Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 1833-1837
Received: 07-07-2018
Accepted: 09-08-2018

Jemila C
Ph.D. Scholar, Professor, Department of Soil Science and Agricultural Chemistry Tamil Nadu Agricultural University Coimbatore, Tamil Nadu, India

R Shanmugasundaram
Professor, Department of Soil Science and Agricultural Chemistry Tamil Nadu Agricultural University Coimbatore, Tamil Nadu, India

Correspondence
Jemila C
Ph.D. Scholar, Professor, Department of Soil Science and Agricultural Chemistry Tamil Nadu Agricultural University Coimbatore, Tamil Nadu, India

A preface screening of zinc use efficient pearl millet varieties in calcareous soil

Jemila C and R Shanmugasundaram

Abstract

A pot experiment was conducted during the year 2015-16 to evaluate the zinc utilization potential of five pearl millet varieties by exogenously applied micro nutrients (Zn) in the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University (TNAU), Coimbatore. Soil application with two levels of zinc (0 mg kg^{-1} and 10 mg kg^{-1}) in a Completely Randomized Design was replicated thrice under factorial arrangement (FCRD). Screening of different genotypes in a potentially zinc deficient soil (calcareous soil) gives a picture to identify the nutrient use efficient genotype of pearl millet and further use it to impose bio fortification approach through fertilization strategies. Agronomic bio fortification increase the concentration of trace mineral elements which efficaciously solve the health related problems in developing areas of the world. Results showed that soil application of Zn at 10 mg kg^{-1}has significant effect on zinc nutrient concentration in pearl millet crop (pre flowering stage). Application of micronutrients also increased and improved growth parameter. Among the varieties studied CO (Cu) 9, ICTP 8203 and ICMV 221 were found to be responsive but not efficient and varieties collected from local farmers at Madurai and Coimbatore Districts were found to be efficient and non-responsive as screened in the preface study through fertilization strategy.

Keywords: Pearl millet, screening, varieties, zinc, zinc use efficiency

Introduction

Nutrient deficiency especially micronutrients is a major concern in today's world, and is an underlying cause for millions of deaths each year. Deficiency concerns the following essential elements: Fe, Zn, Se, I, Cu, Ca and Mg, but mainly Fe and Zn. Malnutrition due to micronutrients especially zinc is our concern. The issue of microelement deficiency is related with food security (Dudarev *et al*., 2013) [4]. Micronutrient deficiencies are difficult to diagnose and consequently the problem is termed 'hidden hunger' (Shukla *et al*., 2014) [19]. It is assessed that one third world population affected by deficiency of Zn (4-73%) from different countries caused several serious health problems which include cancer development, DNA damage, affect immune system and learning ability in human. Since micronutrient malnutrition among humans is typically caused by deficiency in soils and then staple food crops grown on these soils. Soils being alkaline and calcareous in nature whose pH are more than 7 and high concentration of $CaCO_3$ decrease availability of trace mineral elements for plant growth (Alloway, 2009) [1]. Zinc malnutrition could be alleviated by correcting zinc deficiency in soil-plant and human continuum. Zn deficiency can affect the plant by stunting its growth, decreasing number of tillers, chlorosis and smaller leaves, increasing crop maturity period, spikelet sterility and inferior quality of harvested products (Hafeez *et al.*, 2013) [9]. Zinc is essential for the normal, healthy growth and reproduction of plants. It is required in small amounts to allow the normal function of several key plant physiological pathways as well as to ensure the structural and functional integrity of membranes. Zinc has an important physiological role in maintaining the integrity and function of cellular membranes by controlling the generation and detoxification of reactive oxygen species. The effect of Zn fertilization on growth and yield of many plants such as alfalfa, wheat, maize, barley, cotton and potato was investigated in numerous researches and increase in yield and other growth related parameters with Zn application was observed. It was noteworthy to observe a positive response due to the application of Zn fertilizer in wheat (Cakmak, 2010) [1, 3], sorghum and rice (Gao *et al*., 2012) [7]. Zinc concentrations in roots, leaves and stems can be increased through the application of Zn- fertilisers. In whole young plants, the reported values are 8 mg Zn kg^{-1} for sorghum, 22 mg Zn kg^{-1} for rice and 25 mg Zn kg^{-1} for wheat and chickpea. However, differences can also occur between different varieties of these crops (Broadley *et al.*, 2010) [2].

