generalized relationship known as 'C' shaped or Piper-Steenbjerg curve has been reported for zinc (Piper 1942, Steenbjerg 1951). At 30 DAS, the

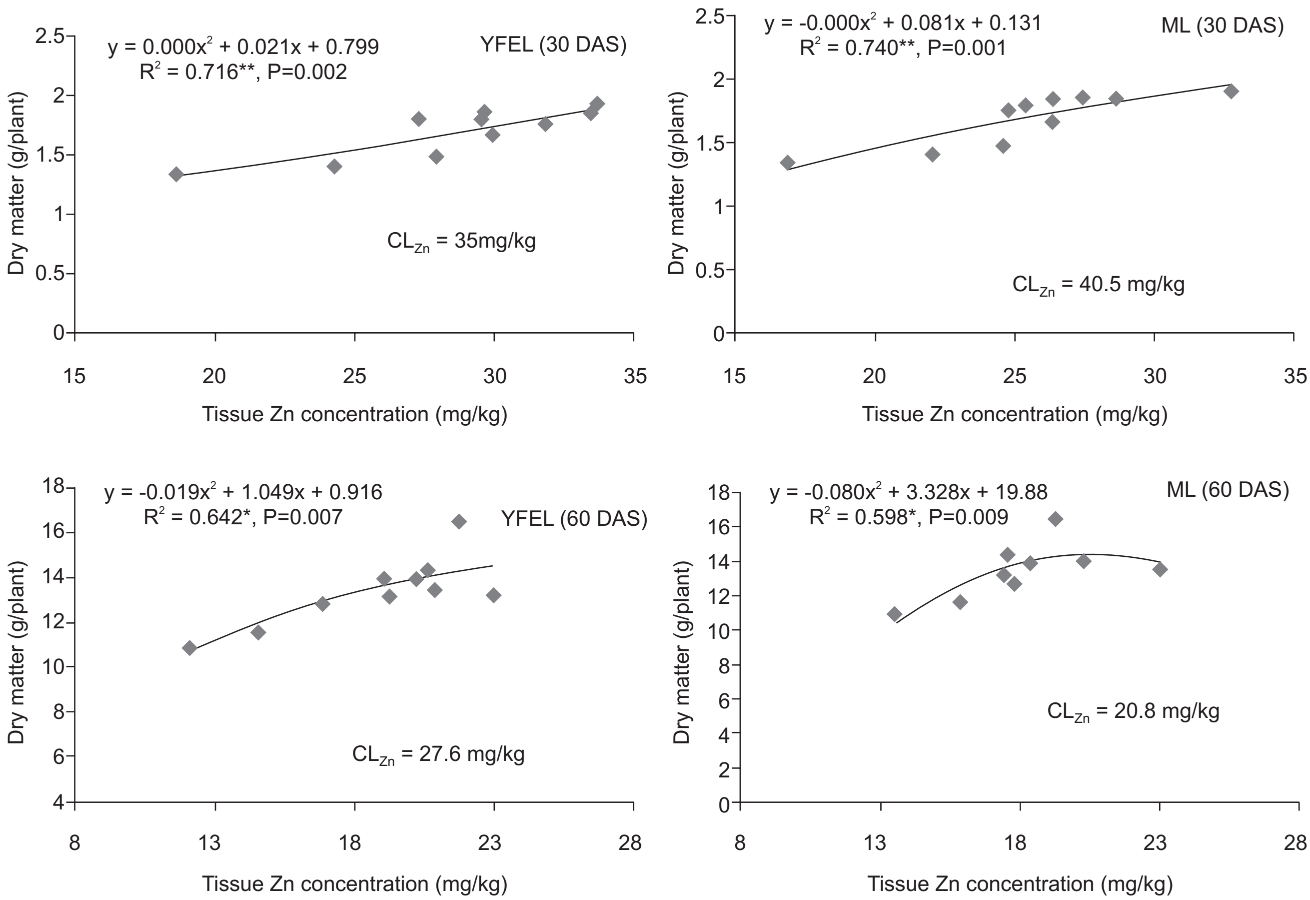

Fig 1 Relationship between Zn concentration (mg/kg) and dry matter (g/plant) in mungbean at different growth stages (30, 45 and 60 DAS) of summer mungbean. YFEL Young fully matured leaf; ML matured leaf. CL_{zn} critical concentration of tissue Zn.

variability in tissue Zn concentration was higher but dry matter was not sufficient enough to be considered as an efficient sampling period and the value of r^2 is also less than the values at 45 DAS. On contrary, the tissue Zn variability was less at 45 DAS. But, high values of r^2 and the dry matter/plant at 45 DAS over 30 DAS was the justification for selecting this stage as an effective sampling stage and the typical C shaped curve at 45 DAS also justifies this recommendation. Among the leaf position selected for sampling, the young fully expanded leaf at 45 DAS had higher tissue Zn variability and higher r^2 value over matured leaf. Therefore, young fully expanded leaf could be appropriate for diagnosing Zn deficiency in short duration mungbean.

