GAU Research Journal **44** (2) : 53-58 (April 2019)

Effect of zinc enriched organics on growth, yield and quality of pearl millet [*Pennisetum glaucum* L.] in loamy sand

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Received: 24 September, 2018 Accepted: 20 March, 2019

ABSTRACT

The present investigation was carried out to study the comparative efficacy of different Zn-enriched organics on the yield of pearl millet (var. GHB 744). The enrichment of different organics was carried with Zn by composting the locally available organics *viz.,* farm yard manure (FYM), poultry manure (PM), vermicompost (VC) and biogas slurry (BGS) for six to seven weeks as required to complete the enrichment process. The zinc was added @ 2.5 and 5.0 kg ha^{-1} through enrichment of 500 kg of organics. The enriched organics were used for field experiment on the pre-identified Zn deficient site. The results revealed that an application of 100% RDNP along with 500 kg PM enriched with 5.0 kg Zn ha^{-1} (T_{12}) significantly improved growth and yield attributes such as plant height, 1000-seed weight, number of tillers plant^{-1} and length of ear head, being at par with T_{11}, T_{10}, T_9, T_{14}, T_{13}, T_5, T_8 and T_7 in case of plant height, whereas in case of 1000-seed weight it was at par with treatment T_{11}, T_{10}, T_5 T_9 and T_{14}, same way in case of number of tillers plant^{-1} it was at par with T_{11}, T_{10} T_9, T_5 and $T_{14,}$ and in case of length of ear head it was at par with T_{11}, T_{10} and T_9. Significantly the highest seed (4517 kg ha^{-1}) and straw (9259 kg ha^{-1}) yields were recorded under the treatment of 100% RDNP with 500 kg PM enriched with 5.0 kg Zn ha^{-1} (T_{12}) over rest of the treatments except the treatments T_{11}, T_{10} and T_9 and T_7, T_8 T_9, T_{10}, T_{11}, T_{13}, and T_{14} in seed and straw, respectively.

Key words: Enriched organics, farm yard manure, poultry manure, vermicompost and biogas slurry

Zinc being one of the essential micronutrients, plays significant role in various enzymatic and physiological activities of the plant system. It is also essential for photosynthesis and N-metabolism. It is important for stability of cytoplasmic ribosomes, cell division, dehydrogenages, proteinase and peptidage enzymes and also helps in the synthesis of protein and carotene.

Crops utilize very low amounts of fertilizer-Zn but very high doses of fertilizer Zn are often applied to correct Zn deficiencies in crops due to a high fixation of applied Zn in the soil. Fertilizer-Zn use efficiency is hardly 1 to 5 per cent. The integrated use of micronutrients in combination with organic manures (8-10 t ha^{-1}) serves as a better option due to high chelation and slow availability which prevent micronutrient losses through precipitation, fixation, oxidation and leaching. The reports in literature indicated that the availability of micronutrients in soil can be enhanced when applied together with organics (Bhoyar *et al.* 1998). Organic matter is an important soil constituent influencing a number of constraints linked with crop productivity. Based on these facts, zinc can be utilized for increasing crop yield by enriching organics.

Organics may serve as a source of micronutrients and complexing agent. On decomposition of organics numerous

compounds like humic acid, fulvic acids and various biological substances including organic acids, polyphenols, amino acid produce, which improve the efficiency of applied nutrients. The information on utilization of Zn enriched organics in different crops are rare and scare , especially in pearl millet crop is practiced in North Gujarat region, where Zn deficiency is widely found.

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MATERIAL AND METHODS

Enrichment of organics with zinc sulphate:

The enrichment process was started 60 days before their use in the summer experiment on pearl millet. The known quantity of organics was filled in pre-dung pits of 1.5×1.5×1.5 m^3 size. The organics were thoroughly mixed with the solution of $ZnSO_4$.$7H_2O$ having required concentration as per the enrichment treatments viz., 2.5 and 5.0 kg Zn through 500 kg of organics per hectare.