Biofortification is one such important technique to increase the concentration of mineral elements which improve the nutritional value of staple food crops and solve health problems in poorer areas of world. Low dietary intake of micronutrients in diets is one of the major reasons in the areas was cereals like rice and wheat being the major consumption. Millets may be a good alternative and nutritious source compared to cereals as they are equally good in enriching soil plant and human continuum with the required nutrient density. Pearl millet is a neglected ancient diet that could be considered to impose bio fortification strategies. Since pearl millet could withstand adverse conditions and require less labour and acquire less cost of cultivation. Equally pearl millet could satisfy the required daily balanced diet and alleviate the micronutrient malnutrition caused due to the poor intake. Keeping this in view the present experiment was done to screen five pearl millet genotypes in a potentially zinc deficient calcareous soil.

Materials and Methods

A pot experiment was conducted in Tamil Nadu Agricultural University, Coimbatore, India in 2016-17. The experimental soil was alkaline in reaction (pH: 8.15), zinc deficient (0.750 mg kg^{-1}) and calcareous (Free $CaCO_3$:17 per cent) in nature. The physicochemical properties of the soil and details of the genotypes used in the study are enlisted below in table 1 and 2 respectively.

Table 1: Initial soil characteristics of experimental soil

Parameters	Result	Procedure	Reference
Soil texture	Sandy clay loam	International pipette method	Piper (1966)
Soil pH	8.15	1:2.5 soil water suspension	Jackson (1973)
Soil EC	0.45dSm^{-1}		
Organic carbon	7 g kg^{-1}	Chromic acid wet digestion	Walkley and Black (1934)
Free $CaCO_3$	17 per cent	Volumetric titration	Piper (1966)
Available N	280 kg ha^{-1}	Alkaline permanganate method	Subbiah and Asija (1956)
Available P	19 kg ha^{-1}	0.5 M $NaHCO_3$ (pH-8.5)	Olsen *et al*. (1954)
Available K	416 kg ha^{-1}	Neutral N NH_4OAC	Stanford and English (1949)
DTPA- Zn	0.750 mg kg^{-1}	DTPA extraction and AAS method	Lindsay and Norvell (1978)
DTPA- Fe	2.96 mg kg^{-1}		
DTPA- Cu	1.49 mg kg^{-1}		
DTPA- Mn	17.1 mg kg^{-1}		

Table 2: Details of the genotypes used in the study

S. No	Name of Genotypes	Source (Location)	Type
1.	V_1: CO (Cu) 9	TNAU	Variety
2.	V_2: local farmer variety	Madurai	Variety
3.	V_3: local farmer variety	Coimbatore	Variety
4.	V_4: ICMV 221	Karnataka	Variety
5.	V_5: ICTP 8203	Karnataka	Variety

Screening of different genotypes in a potentially zinc deficient soil (calcareous soil) gives a picture to identify the nutrient use efficient genotype of pearl millet and further use it to impose bio fortification approach through fertilization strategies. The pearl millet varieties enlisted in the table 2 were subjected to a preface screening for a period upto flowering stage of the crop. Treatments consisted of two levels of zinc (T_1: 0 mg kg^{-1} zinc and T_2: 10 mg kg^{-1} zinc applied in soil as $ZnSO_4$) with the five different pearl millet variety genotypes which was imposed in FCRD and replicated thrice. The study was conducted in plastic pots each containing 7 kg of soil with two plants maintained per pot. All the pots received N, P_2O_5 and K_2O at the rate of 80:40:40 kg ha^{-1} (0.5, 0.7 and 0.2 g pot^{-1}) each as Urea, Single Super Phosphate and Muriate of Potash, respectively and zinc was applied as zinc sulphate. At the end of the experiment (pre flowering stage) dry matter yield of shoot was recorded. The plant material was dried in a hot air oven at about 70°C. Zinc content of the plant was determined by triple acid extraction method (Lindsay and Norvell, 1978). Genotype classification based on nutrient use efficiency (Fageria et al., 2012) otherwise can be termed as Efficient Genotype Index (EGI) was calculated with the dry matter yield and zinc concentration of each genotype using the formula given below and thereafter classifying the genotypes using a scattered diagram.