The optimum concentration of tissue Zn from the quadratic production function was within a range of 21.0 to 40.5 mg/kg throughout the crop growth period. Based on the effectiveness of sampling period and sampling plant part, the critical Zn concentration was found 21.9 and 21.6 for young fully expanded leaf and matured leaf at 45 DAS, respectively. Similarly, Singh and Nayyar (1997) also reported critical Zn concentration of 22.3 mg/kg in mungbean. While, the critical concentration of tissue Zn was reported relatively higher in chickpea (38.0 to 44.3 mg/kg) and lentil (30.6 to 64.5 mg/kg) (Venkatesh *et al.* 2013).

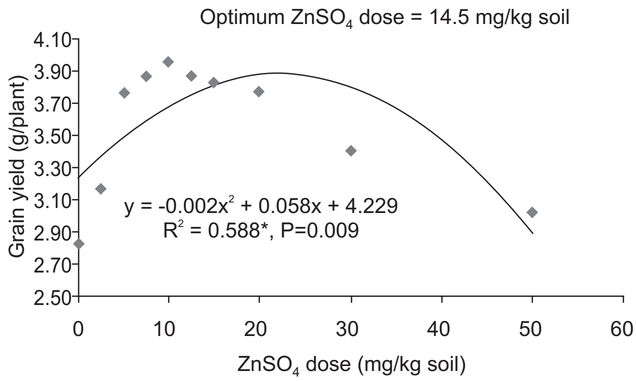

Fig 2 Correlation between applied Zn level (mg $ZnSO_4$/kg soil) and grain yield (g/plant) of summer mungbean.

The Zn content in grain and straw of mungbean also followed similar trend of variation as in case of leaf Zn. Based on the quadratic relationship between applied Zn rate and grain yield/plant calculated the optimum Zn dose which was14.5 mg/kg soil.

SUMMARY

It could be concluded from the above study that growth pattern of short duration mungbean [*Vigna radiata* (L.)

Wilczek] significantly influenced tissue Zn concentration at different stages. Plant tissue Zn concentration was moderate to highly correlated with dry matter production throughout the crop growth stages. Based on the quadratic relationship with dry matter production, the critical concentration of tissue Zn was higher (35.0 to 40.5 mg/kg) at early stage (30 DAS) which was reduced at 45 DAS (21.6 to 21.9 mg/kg). Considerable variation was also observed in critical Zn concentration with leaf position. Based on the variability of Zn concentration in plant tissues and relation with dry matter production, young fully expanded leaf at 45 DAS was found to be the efficient sampling plant part for the plant diagnostics of zinc. While, the optimum Zn dose for summer mungbean was quantified 14.5 mg/kg soil.

REFERENCES

Bates T E. 1971. Factors affecting critical nutrient concentration in plant and their evaluation-A review. *Soil Science* **112**: 1 126–30.

Behera S K, Singh M V and Lakaria B L. 2009. Zinc biofortification of food grains in relation to food security and alleviation of zinc malnutrition. *Indian Farming* **59** (2): 28–31.

Berry W L and Wallace A. 1981. Toxicity: the concept and relationship to the dose response curve. *Journal of Plant Nutrition* **3** (1-4): 13–9.

Gomez K A and Gomez A A. 1984. *Statistical Procedure for Agricultural Research*, 2nd edn. Wiley, New York.

Khan H R, Mcdonald G K and Rengel Z. 1998. Chickpea genotypes differ in their sensitivity to Zn deficiency. *Plant and Soil* **198** (1): 11–8.

Ohki K. 1977. Critical zinc levels related to early growth and development of determinate soybeans. *Agronomy Journal* **69**: 969–74

Piper C S. 1942. Investigation in copper deficiency in plants. *Journal of Agricultural Sciences*. **32**: 132–78.

Prasad R. 2005. Rice–wheat cropping system. *Advances in Agronomy* **86**: 255–339.

Roy R N, Finck A, Blair G J and Tandon H L S. 2006. Plant nutrition for food security. A guide for integrated nutrient management. FAO Fertilizer and Plant Nutrition Bulletin 16, Food and Agriculture Organization of theUnited Nations, Rome, Italy, pp 368.

Sharma U C and Arora B R. 1989. Critical phosphorus concentration in leaves and petioles of potato and prediction of yield potential. *Journal of Indian Society of Soil Science* **37**: 732–7.

Singh S P and Nayyar V K. 1997. Critical deficiency level of zinc in soybean and greengram. *Journal of Indian Society of Soil Science* **45** (1): 201–2.

Steenbjerg F. 1951. Yield curves and chemical plant analysis. *Plant and Soil* **3**: 97.

Venkatesh M S, Hazra K K and Ghosh P K. 2013 Critical tissue zinc concentration: a method to diagnose zinc status in chickpea and lentil. *Indian Journal of Plant Physiology* **18**(2): 191–4.