Treatment details:

Symbol	Treatments
T_1	100% RDNP + 500 kg FYM ha^{-1}
T_2	T_1 + 2.5 kg Zn ha^{-1}
T_3	T_1 + 5.0 kg Zn ha^{-1}
T_4	100% RDNP +500 kg VC ha^{-1}
T_5	100% RDNP +500 kg PM ha^{-1}
T_6	100% RDNP +500 kg BGS ha^{-1}
T_7	100% RDNP + 2.5 kg Zn-enriched FYM @ 500 kg ha^{-1}
T_8	100% RDNP + 5.0 kg Zn-enriched FYM @ 500 kg ha^{-1}
T_9	100% RDNP + 2.5 kg Zn-enriched VC @ 500 kg ha^{-1}
T_{10}	100% RDNP + 5.0 kg Zn-enriched VC @ 500 kg ha^{-1}
T_{11}	100% RDNP + 2.5 kg Zn-enriched PM @ 500 kg ha^{-1}
T_{12}	100% RDNP + 5.0 kg Zn-enriched PM @ 500 kg ha^{-1}
T_{13}	100% RDNP + 2.5 kg Zn-enriched BGS @ 500 kg ha^{-1}
T_{14}	100% RDNP + 5.0 kg Zn-enriched BGS @ 500 kg ha^{-1}

100% RDNP = 120 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}

The moisture percentage of organics after mixing with $ZnSO_4$. $7H_2O$ (except BGS) was kept at about 70 to 80 per cent. The starter inoculums of microorganisms in the form of cow dung slurry @ 1% was applied to boost up the microbiological activities for enhancement of natural process of composting to fix the externally added inorganic Zn into organically bound and naturally chelated form of Zn, a process called as enrichment of organics with Zn. The initial samples were collected and they were subjected to analysis to know the initial status of nutrient in different organics immediately before mixing with $ZnSO_4$.$7H_2O$ solution. The pit was covered by polythene sheet and allowed for decomposition. The mixture was turned over periodically (weekly) and moisture loss was maintained.

Physico-chemical properties of soil:

The soil of experimental plot was categorised as loamy sand in texture. The soil was low in organic carbon, available nitrogen; medium in available phosphorus and potash. (Table 1).

Table 1 Initial Physico-chemical properties of the surface soil (0-15 cm) of the experimental plot

Sr. No.	Properties	Value	Properties	Value
	Physical properties		Chemical properties	
1.	Coarse sand (%)	46.50	Soil pH (1:2.5)	7.58
2.	Fine sand (%)	40.25	EC (1:2.5) dS/m at 25°C	0.11
3.	Silt (%)	07.35	Organic carbon (%)	0.19
4.	Clay (%)	05.90	Available N(kg/ha)	165.00
5	Texture class	Loamy sand	Available P_2O_5(kg/ha)	42.60
6.	Taxonomy	*Typic Ustipsamments*	Available K_2O (kg/ha)	272.50
	DTPA extractable micronutrient cations (mg/kg)			
1.	Zn	0.36		
2.	Mn	11.32		
3.	Fe	3.82		
4.	Cu	0.47		

Lay out

The experiment was laid out in Randomized Block Design.

Quality parameters

Protein content

The protein content of pearl millet seed was worked out by multiplying per cent nitrogen content of seed with a factor of 6.25 as suggested by Gupta *et al.* (1972).

Protein yield (kg ha^{-1})

Protein yield was calculated by using the following formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in seed (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

RESULTS AND DISCUSSION

Growth, yield attribute and yield:

The growth and yield attributes *viz.,* plant height, number of tillers per plant, test weight and length of ear head significantly differed due to different treatments. (Table 2)

Application of 100 per cent recommended dose of fertilizer along with 500 kg poultry manure ha^{-1} enriched with 5.0 kg Zn (T_{12}) gave significantly higher growth and yield attributing character such as plant height, test weight, number of tillers per plant, test weight and length of ear head over rest of the treatments, but in case of plant height all Zn-enriched organics was found at par and superior to rest of the treatments except T_5. The higher test weight of pearl millet was found significantly superior to all treatments except T_{11}, T_{10}, T_5, T_9 and T_{14} treatments. In case of number of tillers plant^{-1} and length of ear head the highest value was recorded under treatment T_{12} it was significantly superior over rest of the treatments but it remain at par with T_{11}, T_{10} and T_9 treatments.

The magnitude of increase in plant height, test weight, number of tillers per^{-1} and length of ear had under treatment (T_{12}) over T_1 (100% RDNP + 500 kg ha^{-1} FYM) was to the tune of 16.28, 39.18, 46.47 and 30.83 per cent, respectively.

The beneficial effect of different organics enriched with Zn alone or its combination on growth and yield attributing character observed in present study could be attributed to the fact that enrichment technique caused mobilization of the native nutrient to increase their availability beside addition of Zn in naturally chelated from

which are expected to become slowly available to grow crop over a longer time to cause better crop growth and thereby higher yields reported by Meena *et al.* (2006)

This can be attributed to higher availability of zinc to meet the demand of growing plants during its growth period as the DTPA-extractable zinc of the experimental plot was deficient in available Zn (0.36 mg kg^{-1}). Better zinc nutrition of crop has helped it in better branching resulting in more growth. The increased plant growth might also be attributed to better activation of enzymes such as triphosphate, dehydrogenase, tryptophan synthetase, proteinase and peptidase *etc,* photosynthetic activity as it plays a direct role in photosynthesis as a result of zinc application to soil.

