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Impact of Continuous Manuring and Fertilization of Micronutrient and Secondary Nutrient Status under Sorghum-wheat Sequence in Vertisols

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Abstract: *The Long Term Fertilizer Experiment (AICRP) on sorghum-wheat sequence is continued since 1988-89 at Akola. The present experiment was studied to assess the impact of long term manuring and fertilization on soil biological properties and productivity of sorghum during 2009-10 (22nd cycle). The treatments comprised of 50% RDF, 100% RDF, 150% RDF,100% RDF (-S), 100% RDF + 2.5 kg Zn ha^{-1} to wheat crop only, 100% RD of NP, 100% RD of N, 100% RDF + FYM @ 10 tonnes ha^{-1}, 100% RDF + S @ 37.5 kg ha^{-1}, FYM @ 10 tonnes ha^{-1}, 75% RDF and Control. The results of the present experiment revealed that, application of 100% NPK + FYM @ 10 t ha^{-1} recorded significantly higher micronutrient cations viz; Fe (7.60 mg kg^{-1}), Mn (6.43 mg kg^{-1}), Cu (4.12 mg kg^{-1}) and B (0.461 mg kg^{-1}), whereas, the Zn status was improved with the continuous application of Zn @ 2.5 kg ha^{-1} along 100% RDF (0.87 mg kg-1) and was closely followed by 100% RDF + FYM @ 10 tonnes ha^{-1}. The application of 100% RDF + FYM @ 10 tonnes ha-1 have profound influence on availability of exchangeable Ca (43.80 c mol (p+) kg^{-1}) and Mg (8.28 c mol (p+) kg^{-1}). The increased levels of RDF from 50% to 150% was drastically increased the exchangeable Ca, however the response was declined under crop fertilized continuously devoid of SSP. The application of 100% NPK + FYM @ 10 t ha^{-1} recorded significantly higher grain yield (65.92 q ha^{-1}) of sorghum. The correlation coefficient among yield of sorghum was higher with Mn (r^2 = 0.726**) followed by Zn (r^2 = 0.700**), Cu (r^2 = 0.645**) and least with Fe (r^2 = 0.639**).*

INTRODUCTION

Agriculture is the backbone of Indian economy and it provides employment to about 70% population. Significance of improving and maintaining soil fertility for enhancing and sustaining crop productivity was realised long back world wide. The most logical way to manage long term fertility and productivity of soil is the integrated use of both organic and inorganic sources of plant nutrients. Long term fertilizer experiments usually provides the best test of sustainability of crop management system (Nambiar, 1994). Sorghum is the premier food grain crop of the peninsular central India in general and Maharashtra in particular. There has been phenomenal increase in it's production after mid sixties with the introduction of high yielding varieties. Increase in production was achieved through increase in area as well as productivity. It is major dual purpose crop which is used as sources of food and also an important sources of fodder. The concept of balanced fertilization can not be confined to nitrogen, phosphorous, potassium only. Balanced fertilization includes application of all plant nutrients required for high agricultural productivity and soil health. Inadequate replenishment of plant nutrients in a imbalanced way has resulted in the emergence of multinutrient deficiencies like P, K, S, Zn, Fe, Cu, Mn and B in soils and plants on large scale. The exchangeable bases like Ca and Mg help in maintaining the pH by improving buffering capacity of soil. The analysis of Ca and Mg at long term fertilizer experiment at various places in India revealed decline in both (Ca and Mg) cation irrespective of treatment, but decline in exchangeable Ca and Mg was largest in plots receiving only N. Micronutrient includes Fe, Cu, Zn, Mn, B and Mo and these elements are required in very minute quantities and they mostly act to stimulate, activate or accelerate the enzymatic activities in metabolic processes of

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plant. These elements are required in trace hence they are also called as trace elements. (Singh, 1996). The micronutrient essential for crops are iron, copper, zinc, manganese, boron, molybdenum and chlorine (Patil *et al.* 2004). Micronutrients are playing a vital role in plant growth but with the green revolution, we have adopted improved management technologies using high yielding varieties and chemical fertilizers which supply mainly major nutrients to increase crop production, which lead to soil degradation and negative nutrient balance in soil. The present experiment mainly focused on "micro and secondary nutrient status as a result of continuous application of manures and fertilizers".

