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Effect of zinc enriched organics on Zn mineralization in calcareous soil vis-à-vis its availability to sugarcane crop

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ABSTRACT

A field experiment was conducted at the Farm of G.S. Sugarcane Breeding and Research Institute, Seorahi for three consecutive years (2007-2011) with sugarcane (variety 'CoSe 01424') to assess the efficacy of zinc enriched organics on cane growth, yield attributes and yield as well as mineralization of zinc in calcareous soil. Results revealed that the enrichment of 25 kg zinc sulphate with 500 kg/ha press mud cake (PMC) or farm yard manure (FYM) as basal application significantly elevated shoot population, number of millable canes, yield and commercial cane sugar (CCS) indices by 6.84, 6.69, 6.48 and 9.49%, respectively without tangible change in juice quality. Additionally, it also increased soil available zinc at grand growth phase (0.76 ppm) and harvest stage (0.62 ppm) with consequent increase in zinc uptake by cane plant (0.89 kg/ha) over control treatment (0.73 kg/ha) at harvest. Therefore, it is inferred that the increase in the cane growth, yield and yield attributes, soil available zinc as well as its uptake by cane plant with basal application of encapsulated 25 kg zinc sulphate may be due to restriction of Zn fixation as calcium zincate. As such this can be reckoned as best package of practice for zinc nutrition of sugarcane crop in calcareous soil.

Keywords: Zinc, Encapsulation, Sugarcane, Press mud cake, Mineralization

Zinc as an essential micronutrient plays a major role in the plant metabolic pathways helps in proper crop growth. It is an indispensible micronutrient needed for activation of several enzymes as co-factor, protection of bio-membrane and proper function of plant hormones such as Indole Acetic Acid (IAA) and Gibberellins. Zinc deficiency may alter metabolism of phosphorus, nitrogen, carbohydrates and nucleic acids. This intern cause toxicity of other elements like Fe and decreases the crop productivity. The available zinc content in the Indian soil varies from 0.08 to 20.5 ppm with nearly 47% soils under deficiency level. The available Zn in soils of UP ranges from 0.08 to 9.76 ppm and 45% soils showing its deficiency. However, the situation is alarming in calcareous tract of UP and Bihar where about 75% of soils have been found deficient in zinc content (Zaidi *et al*. 1997; Singh *et al*. 1998). Low availability of zinc in calcareous soils has been attributed primarily to the high level of calcium carbonate and alkaline soil pH which favors the formation of insoluble calcium zincate compound. Additionally, calcium carbonate acts as strong adsorbent of metals including zinc.

Soil application of zinc sulphate for sugarcane and other crops in rotation mitigates this problem to some extent as only 5-10% of the applied zinc is utilized by the plant leaving behind 90-95% unused or fixed causing ambient monitory loss. Mixing Zn with organic manures might restrict its fixation with calcium carbonate in calcareous soil and elevate accessible zinc for longer time span and thus increase zinc –use –efficiency in sugarcane based cropping systems. The application of zinc enriched organics has been well documented to improve the soil nutrient status, availability of zinc and crop yield (Senthil Kumar *et al*. 2004). Thus, it was thought plausible to undertake this investigation with an objective to evaluate the efficiency of Zn enriched farm yard manure (FYM) and press mud cake (PMC) on mineralization of soil zinc and its availability to sugarcane crop in calcareous soil of eastern UP.

MATERIALS AND METHODS

A field experiment was conducted at the experimental farm of GSSBRI, Seorahi in randomized block design (factorial) with four replications with autumn planted sugarcane (variety 'CoSe 01424') in October for three consecutive years, 2007-2011. Treatment combinations consisted of three levels of zinc sulphate viz. 0.0,12.5 and 25.0 kg/ha with 500 kg/ha each of farm yard manure (FYM) and press mud cake (PMC) and two levels of phosphorus and potassium viz. 0.0 kg/ha and 80.0 + 60.0 kg K/ha. Analytical results revealed that press mud cake and farm yard manure had N- 1.39%, P- 2.05%, K- 1.53% , Zn- 375 ppm and N- 0.56%, P- 0.41%, K- 1.02% , Zn- 179 ppm, respectively. All 12 treatments were formulated by mixing the components. The mixed formulation were covered in polythene bags and kept for 15 days at 60% moisture regime to allow trapping of zinc ions adequately into FYM or PMC. Entire doses of enriched organics were applied basal along with 1/3rd N (Entire dose of N-180 kg/ha) in furrows during

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cane planting. The remaining 2/3rd N was top dressed in two equal doses. The crop was raised as per recommended agronomic practices and harvested at maturity (November i.e. 13 months crop age).

