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Role of zinc, silicate solubiliser and potash mobiliser for improvement in soil fertility and yield of paddy in the high rainfall zone

S Suresh and J Sivakamipriya

Abstract
Field experiments were conducted during kharif and rabi seasons of 2016-2017 and 2017-18 in clay soil of Agricultural Research Station, Thirupathisaram in high rain fall zone of Tamil Nadu to study the role of zinc solubilizing bacteria (ZSB), silicate solubilizing bacteria (SSB) and Potash solubilizing bacteria (PSB) for improvement in soil fertility and yield of paddy [var. ASD 16 (kharif) and TPS 5 (Rabi)] by taking the treatment combinations with $ZnSO_4$, rice husk ask (RHA) at fixed recommended fertilizer scheduled. The experimental soil had pH 7.40, EC 0.16 dS m^{-1}, organic carbon 0.44%, available silica 44 mg kg^{-1}, available N 205 kg ha^{-1}, available P 9.0 kg ha^{-1} and available K 180 kg ha^{-1}. The result showed that the application of the recommended NPK + $ZnSO_4$ @ 25 $kgha^{-1}$ + RHA @ 2 tha^{-1} recorded the highest number of productive tillers m^{-2} with the mean value of 266 & 330 for the kharif and rabi seasons respectively. The above treatment also recorded the highest mean grain and straw yields during both the seasons (6.52 & 9.1 t/ha; 6.62 & 9.22 t/ha for the kharif & Rabi seasons respectively). The grain yield was 31.7 & 26.3% higher than application of Rec. NPK. The highest uptake of N, K, Zn, and silicon was observed in the above treatment. The application of microbial consortium II along with recommended N, P & K showed the highest soil available P than the other treatment combinations. The result showed that the application of RHA @ 2 tha^{-1} along with recommended NPK proved to be superior for the clay soil of high rain fall zone for higher productivity in rice ecosystem. The B:C ratio was 2.28 & 2.40 during the kharif season and 2.12, 2.24 & 2.35 during the rabi season respectively during the different years studied. The residual soil showed marginal increase in the available silicon.

Keywords: Role of zinc, silicate solubiliser, potash mobiliser, soil fertility, yield, paddy

Introduction
In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated application of alternate sources of nutrients for sustaining the desired crop productivity. (Pattanayak *et al.* 2007) [14]. Biofertilizers are low-cost and eco-friendly input have tremendous potential for supplying nutrients which can reduce the chemical fertilizer dose by 25-50% (Vance, 1997) [12]. For increased supply of nutrients through bio-fertilizers, there is a need for improving the efficiency of the biological system. Hence there is a need to inoculate the soil with effective strains of micro-organisms and thereby improving nutritional environment of the soil. These include nitrogen, phosphorus, potassium and micronutrients. (Pattanayak *et al.* 2000) [15]. Rice is prone to various stresses, if the available soil silicon is low for absorption. Adequate supply of silicon to rice from tillering to elongation stage increased the rice productivity (Kumara *et al.* 2013) [16]

Rice- Rice – fallow/fallow pulse is an important cropping system followed in 12,000 hectares (both kharif and rabi season) in the high rainfall zone (Kanyakumari District) of Tamil Nadu. The soil cultivated with paddy is clayey major part (40-50%) in the region and resulted in low productivity (< 4.5 t/ha). Silicon is required for higher productivity. Nutrient management is very much essential for rice crop for maintaining higher crop productivity and soil fertility in these soils, since having the DTPA- Zn ranged from 0.8-0.9 mg kg^{-1}, which is below the critical limit for deficiency. The available silicon is 40-45 $mgkg^{-1}$ which is also found deficient. Hence an attempt has been made is the present investigation to study the effect of inorganic fertilizers, zinc, silica and bio-fertilizers consortium I (Azospirillum, Phosphobacterium and VAM) and consortium II(Zn solubilizing bacteria, silicate solubilizing bacteria, potash solubilizing bacteria, Azospirillum, Phosphobacterium and VAM) on yield, nutrients uptake and economy for the rice-rice fallow cropping sequence.