The significant increase in root and shoot weight may be associated with zinc application because zinc facilitates in synthesis of more auxin (I.I.A.) a growth hormone and tryptophan, a precursor of auxin and metabolism of auxin and in turn enhance growth through cell elongation process. Further application of zinc shows a significant increase in root density with in root volume reported by Khuje (1972).

The beneficial effect of the use of Zn-enriched organics was clearly noticed over straight Zn application as a direct effect in pearl millet crop.

Among different organics, PM proved to be superior in enhancing pearl millet yield. An application of 100 per cent recommended dose of fertilizer along with 500 kg poultry manure ha^{-1} enriched with 5.0 kg Zn (T_{12}) produced significantly highest seed yield (4517 kg ha^{-1}) and straw yield (9259 kg ha^{-1}) over rest of the treatments except treatments in seed yield are $T_{11,}$ T_{10} and T_9 and in straw treatments except are T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14}. The increase in seed and straw yield due to treatment T_{12} was to the tune of 40.41 and 20.97 per cent, respectively over T_1 (100% RDN + 500 kg ha^{-1}FYM). In the present study, the PM contained more quantity of essential nutrient compared to other organics as already mentioned in table 3.1. Further, enrichment of Zn with PM also increased the total Zn content in the organics. The results are in the lines of those reported by Rathod (2003).

Significant increase in seed and straw yield of pearl millet was obtained due to different Zn-enriched organics might be due to fact that the soil of experimental plot was deficient in available Zn (Zn 0.36 mg kg^{-1}) and its application after enrichment of different organics improved its availability in soil which might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which results better flowering and fruiting which enhanced growth and yield. The results are in the lines of those reported by Singh *et al*. (1979), Patel *et al*. (2010) and Rathod *et al.* (2012).

Table 2 Effect of different Zn-enriched organics on plant height, number of tillers $plant^{-1,}$ test weight, length of ear head, seed yield and straw yield.

Treatment No.	Plant height (cm)	No. of tillers $plant^{-1}$	1000-seeds weight (g)	Length of ear head (cm)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	148.20	7.67	8.60	17.5	3217	7654
T_2	152.97	9.00	9.07	18.3	3683	8027
T_3	156.90	9.33	9.50	18.9	3750	8127
T_4	152.13	8.67	9.00	18.2	3383	7892
T_5	163.07	10.33	10.47	20.3	3876	8179
T_6	150.30	8.33	8.97	18.1	3240	7826
T_7	160.27	10.00	10.00	20.1	3780	8240
T_8	162.67	10.33	10.17	20.4	3850	8262
T_9	168.73	12.33	10.43	21.6	4287	8928

T_{10}	169.30	12.67	10.90	22.0	4350	9039
T_{11}	170.17	13.33	11.40	23.8	4410	9149
T_{12}	172.33	14.33	11.97	25.3	4517	9259
T_{13}	164.67	10.67	10.07	20.0	3890	8774
T_{14}	165.70	11.00	10.37	21.1	3915	8818
S.Em.±	5.25	0.85	0.56	1.37	203	359
C.D. @ 5 %	15.23	2.47	1.62	3.96	589	1041
C.V. (%)	5.64	13.98	9.63	11.60	9.10	7.37

Quality of seed:

The protein content in seed and its yield significantly influenced due to different Zn-enriched organics application (Table 3).

The application of 100 per cent recommended dose of fertilizer along with 500 kg poultry manure ha^{-1} enriched with 5.0 kg Zn (T_{12}), considerably increased protein content in seed and its yield over rest of the treatments in protein content treatment except are T_{11} and T_{10} and in protein yield it was remained at par with treatment T_{11}, T_{10}, and T_9. The magnitude of increase in protein content in seed under T_{12}, T_{11} and T_{10} over T_1 was 15.52, 13.40 and 10.88 per cent, respectively. The increase in protein yield under T_{12}, T_{11}, T_{10} and T_9 over T_1 was 62.84, 56.02, 50.51and 45.19 per cent respectively.

The magnificent role of zinc in increasing the metabolic and physiological activity of the plants is of paramount importance as it influenced the nitrogen metabolism, cell division, protein synthesis and auxin concentration. Zinc also enhances the CEC of roots which in turn enhance the absorption of essential elements especially of N, which is responsible for higher protein content of pearl millet seeds. The results are in conformity with the findings of Singh *et al*. (1996), Malakouti (1998).

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