Experimental soils exhibited alkaline reaction with pH- 8.35 to 8.72, EC- 0.08 to 0.21 ds/m, calcium carbonate 22.5-28.4%, organic carbon 0.40-0.43% (low), available P- 8.25 to 8.61 ppm (low), available K- 50.35 to 54.33 ppm (medium) and available zinc- 0.54 to 0.61 ppm (low). Soil samples up to 9 inches depth were collected at grand growth stage and harvesting time for determining available zinc. Plant samples were taken at harvesting time for zinc uptake. Zinc content in soil and plant was determined by atomic absorption spectrophotometry (Tandon 1993). Observations on shoot population (210 DAP), no of millable canes (360 DAP), yield and juice quality (harvesting) were recorded through standard procedures.

RESULTS AND DISCUSSION

The data for individual year as well as mean values over the years on shoot population, millable canes (NMC), yield, juice quality and commercial cane sugar (CCS) have been presented in the Tables 1 & 2 while data on soil available zinc soil and zinc uptake are given in Table 3.

Table 1 Effect of Zinc enriched organics on sugarcane crop in calcareous

Treatments	Shoot population (000/ha)				Millable canes (000/ha)				Yield (t/ha)			
	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean
Level of zinc sulphate (kg/ha)												
0 .0 kg	189.83	192.54	217.43	199.93	121.32	125.17	121.60	122.69	70.65	75.10	69.84	71.86
12.5 kg	194.50	199.67	228.98	207.71	127.03	129.78	124.84	127.21	73.51	77.87	72.91	74.76
25 .0 kg	199.69	205.57	235.57	213.61	130.90	132.79	129.03	130.90	76.01	79.79	73.77	76.52
Organics (500kg/ha)												
PMC	192.37	196.89	224.49	204.58	125.76	128.09	125.13	126.32	72.73	76.85	71.69	73.75
FYM	193.41	201.63	230.24	208.42	127.07	130.54	125.19	127.60	74.03	78.32	72.65	75.00
Level of P+K(kg/ha)												
0. 0	183.66	187.98	216.98	196.20	124.72	122.30	121.45	122.82	70.31	73.37	70.67	71.45
80P+60K	205.55	210.54	237.67	217.92	128.12	136.33	128.86	131.10	76.47	81.80	73.68	77.31
SEm ± and CD at 5%												
For Zn	8.61	3.00	6.37		3.61	5.46	3.50		0.40	1.28	0.11	
	NS	**6.22**	**13.22**		**7.49**	**NS**	**NS**		**NS**	**2.66**	**0.23**	
For Org.	7.03	2.44	5.20		2.94	4.46	2.86		0.33	1.04	0.09	
	NS	**NS**	**NS**		**NS**	**NS**	**NS**		**NS**	**NS**	**NS**	
For P+K.	7.03	2.44	5.20		2.94	4.46	2.86		0.33	1.04	0.09	
	14.35	**5.07**	**10.79**		**NS**	**9.28**	**5.93**		**0.68**	**2.18**	**0.19**	

Table 2 Effect of Zinc enriched organics on sugarcane quality indices in calcareous soil

Treatments	Sucrose %				Purity coefficient				CCS (t/ha)			
	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean
Level of zinc sulphate (kg/ha)												
0 .0 kg	16.05	16.24	16.59	16.29	88.06	87.92	87.10	87.69	7.79	8.51	8.03	8.11
12.5 kg	16.35	16.35	16.55	16.41	88.01	88.11	87.43	87.85	8.29	9.03	8.50	8.60
25 .0 kg	16.62	16.42	17.06	16.70	87.38	88.24	87.46	87.69	8.77	9.18	8.69	8.88
Organics (5000kg/ha)												
PMC	16.27	16.32	16.68	16.42	87.47	88.02	87.27	87.58	8.16	8.71	8.43	8.43
FYM	16.41	16.36	16.46	16.41	88.21	88.16	87.39	87.92	8.40	9.10	8.39	8.63
Level of P+K (kg/ha)												
0. 0	16.26	16.25	16.54	16.35	87.76	88.11	87.28	87.71	7.88	8.36	8.37	8.20
80P+60K	16.42	16.38	16.59	16.46	87.92	88.07	87.38	87.79	8.68	9.46	8.44	8.86
SE m ± and CD at 5%												
For Zn	0.22	0.24	0.16		0.34	0.41	0.35					
	0.46	**NS**	**NS**		**NS**	**NS**	**NS**					
For Org.	0.18	0.20	0.13		0.28	0.33	0.29					
	NS	**NS**	**NS**		**NS**	**NS**	**NS**					
For P+K.	0.18	0.20	0.13		0.28	0.33	0.29					
	NS	**NS**	**NS**		**0.58**	**NS**	**NS**					