Materials and Methods

Field experiments were conducted consecutively for three years in a clay soil of high rainfall zone during both kharif and rabi seasons at Agricultural Research Station, Thirupathisaram. The experiment was conducted in a randomized block design replicated thrice. The rice variety ASD 16 (kharif) and TPS 5 (Rabi) was taken as test crop. The treatments were T1: control; T2: Recommended dose of fertilizers (RDF); T3: T2+ zinc sulphate @ 25 kg ha^{-1}; T4: T2+ Zn solubilizing bacteria (ZSB); T5: T2+ Rice Husk Ash (RHA) @ 2 t ha^{-1}; T6: T2 + Silicate Solubilizing Bacteria (SSB); T7: T3 + RHA @ 2 t ha^{-1}; T8: T3 + SSB; T9: 75% RDF + Microbial consortium I; T10: 75% RDF + Microbial consortium II

The initial soil physico-chemical properties were analysed and presented in table 1. The soil was low in DTPA-Zn (0.85 mg kg^{-1}) and available silicon (44 mg kg^{-1}). The recommended N, P and K fertilizers (125:40:40 and 150:50:50 kg ha^{-1} respectively for kharif and rabi seasons) was applied uniformly to all the treatment plots. The bio-fertilizers (microbial consortium I and II) were applied in the respective treatment plot based on the recommended package. The zinc sulphate and rice ash will be applied @ 25 kg/ha during every dry season only. Silica will be applied as rice husk ash was applied basally. The variety TPS 5 was will be raised during kharif and TPS3 during rabi season respectively. The growth and yield attributes Viz., no. of tillers m^{-2} and no. of productive tillers m^{-2} were recorded. The yield of grain and straw were recorded at harvest. The uptake of nutrients viz. N, P, K, Zn and Si were quantified at harvest. The plant sample were collected, over dried at 60 ± 5 °C for 72 hours and powdered in Wiley mill. The sample were analysed for Si, content colorimetrically after tri-acid digestion and dissolved with sodium carbonate (Nayar *et al.* 1975) [17]. The data obtained were statistically scrutinized following standard procedure.

Results and Discussion

Yield attributes and yield

The number of tiller m^{-2} varied from 204 to 316 during kharif season and from 250 to 371 during rabi season respectively. Among the treatments recommended NPK with $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1} recorded the highest number of tiller m^{-2} during both the seasons and all the years (310 to 371) with the pooled mean value of 313 and 365 respectively during kharif and rabi seasons. This was followed by the application of recommended NPK with RHA alone without $ZnSO_4$ in the kharif season, but during rabi season the application of recommended NPK with Microbial consortium II marginally excelled the above treatment of NPK with RHA application. The Zinc deficiency is more pronounced in flood irrigated soil (Rehman *et al.* 2012) [10] as the electrochemical and bio-chemical reactions are influenced and altered by pH, PCO_3 and as well as the concentration of certain ions upon submergence. The beneficial effect of Zn on tiller production in rice has also been reported by many scientists (Sarwar *et al*., 2013; Impa *et al.*, 2013) [11, 5].

The rice crop has specific ability to absorb silicon and accumulate metabolically, which influences the growth and yield of rice either directly (or) indirectly (Patil *et.al.* 2018) [7, 8]. The rice husk is an easily available organic source of silica and affordable to the farmers. In addition the application of biofertilizers enhanced the microbial population, there by the biological nitrogen fixation, availability of phosphorus, potassium, zinc and silica is enhanced as reported by John *et al.* (2019) [18].

The trend with respect to the number of productive tillers per hill was also highest with the application of recommended NPK +$ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1} during both the seasons and with varieties (Mean value of 313 and 365 nos. m^{-1}) (Table. 2). The superiority over the other treatments might be due to the increasing uptake of nutrients and translocations due to extraneous application (Vandna and Rajesh, 2018) [13].