Zinc Use Efficiency (each genotype)	=	(dry matter yield at high Zn application level/ Zn content at high Zn application level) - (dry matter yield without Zn application level/ Zn content at without Zn application level)

The zinc efficient and inefficient pearl millet genotypes were identified based on the screening of cultivars by drawing a scattered diagram using ZUE of each genotype. A graph (Fig. 1) was drawn plotting dry matter yield of all the genotypes obtained for without zinc application in the X axis and corresponding Zn use efficiency in Y axis. The perpendicular and parallel line to X axis were drawn with average dry matter yield and zinc use efficiency to divide the scattered diagram and to classify the genotypes into four groups *viz.* efficient and responsive (ER), efficient and non-responsive (ENR), inefficient and responsive (IER) and inefficient and non-responsive (IENR). The ER genotypes have high yield as well as high zinc use efficiency, ENR genotypes have high yield and low efficiency, IER genotypes have low yield and high efficiency and IENR have low yield as well as low efficiency. The ER genotypes would be most suitable for cultivation under Zn stress conditions

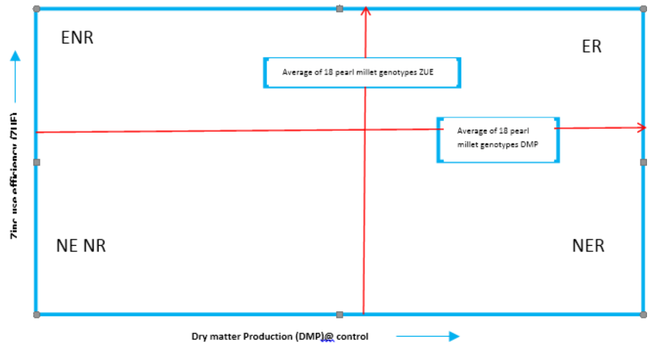

Fig 1: A graph depicting classification of genotypes based on its efficiency

Results and Discussion

The data on various observations recorded during the course of investigation were analyzed statistically by adopting the procedure described by Gomez and Gomez (2010). The results of the experiment are discussed below.

Dry matter Production (DMP)

The DMP varied with genotypes in both control and adequate zinc supply. Among the genotypes CO (Cu) 9 recorded the highest DMP under the treatments with zinc (3003 kg ha^{-1}) and without zinc (2296 kg ha^{-1}) which was followed by V_5 (2996, 2825), V_4 (2884, 2768), V_2 (2693, 2534) and V_3 (2453, 2296). Average dry matter production was registered as 2664 and 2806 kg ha^{-1} in T_1 (without zinc) and T_2 (with zinc application) respectively. This variation might be due to their differential utilization capacity of native soil Zn as well as applied zinc. As Application of zinc @ 10 mg kg^{-1} soil, in a zinc deficient soil increased the shoot dry weight in all pearl millet varieties. Kabeya and Shankar (2013) [12] studied in a field experiment with six rice genotypes and found that application of 30 kg $ZnSO_4$ ha^{-1} increased the leaf (35.33 g $hill^{-1}$) and straw (41.25 g $hill^{-1}$) dry matter production. Tolerance of certain genotypes under zinc stress conditions might be due to their higher rates of organic acid excretion in the rhizosphere facilitating increased native Zn availability in soil. The cultivar which was efficient in Zn utilization was also efficient accumulator of biomass under adequate as well deficient Zn supply. This is in line with the results of Sudha and Stalin (2015) [16].

