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Effect of Zinc Solubilising consortiums on growth and yield parameters of Suru sugarcane

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Abstract

A field experiment was conducted at Post Graduate Institute Farm, Plant Pathology and Agril. Microbiology, MPKV, Rahuri during Feb, 2016 to Feb-2017 (Suru plantation). The experiment was undertaken to study the effect of zinc solubalizing bacteria and zinc solubalizing fungi consortia with graded levels of zinc fertilizer on sugarcane cv. CoM-0265. The application of graded levels of $ZnSO_4$ (50, 75 and 100 per cent of recommended dose) in combination with bacterial consortium, fungal consortium, combination of both and commercial formulation was carried out as per the treatments. In the present study, the fungal consortium + 75 % $ZnSO_4$ treatment showed higher growth and yield parameters among the other treatments followed by bacterial consortium + 75% $ZnSO_4$ treatment. Thus, it can be informed that, the highest solubilising potential of ZSF consortium could be used as carrier based bio-formulation and ZSB consortium as liquid bio-formulation. These findings clearly indicated that 25% savings of the Zinc fertilizers to sugarcane crop could be achieved.

Keywords: Zinc solubilising bacteria, Zinc solubilising fungi, Sugarcane and Yield

1. Introduction

Sugarcane is one of the most important cash crop influencing the economy of state as well as country. The area under Sugarcane during 2017-2018 in India was 5.00 lakh hectare with average productivity 68 t ha^{-1}. Whereas the corresponding figures of Maharashtra was 0.92 m ha with average production 103.10 t ha^{-1} (Anonymous, 2018). However, the productivity in Maharashtra is continuously decreasing. The major factor responsible for decline of productivity is variation in soil health with deficient in micronutrients. Soil health relies on a balance of macronutrients and micronutrients. The increased use of NPK fertilizers by farmers and avoid of micronutrients creates problem of micronutrient deficiencies, of which Zn deficiency is the most predominant. Micronutrient, Zn plays a vital role. Zn is an important component of enzymes that drive and increase the rate of many important metabolic reactions, N_2 metabolism, uptake of N_2, protein quality, photosynthesis and chlorophyll synthesis (Potarzycki and Grzebisz, 2009). Zn deficiencies are most commonly corrected by application of the Zn fertilizer. Several different Zn compounds are used as fertilizers in which $ZnSO_4$ is the most common. Supplementation of Zn in the form of fertilizers like $ZnSO_4$ also remains vain because only 1-4 per cent is utilized by the crop and 75 per cent of applied Zn is transformed into other mineral fractions which is not available. Thus correction of Zn deficiency *via* fertilization is not always successful due to agronomic and economic factors. This requires a system that releases the required quantity of Zn that are converted to unavailable state and retained in the soil to available form. This effect has been due to the involvement of organisms in the solubilization of unavailable mineral nutrients (Cunningham and Kuiack, 1992). Zinc solubilizing potential of few microbial genera such as *Bacillus sp*, *Pseudomonas sp* and *Aspergillus sp* were explored by researchers recently (Saravanan *et al.*, 2003). Thus microbial inoculants will be an alternative approach to overcome constraints due to synthetic fertilizer, and to revive soil's fertility resulting in the intensive farming.

Recently bacterial based approach was devised to solve these micronutrient deficiency problems (Anthoni Raj, 2002). Zn plays a predominant role in the solubilization, transport and deposition of metals and minerals in the environment. The secretion of organic acids appears to be the functional metal resistance mechanism that chelates the metal ions extracellularly (Li *et al.*, 2007). This metal solubilization was due to the production of organic acids and pH drop by organisms (Alexander, 1997). The rhizospheric microorganisms play a pivotal role in the enhancement of crop production by the solubilization of unavailable form of metal into available form. A number of organic acids such as acetic, citric, lactic, propionic, glycolic, oxalic, gluconic acid etc have been considered due to its effect in pH lowering by microorganisms (Cunnigham and Kuiack, 1992). Very little information is available on zinc solubilization by bacteria, their mechanisms of solubilization and their effect on growth and yield of sugarcane crops. Therefore, the present investigation was undertaken to study the effect of Zn solubilising bacteria and fungi on growth and yield attributes of sugarcane.