MATERIALS AND METHODS

The long term fertilizer experiment under sorghum-wheat sequence initiated during 1988 at National Highway Block, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). Akola is situated in subtropical zone about 307.42 m above MSL and geographically situated on $22^0 42'$ N latitude and $77^0 02'$E longitude. The climate is subtropical semi, total rainfall received during 2009-10 was 699.5 mm. Minimum and maximum temperatures recorded during period of experimentation were 13.6°C and 42.7 °C respectively. The soil of experimental site is medium to deep clayey black soil i.e. Vertisol (particularly montmorillonitic type). The initial analysis indicated that soils are low in organic carbon (4.6 g kg ha^{-1}) and available N (120 kg ha^{-1}), very low in available P (8.4 kg ha^{-1}) and high in available K (358 kg ha^{-1}). The treatments consisted of (T_1) 50% RDF, (T_2)100% RDF, ((T_3) 150% RDF, (T4) 100%; RDF (S free), (T_5) 100% RDF plus 2.5 kg Zn ha^{-1} to wheat, (T_6) 100% RD of NP, (T_7) 100% RD of N, (T_8) 100% RDF + FYM @ 10 t ha^{-1} (to sorghum only), (T_9) 100 % RDF + sulphur @ 37.5 kg ha^{-1}, (T_{10}) FYM @10 t ha-^{1}, (T_{11}) 75 % RDF and (T_{12}) control. The treatments were given to each crop every year. FYM was added on oven dry basis before sowing of sorghum. It contains 0.58 % N, 0.21% P and 0.62% K. Zinc and sulphur was applied through zinc sulphate and gypsum respectively. The experiment was laid out in Randomized block design with four replications having plot size 10 x 10 m^2. Sowing of sorghum was done by drilling. Plot wise surface (0-15 cm) soil samples were collected after harvest of sorghum in 2009-10 (23rd cycle). Soils were analyzed for exchangeable Ca and Mg following EDTA method described by Jackson (1967). Available micronutrients (Zn, Fe, Cu and Mn) were estimated by DTPA extract method by using atomic absorption spectrophotometer as described by Lindsay and Norvell (1978). Available Boron was estimated by $CaCl_2$ extractable Azomethine-H method described by Tandon (1995).

RESULTS AND DISCUSSION

Exchangeable Ca and Mg

The exchangeable Ca and Mg at initial were ranged between 34.27 to 41.50 and 6.03 to 7.53 c mol (p+) kg^{-1} respectively (Table 1). The effect of various treatments at harvest of sorghum on exchangeable Ca and Mg over the years of cropping was found significant. Significantly highest exchangeable Ca and Mg (43.80 and 8.28 c mol (p+) kg^{-1}) were recorded in the treatments 100% NPK + FYM @ 10t ha^{-1} showing 25.86 and 34.63 per cent increase in exchangeable Ca and Mg respectively over control. The application of 100% NPK + S @ 37.5 kg ha^{-1} recorded significantly highest exchangeable Ca (41.79 c mol (p+) kg^{-1}) followed 100% NPK + 2.5 kg Zn ha^{-1} (39.97 c mol (p+) kg^{-1}). However, these treatments were found at par in respect exchangeable Mg. Application of FYM @ 10 t ha^{-1} recorded significantly higher exchangble Ca (38.74 c mol (p+) kg^{-1}) as compared to 100% N and control. The results are in conformity with the findings reported by Bellaki *et al.* (1998) and Chander *et al.* (2007).