Statistically it was found that the application of zinc had significantly higher effect on the dry matter production. The combined interaction effect of the treatments with the varieties was also found to be highly significant in influencing the dry matter production of the pearl millet crop. The highest DMP was recorded by variety (G_1) CO (Cu) 9 in both control and adequate zinc supply while the lowest was recorded by the variety (G_3) collected from local farmer at Coimbatore District.

Zinc Content

The total Zn concentration increased with zinc application as noticed in Table 3. The different cultivars varied greatly in respect of zinc concentration at the end of the experiment. The mean zinc concentration varied from 21.97 to 44.92 mg kg^{-1} in different genotypes studied. All the genotypes responded to the application of zinc with CO (Cu) 9 registering the highest zinc content (44.92 mg kg^{-1}) to Zn applied @ 10 mg kg^{-1} as against the lowest Zn content (43.87 mg kg^{-1}). Similarly, higher Zn content (In mg kg^{-1}) recorded by other genotypes in the descending order are as follows G_5 (30.98 & 29.26) > G_4 (31.96 & 30.90) > G_2 (32.98 & 31.68) > G_3 (23.12 & 21.97) under the treatments with zinc and without zinc application respectively. Those differences could be due to differential ability of the genotypes in extracting zinc from the soil solution and diffusion of zinc in leaves and its redistribution to other parts of plant. Increased supply of zinc favoured increased Zn accumulation in the entire plant. The increase in Zn concentration observed in the adequate zinc supply treatments may also be due to increased availability of zinc to the crop through xylem transport from root to shoot in the transpiration stream. The results are supported with the findings of Tayyeba samreen *et al*. (2017) [22].

Statistical results revealed wide variation among the different genotypes studied with respect to the total plant zinc concentration in the study and this might be due to the secretion of phytosiderophores, which are non- proteinogenic amino acids from the roots of efficient genotypes under zinc stress conditions which are highly effective in complexing and mobilizing Zn from root apoplast to long distance transport of Zn within the plant. These results also corroborates with the findings of Fageria (2013) [5]. Though the genotypes showed wide variation in recording variations in concentration of zinc, treatmental effect within the genotypes are found less significant in the present investigation.

Table 3: Zinc content and dry matter production of five pearl millet genotypes at the end of the experiment (upto flowering stage)

(Mean of three replications)							
Genotypes		**Zinc Concentration (mg kg^{-1})**			**Dry Matter Production (kg ha^{-1})**		
S No	**Details**	**T_1 (without zinc)**		**T_2 (with zinc)**	**T_1 (without zinc)**	**T_2 (with zinc)**	
1	G_1	43.87		44.92	2899	3003	
2	G_2	31.68		32.98	2534	2693	
3	G_3	21.97		23.12	2296	2453	
4	G_4	30.90		31.96	2768	2884	
5	G_5	29.26		30.98	2825	2996	
Average		31.5		32.8	2664	2806	
CV		3.73 %			1.86 %		
		T	G	T x G	T	G	T x G
SED		0.432	0.683	0.966	19.220	30.390	42.978
CD (0.05)		0.901	1.425	NS	40.093	63.393	89.652

Table 4: Classification of Genotypes based on dry matter yield

S No	Genotypes	DMP @ control	ZUE
G_1	CO (Cu) 9	2899	0.77
G_2	local farmer variety	2534	1.67
G_3	local farmer variety	2296	1.59
G_4	ICMV 221	2768	0.66
G_5	ICTP 8203	2825	0.16
Average		2664	0.97

