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Krishnakumar S
Assistant Professor, ICAR-Krishi Vigyan Kendra, Virudhunagar, Tamil Nadu, India

Chelvi Ramessh
Programme Coordinator, ICAR-Krishi Vigyan Kendra, Virudhunagar, Tamil Nadu, India

Krishna Surendar K
Assistant Professor, Regional Research Station, Virudhunagar, Tamil Nadu, India

Balaji T
Assistant Professor, ICAR-Krishi Vigyan Kendra, Virudhunagar, Tamil Nadu, India

Selvi J
Assistant Professor, ICAR-Krishi Vigyan Kendra, Madurai, Tamil Nadu, India

Arul Arasu P
Assistant Professor, ICAR-Krishi Vigyan Kendra, Madurai, Tamil Nadu, India

Jegadeesan M
Assistant Professor, ICAR-Krishi Vigyan Kendra, Ramanathapuram, Tamil Nadu, India

Corresponding Author:
Krishnakumar S
Assistant Professor, ICAR-Krishi Vigyan Kendra, Virudhunagar, Tamil Nadu, India

Biofertilizers assessment for rice production under alkali soils

Krishnakumar S, Chelvi Ramessh, Krishna Surendar K, Balaji T, Selvi J, Arul Arasu P and Jegadeesan M

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Abstract
The growing and turning of green manure crops i.e Dhaincha enriches soil organic matter vis-à-vis additional nutrients to the soil besides reclamation of sodic soils. When incorporated into the soil, these plants break down, eventually releasing important nutrients which are necessary for adequate plant growth and development. In addition to the supply of nutrients, green manuring crops can help to scavenge the leftover nutrients from the preceding crop. It also increases soil drainage and water retention capacities that help to prevent leaching losses, soil erosion, and weed problems too as these are also incorporated. The different biofertilizers (FP: Pre season fallow+ Rice cv. Atchaya, TO1: Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv. TRY 3, TO2: Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application+ Rice cv. TRY 3) were used to manage the sodic soil. Technology option 1 (Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv. TRY 3), resulted in higher yield (30%) followed by technology option 2 (Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application + Rice cv. TRY 3) and the least was recorded by farmers practice (Pre season fallow+ Rice *cv*. Atchaya). Apart from this TRY 3 is highly salt tolerant variety which was known to the farmers. Hence Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv. TRY 3 will be a suitable alternative practices for getting higher yield in sodic condition. The technology will promotes growth and yield of rice in sodic soil of pH 9.3 and also protects against soil borne disease. The farmers were willing to take up the seed treatment, soil application of biofertilizer. TRY 3 is medium duration and salinity tolerant variety. This variety is resistant to leaf folder, stem borer, brown plant hopper, blast, brown spot, sheath rot and sheath blight.

Keywords: Green manure, biofertilizer, TRY 3, Arka microbial consortium, CSR bio, sodic soil

Introduction
Rice is a major crop grown in Madurai district as it is lying under Periyar Vaigai command area. There are nearly 1000 ha of area in sodic condition in Madurai District. Continuous usage of drainage and irrigation water to the soil leads to sodic. At sodic pH values, greater than pH 7.5 for example, phosphate ions tend to react quickly with calcium (Ca) and magnesium (Mg) to form less soluble compounds. This will leads to less nutrient availability and poor yield. The availability of the micronutrients manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and boron (B) be likely to decrease as soil pH increases. The exact mechanism responsible for reducing availability differ for each nutrient, but can include formation of low solubility compounds, greater retention by soil colloids (clays and organic matter) and conversion of soluble forms to ions that plants cannot absorb. There are a number of useful soil micro organisms which can help plants to absorb nutrients. Their utility can be enhanced with human intervention by selecting efficient organisms, culturing them and adding them to soils directly or through seeds. The cultured micro organisms packed in some carrier material for easy application in the field are called bio-fertilisers. Thus, the critical input in Biofertilisers is the micro organisms. Soil saline–alkalization is a key environmental factor that severely limits the functional roles of soil microbes in arid and semi-arid regions globally (Qadir, 2008 and Liu, 2017) [1, 2]. It has been suggested that crop management practices such as organic amendments (e.g., bio-fertilizer and rotten straw) are more effective than inorganic amendments (e.g., gypsum) for altering soil

nutrient and physiochemical properties, shifting the composition of soil (Shaaban *et al*., 2013) [3] microbial communities and increasing crop yields (Tejada *et al*., 2006 and Celestina *et al*., 2019) [4, 5]. Bio-fertilizers are natural organic amendments (Mahdi, 2010; Pindi and Satyanarayana, (2012) and Borkar, 2015) [6, 7, 8], which have been widely used in saline–alkali soils (Alla *et al*., 2014) [9] to improve soil fertility and productivity (Singh, 2019) [10]. The green manuring and biofertilizers are key factors to rectify the alkalinity problem and hence the research work was taken.