2. Materials and Methods

A total of 191 rhizosphere soil samples upto 10-20 cm depth of sugarcane and sugarcane setts was collected from selected 10 district places of Western Maharashtra *viz*., Ahmednagar, Nasik, Pune, Satara, Sangli, Solapur, Kolhapur, Nandurbar, Dhule, and Jalgaon, so as to isolate the beneficial zinc solubilizing microorganisms (ZSM). The serial dilutions were made from 10^{-1} to 10^{-5}. One ml aliquot of dilutions from 10^{-3} to 10^{-5} was transferred aseptically to presterilize Petri plates separately.

The primary screening of bacterial and fungal isolates of Zinc solubilization assay for *Bacillus* and *Psudomonas* was done by taking the modified Pikovskaya's medium. The halo zone around the colony was measured and considered as zinc solubilizing bacteria (Ghevariya and Desai, 2014). The obtained efficient Zinc solubilizing bacteria were formulated for their mass production as a liquid consortium by comparing the selective media of these isolates and appropriate M_3 medium was designed. The M_3 medium was again formulated and efficient L_1M_3 used for bacterial consortia. The most efficient two fungal isolates were multiplied on potato dextrose broth culture and mix with talcum powder.

A field experiment was laid out in clayey soil during Feb, 2016 to Feb-2017 (*Suru* sugarcane, cv. CoM-0265) at PGI Farm of Plant Pathology and Agril. Microbiology, MPKV, Rahuri. The double eye bud setts of sugarcane were planted by ridges and furrows of 6 x 5 m at 10 to 15 cm apart. The recommended dose of fertiliser was applied as 250:115:115 kg/ha as N:P:K respectively. Zinc sulphate @ 20 kg/ha was applied into three levels *viz.*, 50, 75 and 100 per cent per hectare as per treatments. Four split doses of N *viz.*, 10 per cent at planting, 40 per cent at 6-8 weeks after planting, 10 per cent at 12-16 weeks after planting and 40 per cent at earthing up stage were applied. A randomized block design (RBD) having thirteen treatments which were replicated three times as given below.

Treatments

T_1 : Recommended dose of fertilizer (RDF)
T_2 : Bacterial (Zinc solubilizing bacteria) consortium + 50 % $ZnSO_4$
T_3 : Bacterial (Zinc solubilizing bacteria) consortium + 75 % $ZnSO_4$
T_4 : Bacterial (Zinc solubilizing bacteria) consortium + 100 % $ZnSO_4$
T_5 : Fungal (Zinc solubilizing fungi) consortium + 50 % $ZnSO_4$.
T_6 : Fungal (Zinc solubilizing fungi) consortium + 75 % $ZnSO_4$.
T_7 : Fungal (Zinc solubilizing fungi) consortium + 100 % $ZnSO_4$.
T_8 : Bacterial (Zinc solubilizing bacteria) consortium+ Fungal (Zinc solubilizing fungi) consortium + 50 % $ZnSO_4$
T_9 : Bacterial (Zinc solubilizing bacteria) consortium+ Fungal (Zinc solubilizing fungi) consortium + 75 % $ZnSO_4$.

T_{10}: Bacterial (Zinc solubilizing bacteria) consortium+ Fungal (Zinc solubilizing fungi) consortium + 100 % $ZnSO_4$.
T_{11} : Commercial formulation + 50 % $ZnSO_4$
T_{12} : Commercial formulation + 75 % $ZnSO_4$
T_{13} : Commercial formulation + 100 % $ZnSO_4$.