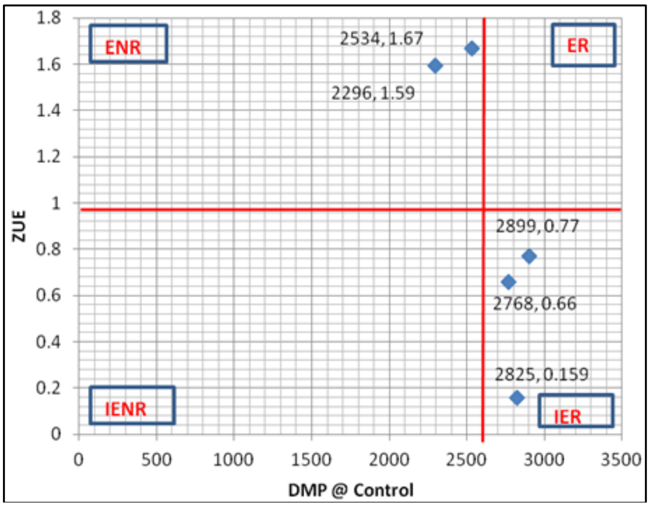

Fig 2: Classification of genotypes for zinc use efficiency Screening for Zinc Use Efficiency (ZUE)

Graham and Rengel (1993) [8] suggested that more than one mechanism could be responsible for establishing Zn efficiency in a genotype and it is likely that different genotypes subjected to Zn deficiency under different environmental conditions will respond by, one or more, different efficiency mechanisms. In the present study, the pearl millet genotypes were screened based on dry matter yield recorded at the control plot and its respective ZUE to identify the Zn- efficient and Zn- inefficient groups by drawing scattered diagram (Fig. 2).

Varieties collected from local farmers at Madurai and Coimbatore districts were the genotypes found efficient but fall under the category of non-responsive quadrant. The other varieties like CO (Cu) 9, ICMV 221 and ICTP 8203 were found to be responsive rather than efficient. The identified efficient genotypes could be grown under Zn stress condition due to their efficiency of Zn utilization from native Zn source in the soil. Zinc efficiency (ZE), mainly defined as the ability of a plant to grow and yield well under Zn deficiency. Hafeez *et al*. (2013) [9] reported that efficient genotypes are those with high ability to absorb nutrients from soil and fertilizer and store relatively little nutrients. The mechanisms responsible for this tolerance of genotypes in zinc stress condition include multi-various reasons and one of the major reason being the increased Zn bioavailability in the rhizosphere due to release of root exudates, higher Zn uptake by roots, and efficient utilization and (re)-translocation of Zn (Sadeghzadeh, 2013) [17]. The genotypes which are high yielding under Zn stress conditions (Shivay *et al*., 2015) [18] and also responsive to Zn fertilizer (Impa *et al*., 2013) [10] are the cultivars that can be grown widely under stress conditions and are genotypically efficient to carry out further enhancement techniques to boost nutrient content in crops.

Conclusion

Among the varieties screened for zinc use efficiency CO (Cu) 9, ICMV 221 and ICTP 8203 were registered and released varieties that were found to be responsive and the other local varieties collected from farmers (at Madurai and Coimbatore Districts) were found to be efficient in utilizing native zinc. That was evident to note that the varieties which were efficient are not responsive and the varieties responsive are not efficient. These are to be further confirmed by secondary phase screening and field trials to prove the efficiency of genotypes for their nutrient uptake and utilization capacity and also to impose further enhancement techniques for enriching the crop with nutrient density. Screening will be a preface study that gives a picture to identify the best cultivars to enhance nutrient in a particular crop after successive trials on various imposed treatments.