DTPA-micronutrients Status

The data pertaining to DTPA- Zn and Fe are presented in Table 1. The initial Zn status varied from 0.31 to 0.90 mg kg^{-1}. The Zn status of soil after harvest of sorghum was influenced significantly with the application of 100% NPK + Zn @ 2.5 kg ha^{-1} and 100% NPK along with FYM @ 10 t ha^{-1} i.e. 0.87 mg kg^{-1} and 0.84 mg kg^{-1} respectively. However, application of 150% NPK (T_3), 100% NPK + S @ 37.5 kg ha^{-1} (T_9) and 100% NPK (T_2) was found at par in respect of DTPA-Zn status. Highest available Zn status of soil in treatment 100% NPK + 2.5 kg Zn ha^{-1} (T_5) was due to addition of Zn through Zinc sulphate along with 100% NPK over the years of cropping. Continuous cropping without manures and fertilizers resulted drastic reduction in the status of DTPA-Zn (0.28 mg kg^{-1}), even below the critical limits (0.60 mg kg^{-1}). Indicating there is an urgent need to improve the micronutrient status of calcareous soils otherwise productivity can be adversely affected. Bhoyar *et al.*, (1998) also recorded highest Zn status of soil due to application of 10 kg $ZnSO_4$ along with 100% NPK.

The DTPA-Fe status of soil was improved significantly with the application of 100% NPK + FYM @ 10 t ha^{-1} (7.60 mg kg^{-1}) which was found superior over all other treatments. Application of 100% NPK + S @ 37.5 kg ha^{-1} recorded available Fe (6.76 mg kg^{-1}) followed by FYM @ 10t ha^{-1} (6.42 mg kg^{-1}. Highest value under 100% NPK +FYM @ 10 t ha^{-1} indicating need of FYM in maintaining primary as well as micronutrients status of soil. Verma *et al.*, (2005) quoted FYM as a good source of micronutrients besides improving the physical properties of soil. Similar results were also reported by Prasad *et al.*, (1980).

The data pertaining to DTPA- Cu and Mn are presented in Table 2. Significantly highest DTPA-Cu of soil (4.12 mg kg^{-1}) was recorded with the application of 100% NPK + FYM @ 10 t ha^{-1}, followed by 150% NPK (3.94 mg kg^{-1}). Ismail *et al.* (2002) reported significant build up of Cu in Vertisol with application of 50% RDF + 5 t FYM ha^{-1}. Patel (2005) also reported higher available Cu status of soil was observed with 100% NPK + FYM @ 10 t ha^{-1} and 150% NPK application as compared to 50% NPK. These results supported the findings of Selvi (2002) who reported maximum Cu status observed with 100% NPK + FYM.

Significantly highest available Mn (6.43 mg kg^{-1}) was observed with the application of 100% NPK + FYM @ 10 t ha^{-1}, followed by 150% NPK (5.60 mg kg^{-1}). Further, it was observed that the application of FYM alone also recorded significantly higher Mn (5.22 mg kg^{-1}) over rest of the treatments, except 100% NPK + S @ 37.5kg ha^{-1} (5.36 mg kg^{-1}). Similar increasing trend on available Mn due to application of FYM has been reported by Bellaki and Badanur (1997).

The data in respect of available boron is presented in Fig. 1. The treatment 100% NPK + FYM @ 10 t ha^{-1} recorded highest boron (0.461 mg kg^{-1}) followed by treatment 150 per cent NPK (0.402 mg kg^{-1}). Treatment receiving FYM @ 10 t ha^{-1}recorded highest boron (0.322 mg kg^{-1}) than control. Application of 100% NPK + Zn @ 2.5 kg ha^{-1} recorded highest available boron (0.392 mg kg^{-1}), however it was found at par with 100% NPK + S @ 37.5 kg ha^{-1} (0.382 mg kg^{-1}) , 100% NPK (0.378 mg kg^{-1}), 100% NPK(-S) (0.371 mg kg^{-1}). Application of FYM increased the availability of boron as compared to it's initial status as some quantity of boron is added through FYM, but it was found at par with 100% N (0.298 mg kg^{-1}). Among all treatments control recorded lowest available boron. Similar results were recorded by Pal *et al.* (2009).