Table 3 Mineralization of Zinc in soil through enriched organics and its effect on soil available Zn and its uptake by sugarcane crop

Treatments	Soil available Zn (Grand growth Phase) ppm				Soil available Zn (Harvesting stage) ppm				Zinc uptake (kg/ha)			
	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean	2007-09	2008-10	2009-11	Mean
Levelof Zinc sulphate (kg/ha)												
0 .0 kg	0.56	0.67	0.61	0.61	0.49	0.52	0.50	0.50	0.75	0.70	0.74	0.73
12.5 kg	0.64	0.74	0.67	0.68	0.58	0.59	0.57	0.58	0.86	0.82	0.81	0.83
25 .0 kg	0.73	0.81	0.75	0.76	0.62	0.65	0.60	0.62	0.96	0.88	0.84	0.89
Organics (500kg/ha)												
PMC	0.64	0.74	0.65	0.67	0.56	0.57	0.51	0.54	0.84	0.79	0.77	0.80
FYM	0.65	0.75	0.69	0.69	0.57	0.59	0.57	0.57	0.87	0.82	0.82	0.83
Level of P+K (kg/ha)												
0. 0	0.64	0.73	0.66	0.67	0.56	0.58	0.55	0.56	0.83	0.76	0.76	0.78
80P+60K	0.65	0.75	0.69	0.69	0.58	0.59	0.56	0.57	0.88	0.84	0.83	0.85

The findings revealed that basal application of Zn enriched PMC or farm yard manure with 25 kg zinc sulphate produced shoot population (213.61 thousands/ha), number of millable canes (130.90 thousand/ha), cane yield (76.52 t/ha) and commercial cane sugar (8.88 t/ha) than control treatment. The data were significant during 2008-10, 2009-11 for shoot population, 2007-09 for NMC and 2008-10 & 2009-11 for yield (Table 1 & 2). Juice quality was not altered significantly due to different Zn levels, organics or dose of encapsulated P, K application (Table 2). The beneficial effect of Zn enriched organics may be attributed to the production of chelating agent forming soluble complexes with Zn which are efficiently utilized by the plants and enhance diffusion and mass flow of Zinc (Prasad *et al.* 1976).

Farmyard manure (FYM) and press mud cake (PMC) were almost equally effective in elevating growth, yield and cane quality characters (Table 1 & 2) suggested that either of these two may be utilized for zinc encapsulation purpose in calcareous soil. On the other hand, mixing of 80 kg P+ 60 kg K/ha with both the organics significantly elevated shoot population (217.92 thousands/ha), number of millable canes (131.1 thousands/ha) and yield (77.31 t/ha) with no remarkable change in juice quality over without P+K mixing. It inferred that encapsulation of P+K in organics restricts its direct contact with soil having high calcium carbonate and hence their elevated availability continues for longer duration in soil for plant uptake and its growth (Sharma *et al*., 2009).

Basal application of encapsulated 25 kg zinc sulphate/ha with organics increased soil available zinc at grand growth phase and also at harvesting stage though with low magnitude. However, the effect of FYM or PMC and P+K on available soil Zn content was not noted to be tangible (Table 3). Plant uptake of zinc also followed the similar trend and 25 kg /ha zinc sulphate encapsulation exhibited the highest zinc uptake over other treatments. Thus, increase in the soil available zinc at different crop stages and its uptake by cane plant due to application of encapsulated 25 kg zinc sulphate/ha might be attributed to the restriction in fixation of Zn as calcium zincate in calcareous soil on one hand, slow mineralization of Zn vis-à-vis presence of Zn in chelated form with biomolecules released by FYM or PMC for longer time span on the other hand. Therefore, the results clearly exhibited the beneficial effect of Zn encapsulation and can be reckoned as a best package of practice for zinc nutrition of sugarcane in calcareous soil.

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