References

1. Alloway BJ. Soil factors associated with zinc deficiency in crop and humans, Environmental Geochemical Health. 2009; 31:537-548.
2. Broadley MR, SO Lochlainn, JP Hammond, HC Bowen, I Cakmak, S Eker *et al*. Shoot zinc (Zn) concentration varies widely within *Brassica oleracea* L. and is affected by soil Zn and phosphorus (P) levels, J. Hort. Sci. Biotech. 2010; 85:375-380.
3. Cakmak I, WH Pfeiffer, B Mc Clafferty. Biofortification of durum wheat with Zinc and Iron. J Cereal Chem. 2010; 87:10-20.
4. Dudarev AA, PR Alloyarov, VS Chupakhin, EV Dushkina, YN Sladkova, VM Dorofeyev. *Et al*. Food and water security issues in Russia I: food security in the general population of the Russian Arctic, Siberia and the Far East, 2000-2011. International Journal of Circumpolar Health, 2013, 72.
5. Fageria NK. Mineral Nutrition of Rice. Boca Raton, FL: CRC Press. 2013. 10.1201/b15392
6. Fageria NK, MF Moraes, EPB Ferreira, AM Knupp. Biofortification of trace elements in food frops for human health. Commun. Soil. Sci. Plant Anal. 2012; 43:556-570.
7. Gao X, E Hoffland, T Stomph, CA Grant, C Zou, F Zhang. Improving zinc bioavailability in transition from flooded to aerobic rice: A review. Agronomy for Sustainable Development. 2012; 32(2):465-478.
8. Graham RD, Z Rengel. Genotypic variation in Zn uptake and utilization by plants. In: Robson D, ed. Zinc in soils and plants. Dordrecht, the Netherlands: Kluwer Academic Publishers, 1993, 107-114.
9. Hafeez B, YM Khanif, AW Samsuri, O Radziah, W Zakaria, M Saleem. Direct and Residual Effect of Zinc on Zinc Efficient and Inefficient Rice Genotypes Grown under Less Zinc Content Submerged Acidic Condition. Comm. Soil Sci. Plant Analysis, 2013, 1-59.
10. Impa SM, A Gramlich, SR Tandy Schulin, E Frossard, SE Johnson-Beebout, Internal Zn allocation influences Zn deficiency tolerance and grain Zn loading in rice (*Oryza sativa* L.). Front. Plant Sci. 2013; 4:534.
11. Jackson ML. Soil Chemical Analysis. Prentice hall of India Pvt. Ltd., New Delhi, 1973.
12. Kabeya MJ, AG Shankar. Effect of different levels of zinc on growth and uptake ability in rice zinc contrast lines (*Oryza Sativa* L.). Asian J Plant Sci. Res. 2013; 3(3):112-116.
13. Lindsay WL, WA Norvell, Development of a DTPA soil test for zinc, iron, manganese and copper, Soil Sci. Am. J. 1978; 42(1996):421-428.
14. Olsen SR, CV Cole, FF Watanabe, AL Bean, Estimation of available phosphorus of soil extraction with sodium bicarbonate. U.S. Dept. Agric. Cir. 1954; 939:1-19.
15. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay. 1966, 15.
16. Sudha S, P Stalin, Effect of zinc on yield, quality and grain zinc content of rice genotypes. International journal of farm sciences. 2105; 5(3):17-27.

17. Sadeghzadeh B. A review of zinc nutrition and plant breeding. J Soil Sci. Plant Nutr. 2013; 13:905-927.
18. Shivay YS, RM Prasad Pal, Effects of source and method of zinc application on yield, zinc bio fortification of grain, and Zn uptake and use efficiency in chickpea (*Cicer arietinum* L.), Commun. Soil Sci. Plant Anal. 2015; 46:2191-2200.
19. Shukla AK, TK Pankaj, Chandra Prakash. Micronutrients Deficiencies vis-a-vis Food and Nutritional Security of India. Indian J Fert. 2014; 10(12):94-112.
20. Stanford S, L English. Use of flame photometer in rapid soil tests of K and Ca. Agron. J. 1949; 41: 446-447.
21. Subbiah BV, CC Asija, A rapid procedure for estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.
22. Tayyeba Samreen, Humaira, Hamid UllahShah, Saleem Ullah, Muhammad Javid, Zinc effect on growth rate, chlorophyll, protein and mineral contents of hydroponically grown mungbeans plant (*Vigna radiata*), Arabian journal of Chemistry. 2017; 10(2):1802-1807
23. Walkley A, IA Black, An estimation of the digestion method for determining soil organic matter and proposed modification of the chromic acid filtration method. Soil Sci. J. 1934; 37:27-38.