The improvement in available micronutrients status of soils in the plots which were receiving RDF along with FYM since long period might be due to release of chelating agents from organic matter decomposition which might have prevented micronutrients from precipitation, oxidation and leaching (Sharma *et al.*, 2001). The application of RDF alone resulted decline in DTPA- micronutrients status as compared to organics and inorganic combination of fertilizer treatments. It was attributed to non replenishment of micronutrients through chemical fertilizers (Katyal and Sharma, 1979). In the present experiment intensive cultivation and growing exhaustive crops such as sorghum have made the soil deficient in macro as well as in micronutrients. The long term fertilizer experiment continuing at many places in India comprising various cropping sequences has shown deficiency of macro as well as micronutrients besides supplying nutrients through inorganic sources. Thus, the success of any cropping system depends not only upon the balanced use of chemical fertilizers but appropriate management of resources including balanced use of manures and fertilizers.

Productivity of Sorghum

The application of 100% NPK + FYM @ 10 t ha^{-1} recorded significantly higher grain yield (65.92 q ha^{-1}) of sorghum (Fig. 2). The yield obtained from 100 % N, 100% NP and 100% NPK showed significant increasing trend from N to NPK. This suggests the importance of balance fertilization for achieving productivity of crop. Similar results were obtained by Ravankar *et al.* (2005). They reported that the highest yield of sorghum was obtained with the application of full recommended dose of NPK + FYM @ 10 t ha^{-1} in Vertisol. This increase in crop productivity may be due to the combined effect of nutrient supply, improved physical properties like bulk density, available water capacity, mean weight diameter and hydraulic conductivity which provided a desirable soil condition for root development, enhanced nutrient uptake, crop growth and yield.

Relationship among Grain Yield and DTPA-micronutrients

The relationship among sorghum grain yield and DTPA- micronutrients (Zn, Fe, Mn and Cu) are depicted in Fig. 3 and 4, the data revealed that grain yield of sorghum was significantly correlated with Zn ($r^2 = 0.700^{**}$), Fe ($r^2 = 0.639^{**}$), Cu ($r^2 = 0.645^{**}$) and Mn ($r^2 = 0.726^{**}$). From the correlation study, it revealed that the productivity of sorghum is largely influenced by soil's micronutrients status. Among

Table 1
Exchangeable Ca and Mg as influenced by long term manuring and fertilization under sorghum-wheat sequence

	Treatment	*Exchangeable Ca (c mol (p^+) kg^{-1})*		*Exchangeable Mg (c mol (p^+) kg^{-1})*	
		Initial	*At harvest*	*Initial*	*At harvest*
T_1	50% NPK	36.21	38.18	6.29	6.69
T_2	100% NPK	37.22	39.93	6.57	7.21
T_3	150% NPK	40.92	42.18	7.45	7.95
T_4	100% NPK (S free)	36.92	39.01	6.49	7.03
T_5	100% NPK + Zn @ 2.5 kg ha^{-1}	37.42	39.97	6.67	7.29
T_6	100% NP	36.45	38.42	6.48	6.90
T_7	100% N	35.01	37.18	6.15	6.68
T_8	100% NPK + FYM @ 10 t ha^{-1}	41.50	43.80	7.53	8.28
T_9	100% NPK +S @ 37.5 kg ha^{-1}	37.55	41.79	6.77	7.53
T_{10}	FYM @ 10 t ha^{-1}	40.84	38.74	7.25	6.52
T_{11}	75% NPK	36.33	38.28	6.32	6.94
T_{12}	Control	34.27	34.79	6.03	6.15
SE (m±)		0.42	0.55	0.085	0.09
CD at 5%		1.22	1.58	0.24	0.27

Table 2
Micronutrients (Zn and Fe) status as influenced by long term manuring and fertilization under sorghum-wheat sequence