Besides Zn, the availability of silicon is increased by the application of rice husk ash (Patil *et al.* 2018) and N, K from the applied inorganic fertilizers, thereby nutrient balance application based on deficiency resulted in development of more productive tiller in the above treatment (John *et al.* 2018) [19]

Yield of Grain and Straw

The highest grain yield (Table 2) ranging from 6.64 to 6.63 t ha^{-1} during kharif and from 6.2 to 7.00 t ha^{-1} during rabi seasons with the mean yield of 6.52 and 6.62 t ha^{-1} respectively was recorded by the application of recommended NPK with $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1}. The mean increasing yield was 31.7 percent during kharif and 26.3 percent during rabi season then the recommended NPK alone application. This might be due to the efficient utilization of all the applied nutrients including Zn and Si. This was in agreement with chardramani *et al.* (2019). This was on par with the application of recommended NPK either with RHA @ 2 t ha^{-1} (or) with microbial consortium. The highest B:C ratio of 2.12 to 2.40 was recorded with the above treatment during both the season

(Table. 5). The correlation study showed significant positive influence for the nutrients uptake and grain yield.

The highest straw yield varied from 8.90 to 9.30 t ha^{-1} with mean yield of 9.10 t ha^{-1} during kharif and from 9.05 to 9.50 t ha^{-1} during rabi season with mean yield of 9.10 and 9.92 t ha^{-1} respectively with the application of recommended NPK with $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1} (Table. 4). This was followed by the application of the recommended NPK + RHA @ t ha^{-1}. This might to due to the reasons that the soil is deficient in Si status and the application of RHA favoured the release and effective utilization of Si. The similar finding was also reported by Das *et al.* (2013) [3].

Simple correlation matrix showing the relationship of nutrient uptake and grain yield of rice.

	No. of productive tillers $hill^{-1}$	N uptake	P uptake	K uptake	Si uptake	Grain yield
No. of productive tillers $hill^{-1}$	1					
N uptake	0.81**	1				
P uptake	0.78**	0.74**	1			
K uptake	0.88**	0.76**	0.74**	1		
Si uptake	0.85**	0.81**	0.71*	0.76**	1	
Grain yield	0.91**	0.90**	0.84**	0.88**	0.78**	1

* Significant at 0.05 probability and ** significant at 0.01 probability level

Nutrient Uptake

The results indicated that the highest mean uptake of N (188 & 183 kg ha^{-1} respectively), K (148 & 149 kg ha^{-1} respectively), Zn (198 & 194 g ha^{-1} respectively) and Silicon (137 & 138 kg ha^{-1} respectively)during kharif and rabi seasons was recorded by the application of recommended N, PK + $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1}. In case of phosphorus uptake the highest mean value (23.2 and 22.9 kg ha^{-1} during kharif and rabi season respectively) was recorded with the recommended N, P, K with microbial consortium II. The trend was similar for the different seasons and during the different years. The application of balanced nutrition (N, K, Zn and Si) promoted their increased soil availability, content in plant and dry matter production. The similar finding was also reported by Aarekar *et al.* (2014) [1]. The application of microbial consortium II viz., Azophos, VAM, Potash solubilizing bacteria, Zinc solubilizing bacteria and silicate solubilizing bacteria along with recommended N, PK increased the availability and uptake of N&P, which showed on par influence with the above treatment. Apart from application of RHA, the silica availability and uptake also showed marginal increase with the application of microbial consortium II. The favourable effect of N, P and Si availability upon biofertilizer application was also reported by Peera *et al.* (2016) [9]