Note: RDF was common to T_2 to T_{13}

Five plants randomly selected from each plot were used for field observations. The crop was harvested at appropriate maturity stage. The plant growth attributes *viz.*, plant height, number of leaves and leaf area at earthing up and harvest was recorded. The yield and yield attributes viz; number of intermodal characteristics and yield at harvesting were recorded. All the canes from treatment plot were harvested separately and detrashed. The yield of canes was recorded per plot on electronic platform balance.

3. Results

The significant differences were observed between various treatments by applications of consortium under graded levels of Zinc sulphate on all the growth attributing parameters, yield and juice quality parameter of sugarcane crop.

Growth attributes: The data pertaining to plant height, number of leaves per plant and leaf area presented in Table 1

Table 1:Growth parameters of sugarcane at earthing-up and harvest as influenced by various treatment

Treatments	Plant height (cm)		Number of leaves		Leaf area (dm^2)	
	Earthing-up	Harvest	Earthing-up	Harvest	Earthing-up	Harvest
T_1	164.68	370.53	6.33	5.33	29.85	82.94
T_2	178.42	388.33	7.00	6.00	33.69	88.28
T_3	220.61	417.43	8.67	7.67	44.09	96.12
T_4	195.98	412.10	7.33	6.67	39.43	91.14
T_5	184.37	396.43	8.00	6.00	35.66	90.22
T_6	228.18	427.33	9.67	7.67	44.50	96.77
T_7	217.74	413.93	7.67	7.00	42.70	94.35
T_8	153.94	342.37	5.67	5.00	22.36	75.17
T_9	158.46	350.17	6.00	5.00	27.87	81.31
T_{10}	171.48	372.67	6.67	5.67	33.34	87.12
T_{11}	160.52	360.73	6.00	5.33	29.07	82.19
T_{12}	168.79	372.23	6.67	5.67	31.31	85.09
T_{13}	191.67	405.00	8.67	6.33	35.90	90.25
S.Em. $\pm$	2.83	4.72	0.38	0.35	1.65	3.41
CD at 5%	8.25	13.79	1.11	1.01	4.80	9.94
General mean	184.22	386.87	7.26	6.10	34.60	87.77

1. **Plant Height:** The increasing trend was observed in plant height from earthing up stage to harvesting stage. The application of treatment T_6 viz., ZSF consortium + 75 % $ZnSO_4$ recorded the maximum plant height (228.18 cm) and (427.33 cm) at earthing up and harvest, respectively. Whereas the application treatment T_3 ZSB consortium + 75 % $ZnSO_4$ (220.61 and 417.43 cm at earthing-up and harvest, respectively) was at par with each oher. However, the another treatment T_7 (413.9 cm), T_4 (412.10 cm), T_{13} (405.00 cm) whic was found at par with T_6 at harvesting stage.

2 . Number of leaves: The highest number of leaves per plant were recorded in treatment T_6 at earthing up (9.67 leaves per plant) and at harvest stage (7.67 leaves per plant) and it was at par with T_3 and T_{13} (8.67 leaves per plant) at earthing up stage but whereas the treatment T_3 (7.67 leaves per plant), T_4 (6.67 leaves per plant) and T_7 (7.00 per plant) was at par with T_6 treatment at harvesting stage.

3. Leaf area: The maximum leaf area reported in treatment T_6 at earthing up and harvest and it was increased from 44.50 to 96.77 d m^2. However; the treatment T_3 (44.09 dm^2) and T_7 (42.70 dm^2) at earthing up stage was at par with T_6 (44.50 dm^2). At harvest it was at par with T_3 (96.12 dm^2) T_7 (94.35 dm^2), T_4 (91.14 dm^2), T_5 (90.22 dm^2), T_2 (88.28 dm^2) and T_{13} (90.25 dm^2). The lowest leaf area was observed in treatment T_8 treatment at both the observed stages of sugarcane plant.