	Treatment	*DTPA-Zn*		*DTPA-Fe*	
		Initial	*At harvest*	*Initial*	*At harvest*
T_1	50% NPK	0.41	0.44	5.94	5.91
T_2	100% NPK	0.68	0.68	6.50	6.20
T_3	150% NPK	0.71	0.75	7.37	7.28
T_4	100% NPK (S free)	0.52	0.55	6.18	6.13
T_5	100% NPK + Zn @ 2.5 kg ha^{-1}	0.90	0.87	5.77	5.66
T_6	100% NP	0.49	0.53	6.36	6.27
T_7	100% N	0.31	0.40	5.98	5.96
T_8	100% NPK + FYM @ 10 t ha^{-1}	0.81	0.84	7.48	7.60
T_9	100% NPK +S @ 37.5 kg ha^{-1}	0.65	0.69	6.68	6.76
T_{10}	FYM @ 10 t ha^{-1}	0.62	0.63	6.28	6.42
T_{11}	75% NPK	0.48	0.50	6.08	6.04
T_{12}	Control	0.31	0.28	4.65	4.58
SE (m±)		0.007	0.030	0.37	0.11
CD at 5%		0.022	0.087	1.08	0.34

Table 3
Micronutrients (Cu and Mn) status as influenced by long term manuring and fertilization under sorghum-wheat sequence

	Treatment	*DTPA-Cu*		*DTPA-Mn*	
		Initial	*At harvest*	*Initial*	*At harvest*
T_1	50% NPK	3.17	3.08	4.96	4.82
T_2	100% NPK	3.66	3.70	5.18	5.02
T_3	150% NPK	3.71	3.94	5.66	5.60
T_4	100% NPK (S free)	3.56	3.47	5.07	4.94
T_5	100% NPK + Zn @ 2.5 kg ha^{-1}	3.65	3.68	5.19	5.10
T_6	100% NP	3.02	3.07	5.02	4.90
T_7	100% N	2.92	3.00	4.82	4.72
T_8	100% NPK + FYM @ 10 t ha^{-1}	3.98	4.12	6.19	6.43
T_9	100% NPK +S @ 37.5 kg ha^{-1}	3.74	3.89	5.56	5.36
T_{10}	FYM @ 10 t ha^{-1}	3.49	3.69	5.20	5.22
T_{11}	75% NPK	3.18	3.23	5.03	4.99
T_{12}	Control	2.94	2.83	3.97	3.75
SE (m±)		0.028	0.025	0.03	0.02
CD at 5%		0.082	0.071	0.10	0.07