Table 1: Initial soil characteristics of experimental field

Physical properties			Nutrients availability		
Bulk density (Mg/m3)	:	1.17	Exch. Ca (cmol(p+)/kg)	:	34.0
Particle density (Mg/m3)	:	2.27	Exch. Mg (cmol(p+) kg^{-1})	:	14.0
Total porosity (%)	:	56.1	DTPA-Zn (mg kg^{-1})	:	0.85
Maximum water holding capacity (%)	:	47	DTPA-Cu (mg kg^{-1})	:	1.10
Texture	:	Clay	DTPA-Fe (mg kg^{-1})	:	53.5
			DTPA-Mn (mg kg^{-1})	:	7.8
			Available Si (mg kg^{-1})	:	44
Physico – chemical properties					
pH (1: 2.5)	:	7.4	Available N(kgha^{-1})	:	205
EC (dSm^{-1})	:	0.16	Available P(kg ha^{-1})	:	9.0
CEC (cmol(p+)kg^{-1})	:	50	Available K(kg ha^{-1})	:	180
Org C (%)	:	0.44			

Table 2: Effect of treatments on number of productive tillers m^{-2} of rice during different season and years

Tr. No.	Treatments	Kharif		Rabi			Kharif	Rabi
		2016-17	2017-18	2015-16	2016-17	2017-18	Pooled mean	
T_1	Control	184	179	210	220	224	182	218
T_2	Rec NPK	216	222	229	276	279	219	261
T_3	T2 + zinc sulphate @ 25 kg ha^{-1}	240	246	316	304	310	243	310
T_4	T2+ Zn solubilizing bacteria	230	234	300	308	313	232	307
T_5	T2+ Rice Husk Ash @ 2 t ha^{-1}	258	264	322	314	320	261	319
T_6	T2 + .Silicate Solubilizing Bacteria	232	236	312	288	302	234	301
T_7	T3 + Rice Husk Ash @ 2t ha^{-1}	262	269	342	320	327	266	330
T_8	T3 + Silicate Solubilizing bacteria	238	243	314	304	309	241	309
T_9	75% RDF + Microbial consortium I	212	217	286	276	281	215	281
T_{10}	75% RDF + Microbial consortium II	246	252	330	312	319	249	320
SED CD(5%)		9.55 20	8.77 18	5.373 11.0	9.9 21	9.96 21	9.16 19	7.48 16

Table 3: Effect of treatments on the grain yield (t/ha) of rice during different season and years

Tr. No.	Treatments	Kharif		Rabi			Kharif	Rabi
		2016-17	2017-18	2015-16	2016-17	2017-18	Pooled mean	
T_1	Control	4.30	4.37	3.83	3.70	3.77	4.34	3.77
T_2	Rec NPK	4.90	5.00	5.23	5.20	5.30	4.95	5.24
T_3	T2 + zinc sulphate @ 25 kg ha^{-1}	5.90	5.70	5.73	6.00	6.20	5.80	5.98
T_4	T2+ Zn solubilizing bacteria	5.70	5.50	5.40	5.75	6.03	5.60	5.73
T_5	T2+ Rice Husk Ash @ 2 t ha^{-1}	6.20	6.50	5.97	6.45	6.77	6.35	6.40
T_6	T2 + .Silicate Solubilizing Bacteria	5.70	5.80	5.47	5.90	6.10	5.75	5.82
T_7	T3 + Rice Husk Ash @ 2t ha^{-1}	6.40	6.63	6.20	6.65	7.00	6.52	6.62
T_8	T3 + Silicate Solubilizing bacteria	5.70	5.97	5.67	6.00	6.40	5.84	6.20
T_9	75% RDF + Microbial consortium I	4.80	5.07	5.17	5.15	5.40	4.94	5.28
T_{10}	75% RDF + Microbial consortium II	5.90	6.25	6.03	6.20	6.53	6.08	6.37
SED CD(5%)		0.215 0.45	0.219 0.50	0.132 0.28	0.303 0.64	0.159 0.34	0.217 0.46	0.231 0.49

Table 4: Effect of treatments on the straw yield (t/ha) of rice during different season and years