Yield Contributing Parameters

1. Internodal characters of cane^{-1}: The application of treatment T_6 viz., ZSF consortium + 75% $ZnSO_4$ recorded the highest number of millable cane internode (30.67), girth (15.33 cm) and length (16.40 cm). However the treatment T_3 *viz.*, ZSB consortium + 75 % $ZnSO_4$, (T_7) and (T_4) was at par in relation to number of millable cane internode and girth.

Table 2: Cane yield and yield parameters of sugarcane at harvest as influenced by various treatment

Treatments	Yield (t/ha)	Internodes		
		Number	Girth (cm)	Length (cm)
T_1	122.19	27.33	13.47	13.63
T_2	131.14	28.00	13.73	14.00
T_3	160.86	30.33	14.90	16.10
T_4	152.41	29.00	14.80	15.50
T_5	144.79	28.00	13.67	14.07
T_6	171.29	30.67	15.33	16.40
T_7	153.92	29.67	14.87	15.93
T_8	89.59	23.67	11.23	13.23
T_9	98.15	26.00	12.87	13.23
T_{10}	124.99	27.67	13.60	13.93
T_{11}	119.99	27.00	13.20	13.57
T_{12}	124.33	27.67	13.50	13.67
T_{13}	149.33	28.33	14.27	14.37
S.Em. $\pm$	6.83	0.80	0.56	0.65
CD at 5 %	19.95	2.33	1.63	1.90
General mean	134.08	27.95	13.82	14.43

Yield: It was observed that the crop had significantly resulted in obtaining additional yield due to the application of ZSB consortium and ZSF consortium. The application of ZSF consortium + 75 % $ZnSO_4$ recorded the highest yield (171.29 t/ha) which was at par by the treatment of ZSB consortium + 75 % $ZnSO_4$ (160.86 t/ha). The yield of both the treatments was highest but their consortium organisms were different. The consortium containing fungal organism recorded highest crop yield. i.e 171.29 t/ha and consortium containing bacterial organism recorded highest crop yield. i.e 160.86 t/ha. Though both consortiums recorded highest crop yield their delivery to Sugarcane stem is different. One formulation was applied through talc carrier i.e. it was fungal consortium, whereas another formulation i.e. bacterial consortium was applied through drip irrigation. There was only 0.93 per cent difference in yield between the treatment T_6 and T_3. The yield of both the treatments were highest as compared with the application of commercial formulation and RDF (T_1).

4. Discussion

In all, the treatment T_6 showed maximum number of observed growth parameters. In most cases T_3 was at par with the treatment T_6. The increasing trend was observed in plant height from earthing up stage to harvesting stage. The application of ZSF consortium + 75% $ZnSO_4$ recorded the maximum plant height at earthing up and harvesting stage respectively. It may due to the several strains of bacteria like *Bacillus subtilis* and *Pseudomonas fluorescens* which are well known to synthesize phytohormones such as indole acetic acid, gibberellins, cytokinins and zeatin which promote plant growth at various stages (Salamone *et al.* 2001), but a very few fungi can promote growth. Evidences exists which indicate that some *Aspergillus niger* isolates also produce IAA and other phytohormones (Mostafa and Youssef, 1962) which significantly increased the growth. Pandey *et al.* (2014) revealed that, the leaf area, dry weight, chlorophyll content and number of leaves increased with the increase in plant age in VAM + *Pseudomonas* inoculated Ocimum plants.

As the all growth parameters were at highest peak in T_6 treatment and at par with T_3 treatment, The yield and yield parameters also showed same trend due to the increase in physiological processes in sugarcane crop. There was only 0.93 per cent difference in yield between the treatment T_6 and T_3. Amalraj *et al.* (2012) indicated superior plant growth and photosynthetic activities in treatment with *B. megaterium* var. phosphaticum + 75 % of recommended chemical fertilizer dose as compared to treatment with 100 % chemical fertilizers.

5. Conclusion

From the above results it is concluded that, the consortium of efficient strain of Zinc solubilizers promote the plant growth and yield which could reduce Zinc sulphate application by 25 % without any significant reduction of yield

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