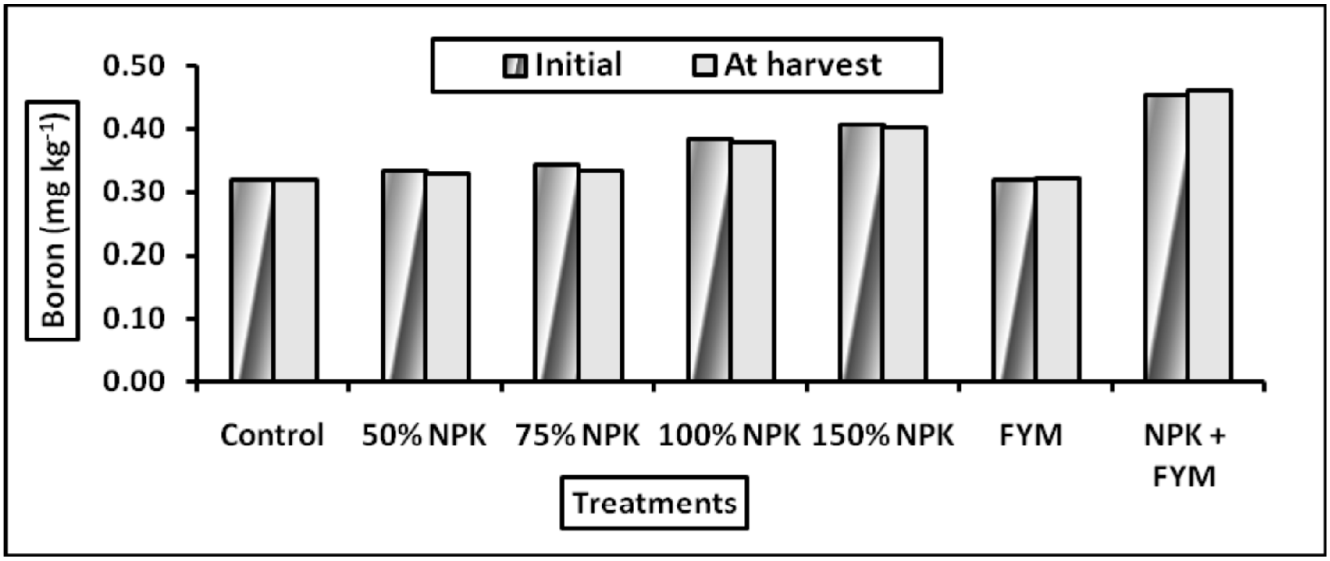

Figure 1: Available boron status as influenced by long term manuring and fertilization under sorghum-wheat sequence

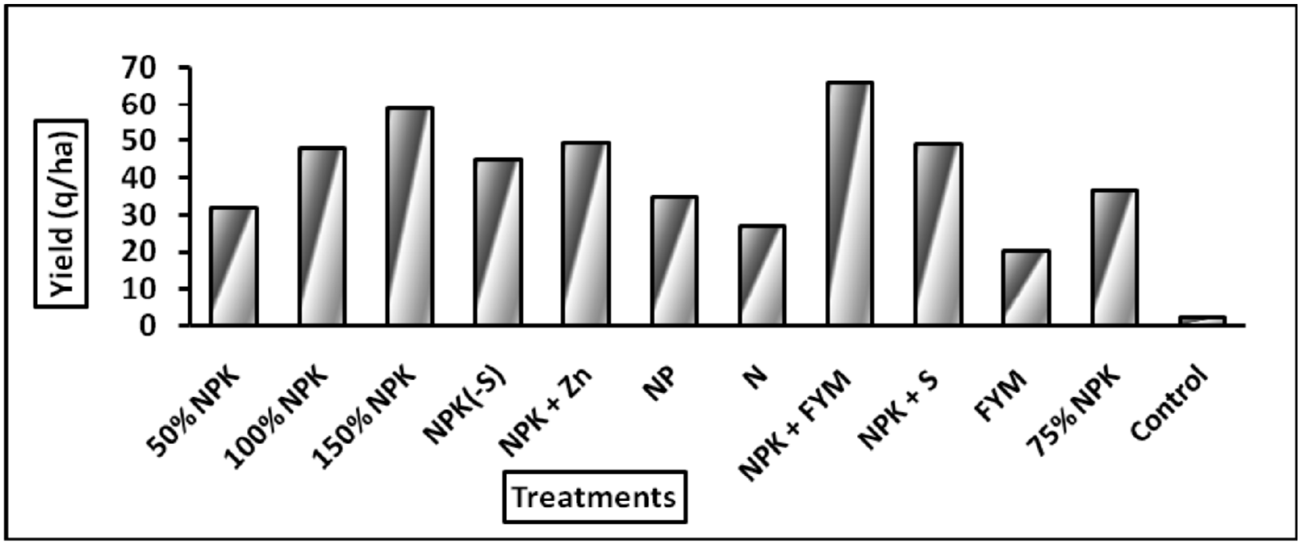

Figure 2: Yield of sorghum as influenced by long term manuring and fertilization under sorghum-wheat sequence