Tr. No.	Treatments	Kharif		Rabi			Kharif	Rabi
		2016-17	2017-18	2015-16	2016-17	2017-18	Pooled mean	
T_1	Control	5.80	5.90	4.87	4.80	4.93	5.85	4.87
T_2	Rec NPK	7.00	7.14	7.13	7.25	7.40	7.07	7.26
T_3	T2 + zinc sulphate @ 25 kg ha^{-1}	7.50	7.83	8.20	7.70	8.03	7.67	7.98
T_4	T2 + Zn solubilizing bacteria	8.00	8.20	7.40	8.15	8.40	8.10	7.97
T_5	T2 + Rice Husk Ash @ 2 t ha^{-1}	8.71	9.03	8.74	8.90	9.23	8.87	8.96
T_6	T2 + .Silicate Solubilizing Bacteria	7.70	7.97	7.67	7.95	8.20	7.84	7.94
T_7	T3 + Rice Husk Ash @ 2t ha^{-1}	8.90	9.30	9.05	9.10	9.50	9.10	9.22
T_8	T3 + Silicate Solubilizing bacteria	7.90	8.20	7.93	8.25	8.57	8.05	8.25
T_9	75% RDF + Microbial consortium I	6.80	7.10	6.80	7.10	7.40	6.95	7.10
T_{10}	75% RDF + Microbial consortium II	8.30	8.70	8.83	8.45	8.50	8.50	8.59
SED		0.251	0.185	0.174	0.261	0.206	0.218	0.214
CD(5%)		0.53	0.39	0.36	0.55	0.43	0.46	0.45

Table 5: Effect of treatments on the B-C ratio of rice during different seasons and years

Tr. No.	Treatments	Kharif		Rabi		
		2016-17	2017-18	2015-16	2016-17	2017-18
T_1	Control	1.81	1.80	1.71	1.60	1.62
T_2	Rec NPK	1.96	1.98	1.91	1.89	1.91
T_3	T2 + zinc sulphate @ 25 kg ha^{-1}	2.12	2.21	2.06	2.04	2.13
T_4	T2+ Zn solubilizing bacteria	2.20	2.22	1.95	2.03	2.21
T_5	T2+ Rice Husk Ash @ 2 t ha^{-1}	2.22	2.38	2.08	2.22	2.32
T_6	T2 + .Silicate Solubilizing Bacteria	2.18	2.24	1.98	2.12	2.17
T_7	T3 + Rice Husk Ash @ 2t ha^{-1}	2.28	2.40	2.12	2.24	2.35
T_8	T3 + Silicate Solubilizing bacteria	2.20	2.27	2.03	2.05	2.26
T_9	75% RDF + Microbial consortium I	1.82	1.98	1.77	1.78	2.01
T_{10}	75% RDF + Microbial consortium II	2.21	2.37	2.07	2.09	2.30

Conclusion

The growth and yield attributes viz., number of tillers per hill, number of productive tillers per hill, grain and straw yield of rice cultivated in clay soil of high rainfall zone was increased by the application of recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1}. The application of recommended NPK + RHA @ 2 t ha^{-1} without zinc sulphate was found to be the next best. In case of nutrient availability and uptake the same trend was obtained with the application of recommended NPK+ $ZnSO_4$ @ 25 kg ha^{-1} +RHA @ 2 t ha^{-1}. The application of recommended NPK + microbial consortium performed next best. From the above experiments the application of recommended NPK + $ZnSO_4$ @ 25 kg ha^{-1} + RHA @ 2 t ha^{-1} was found to be the superior treatment in improving the yield and yield attributes of rice. It is the best alternative and economical treatment for getting higher yield in the clay soil of high rainfall zone.