Materials and Methods

The research work was done at farmers field located in Varichur village, Madurai East Block in the year 2020-21 in *Rabi* season. Three treatments *viz*., FP: Pre season fallow+ Rice cv. Atchaya, TO1: Pre rice Green Manuring (GM) + Application of CSR bio through seed treatment and soil application + Rice cv.TRY 3, TO2: Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application+ Rice cv. TRY 3 were taken. The initial soil (Table 1) and water (Table 2) samples were analyzed.

Results and Discussion

Zinc is an essential micronutrient. The results of zinc deficiency in plants are reduction in leaf size, chlorosis, increase in plant susceptibility to heat, light stress, and pathogenic attack (Dubey *et al*., 2020) [11] The application of Zn fertilizers has been suggested to pose a threat to the environment (Rajput *et al*., 2020) [12]. Thus, the application of zinc solubilizing microorganisms as an alternative to Zn supply is gaining traction. Several strains of Zn solubilizing microorganisms have been applied in the production of biofertilizers. These include *Pseudomonas* spp., *Rhizobium* spp., *Bacillus aryabhattai*, *Thiobacillus thioxidans*, and *Azospirillum* spp. (Ijaz *et al*., 2019) [13]. Solubilization of Zn by microorganisms depends on both soil pH and capacity of cation exchange. Application of Bacillus spp. AZ6, as a Zn solubilizing biofertilizer on maize, was reported by Hussain *et al*. to have a positive impact on total maize biomass and increase plant physiology, chlorophyll content by 90%, and yield when compared to uninoculated plants. Green manuring *i.e*. Daincha enhances microbial activities due to readily available food material. Green manure is broken down into plant nutrient components by heterotrophic bacteria that consume organic matter. Application of green manure enhances the reclamation of saline and sodic soils by improving physical and chemical properties. Plant litter incorporation improves aggregation, aeration and water retention. Application of green biomass helps to curtail the evaporation from soil surface and thereby decreases salt concentration in the root zone profile which results in arresting sub soil sodicity. Technology option 1 (Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv. TRY 3), resulted significantly higher yield followed by technology option 2 (Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application + Rice cv. TRY 3) and the least was recorded by farmers practice (Pre season fallow+ Rice cv. Atchaya) given in Table 4. The percent increase over control treatment is 31.8.

Table 1: Chemical properties of initial soil sample

Soil analysis	
pH	8.52
EC (dS m^{-1})	2.2
Organic C (g kg^{-1})	2.58
Nitrogen (kg ha^{-1})	102
Phosphorus	11
Potassium	135
Iron (ppm)	1.30
Zinc (ppm)	0.20
CEC (C mol (p^+) kg^{-1})	14.5
Exchangeable Ca (C mol (p^+) kg^{-1})	6.0
Exchangeable Mg (C mol (p^+) kg^{-1})	4.8
Exchangeable Na (C mol (p^+) kg^{-1})	2.2
Exchangeable K (C mol (p^+) kg^{-1})	1.5
Exchangeable Sodium Percentage	15.4

Table 2: Chemical properties of irrigation water sample

Irrigation Water analysis	
pH	8.00
EC (dS m^{-1})	1.10
Carbonate (meq. l^{-1})	1.0
Bicarbonate (meq. l^{-1})	4.0
Sodium (meq. l^{-1})	1.0
Calcium (meq. l^{-1})	2.5
Magnesium (meq. l^{-1})	1.0
RSC (meq. l^{-1})	1.5
SAR	0.57

Table 3: Effect of pre rice green manuring and biofertilizers on growth and yield attributes of rice (average of 10 replications)

Technology Option	Plant height (cm)	No. of productive tillers	Panicle Length (cm)
FP: Pre season fallow+ Rice cv. Atchaya	70	10.2	18.5
TO1: Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv.TRY 3	125	15.5	24.3
TO2: Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application+ Rice cv. TRY 3	120	13.3	23.5
C.D	0.34	0.07	0.07
SE(d)	0.16	0.03	0.03

Table 4: Effect of pre rice green manuring and biofertilizers on economics attributes of rice (average of 10 replications)

Technology Option	Yield (t)	Cost of cultivation (Rs.)	Gross Return (Rs.)	Net Return (Rs.)	B: C
FP: Pre season fallow+ Rice cv. Atchaya	4.272	55630	93984	38354	1.69
TO1: Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv.TRY 3	5.925	56200	112575	56375	2.00
TO2: Pre rice GM + Application of Arka microbial consortium through seed treatment and soil application+ Rice cv. TRY 3	5.630	56590	106970	50380	1.89
C.D	21	-	-	-	-
SE(d)	10	-	-	-	-

Conclusion

Zinc solubilizing bateria interact with the rhizosphere or endosphere of plants by improving zinc availability and stimulating zinc uptake to increase yield. The application of zinc solubilizing bateria reduces the high cost of purchasing chemical fertilizers and addresses the world's demand for green technology for crop production. The Pre rice GM + Application of CSR bio through seed treatment and soil application + Rice cv. TRY 3 will be a suitable alternative practices for getting higher yield in sodic condition. The farmers were willing to take up the seed treatment, soil application of biofertilizer. TRY 3 is medium duration and salinity tolerant variety. This variety is resistant to leaf folder, stem borer, brown plant hopper, blast, brown spot, sheath rot and sheath blight.

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