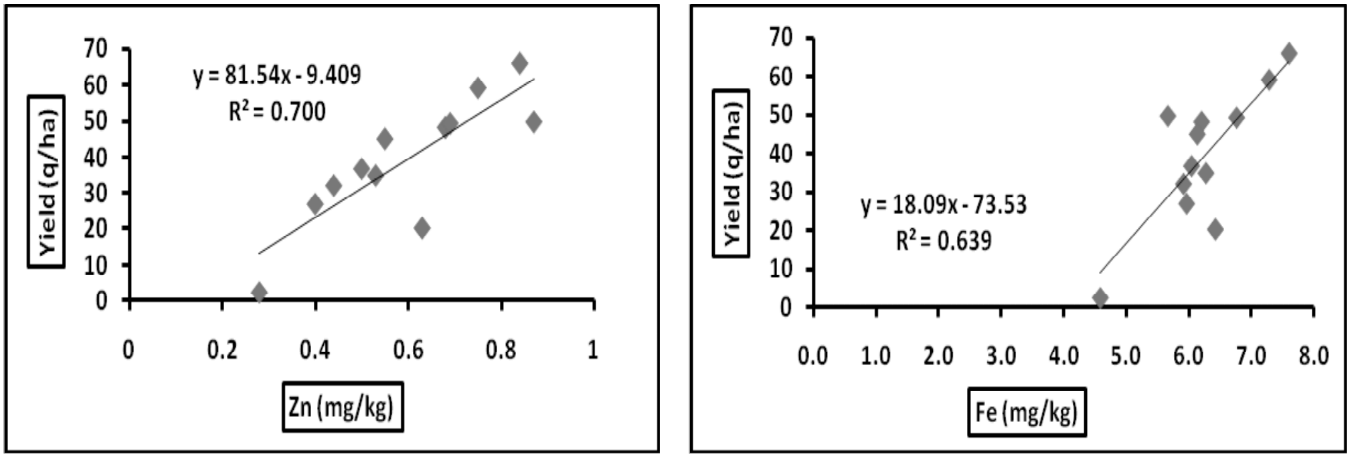

Figure 3: Relationship between DTPA- micronutrients (Zn, Fe) and yield of sorghum

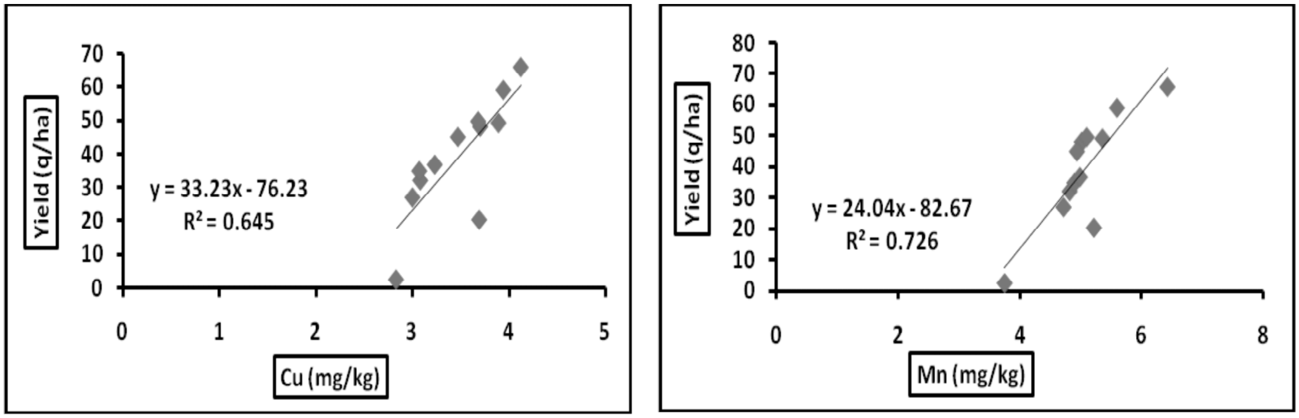

Figure 4: Relationship between DTPA- micronutrients (Cu, Mn) and yield of sorghum

these, the correlation coefficient was higher with Zn and Mn, indicating yield limiting factors, which ultimately decline yield if soils are deficient in such micronutrients.

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