References

1. Aarekar SA, Pawer RB, Kulkarni RV, Pharande AL. Effect of silicon on yield and nutrient uptake by paddy plant and soil properties. J Agri. Res. Tech. 2014;39(2):328-331.
2. Chandramani P, Rajendran R, Sivasubramanian P, Muthiah C. Management of hoppers in rice through host nutrient. A novel approach Journal of Bio pesticides. 2009;2(1):99-106.
3. Das BK, Chaudhary BH, Das KN. Effect of integration of fly ash with fertilizers and FYM on nutrient availability, yield and nutrient uptake of rice in inception of Assam, India. International Journal Advancement in Research and Technology. 2013;2(11):190-208
4. Heerendra Prasad, Paramjeet Sajwan, Meena Kumari, SPS Solanki. Effect of Organic Manures and Biofertilizer on Plant Growth, Yield and Quality of Horticultural Crop: A Review ZH. J of channel studied. 2017;5(1):217-221.
5. Impa SM, Morete MJ, Ismail AM, Schulin R, Johnson SE. Be about. Zn uptake, translocation and grain Zn loading in rice (*Oryza sativa* L.) genotypes selected for Zn deficiency tolerance and high grain Zn. J Exp. Bot. 2013;64:2739-2751.
6. John CN, Benedict OW, Chakwrebuke CO, Charles AI, Toshiyaki W. Improving sold silicon and selected fertility studies for rice production through rice – mill waste application in low land sawate (P 70 rice field of south eastern Nilgris. Intt. J Recycling Organic waste in Agriculture. 2017;8(Suppl 1):5527-5272.
7. Patil S, Pal B, Bedole S, Hazra GC, Mandel B. Effect of silicon fertilizer on growth, yield and nutrients uptake in rice communication in soil science and plant analysis 2018;47(30):284-290.
8. Patil VN, Pawax RB, Patil AA, Parande AL. Influence of rice husk ash and bagasse and as a source of silicon on growth, yield and nutrient uptake of rice. Intl. J Chem Students. 2018;6(1):317-320.
9. Peera SKPD, Balasubramanian P, Mahendran PP. Effect of silicate solubilizing bacteria and fly ash on silicon uptake and yield of rice under lowland ecosystem. J Applied and Natural Science. 2016;8(1):55-59
10. Rehman HU, Aziz T, Farooq. Zinc nutrition in rice production systems: A review plant soil. 2012;361(1-2):203-206.
11. Sarwar NH, Abi Ahmad A, Ullah E, Ahmad S, Mubern

K, Hill JE. Water wise rice cultivation and calcarees soil with the addition of essential micronotrients. J Anim. Plant Sci. 2013;23(10):244.
12. Vance CP. Enhanced agricultural sustainability through biological nitrogen fixation. In biological fixation of nitrogen for economic and sustainable agriculture. In proceedings of a NATO Advanced Research Workshop. Penznanpoland; c1997. p. 179-18.
13. Vandna C, Rajesh K. Role of zinc application on rice growth and yield, Plant Archives. 2018;18(2):1382-1384.
14. Van Houtven G, Powers J, Pattanayak SK. Valuing water quality improvements in the United States using meta-analysis: Is the glass half-full or half-empty for national policy analysis?. Resource and Energy Economics. 2007 Sep 1;29(3):206-228.
15. Pattanayak J, Mondal K, Mathew S, Lalvani SB. A parametric evaluation of the removal of As (V) and As (III) by carbon-based adsorbents. Carbon. 2000 Jan 1;38(4):589-96.
16. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: an overview. The scientific world journal. 2013 Oct;2013.
17. Nayar JK, Sauerman Jr DM. The effects of nutrition on survival and fecundity in Florida mosquitoes: Part 2. Utilization of a blood meal for survival. Journal of Medical Entomology. 1975 Apr 30;12(1):99-103.
18. Cohen R, Fardouly J, Newton-John T, Slater A. BoPo on Instagram: An experimental investigation of the effects of viewing body positive content on young women's mood and body image. New Media & Society. 2019 Jul;21(7):1546-1564.
19. John A, Glendenning AC, Marchant A, Montgomery P, Stewart A, Wood S, Lloyd K, Hawton K. Self-harm, suicidal behaviours, and cyberbullying in children and young people: Systematic review. Journal of medical internet research. 2018 Apr 19;20(4):e9044.