ISSN: 1394-7990
Malaysian Journal of Soil Science Vol. 23: 167-172 (2019) Malaysian Society of Soil Science

Effect of Azolla Compost and Biofertiliser on Phosphate Solubilising Bacteria, Available-P and Dry Weight of Rice Cultivated in Saline Soil

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ABSTRACT

Saline soils can be developed for the cultivation of food crops such as rice. Despite offering this potential, the utilisation of saline soils is limited by its physical, chemical and biological properties. These barriers can be amended through the application of azolla compost and biofertilisers. In this research, combinations of azolla compost and biofertiliser consortia were assessed to identify the best treatment for rice plants grown in soil at various salinity levels. showed that the application of azolla compost and biofertiliser increased the phosphate solubilising bacteria (PSB) population and the dry weight of rice dry cultivated in a saline soil. The salinity treatment of 2-6 mm hos cm^{-1} influenced PSB population and rice dry weight. An ncreasing level of salinity decreased PSB population and rice dry weight.

Keywords: Azolla compost, biofertiliser, saline soil.

INTRODUCTION

Over 13.2 million of the 40 million hectares of degraded land in Indonesia consists of saline soil. The land is commonly found in coastal areas, river estuaries, and deltas affected by seawater intrusion (Setiawati *et al.* 2007). One stretch of saline land with a salinity level of 6,59 mmhos cm^{-1} in West Java is located in Panyingkiran Lor Village, Cantigi District, Indramayu..

Indonesia's saline soils have the potential to be utilised for the cultivation of food crops.In addition, rice demand throughout Indonesia is continually increasing despite a government policy on staple food substitutes. This can be seen from the consumption of rice in 2015 which was estimated at 35.123 million tons, assuming a per capita consumption of 139 kg / year and a population of 260 million. By 2020, it is forecasted that there will be a shortage of 1.09 million tons of rice, with the deficit increasing to 12.25 million tons by 2045 (Ali *et al.* 2013). Salinity decreases potassium (K) and phosphorus (P) availability and also leads to low K^+/ Na^+ ratios. Salinity in soil will significantly reduce the absorption of

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mineral nutrients, especially P, since phosphate ions binds with Ca^{2+}, Mg^{2+} and Zn^{2+} ions. This will result in the unavailability of these elements for plant uptake. P deficiency in soil will lower energy in the form of Adenosine triphosphate (ATP) (Lacerda *et al*., 2003).

In order to solve the complex problems posed by saline soils, technology is being constantly developed to enhance land productivity. A known method of soil enhancement is through the application of biological fertilisers (biofertiliser) and organic matter. Organic matter such as azolla compost can be applied to remediate soil salinity and increase crop production. *Azolla pinnata* is a type of fern known for its symbiotic association with the N_2-fixing blue-green algae *Anabaena azollae*. *Azolla pinnata* can be degraded easily by soil microorganisms; therefore, its addition is expected to increase the nitrogen needed by plants (Rosiana *et al.* 2013).

A biofertiliser is an inoculant with living organisms that serves as an active ingredient, and its addition can inhibit or facilitate the availability of certain nutrients in the soil for plants (Simanungkalit *et al.* 2006). Biofertilisers aid balanced nutrient supply for plants, and reduce the necessity of inorganic fertiliser application. It is also beneficial for the environment through the reduction of pollution caused by inorganic fertilisers. In this research, we studied the effect of a biofertliser consortia on a phosphate solubilising bacteria (PSB) population, available phospohorus, and dry weight of rice (*Oryza sativa* L.) grown at different salinity levels.

MATERIALS AND METHODS

The experiment was done in a randomised complete block design. Treatments consisted of various salinity levels, biofertiliser consortium consisting of *Azotobacter* sp, *Azospirillum* sp., phosphate solubilising bacteria, endophytic bacteria with a population of 10^7 cfu mL^{-1}, mycorhiza with a density of 10 spores/gr) and azolla compost (Table 1).

The soil used was Inceptisols from Jatinangor, West Java, Indonesia taken from 0-20 cm depth. Azolla compost (10 g pot^{-1}) was mixed with 1 kg soil

TABLE 1
Treatment of salinity, biofertiliser and azolla compost

Code	Salinity	Biofertiliser	Azolla compost
A	0 mmhos cm^{-1}	-	-
B	0 mmhos cm^{-1}	+	+
C	2 mmhos cm^{-1}	-	-
D	2 mmhos cm^{-1}	+	+
E	4 mmhos cm^{-1}	-	-
F	4 mmhos cm^{-1}	+	+
G	6 mmhos cm^{-1}	-	-
H	6 mmhos cm^{-1}	+	+

and incubated for one week. The biofertiliser consortium (10 ml per plant) was applied during the rice cultivation.

RESULT AND DISCUSSION

Phosphate Solubilising Bacteria Population

Observation data and statistical analysis are presented in Table 2 which shows the increase in PSB after biofertiliser consortium and azolla compost application.

Table 2 explains that the highest bacterial populations are found in the consortium fertiliser and azolla compost treatment with salinity 0 mmhos cm^{-1}. Along with increased salinity, the bacterial population also decreased while the biofertiliser consortium and azolla compost increased the population of phosphate solubilising bacteria by 244% at 0 mmhos cm^{-1}, 280% at 2 mm hos cm^{-1}, 342% at 4 mmhos cm^{-1} and 74% at 6 mmhos cm^{-1}.

Widawati (2015) reported that PSB can survive salinity for up to 2 mmhos cm^{-1}, but cannot withstand higher salt concentrations. Microorganisms that can tolerate higher levels of salinilty have the ability to balance the intracellular and extracellular osmotic pressure by increasing the amount of solubilised compound inside of their cells (Cherif-Silini *et al.* 2013).

TABLE 2
Application effects of biofertiliser consortium and azolla compost on the phosphate solubilising bacteria population

Treatments	PSB population (10^7 CFU g^{-1})*
A = 0 mmhos cm^{-1} of saline soil (negative control)	2.13 a
B = 0 mmhos cm^{-1} of saline soil+ biofertliser + azolla compost	7.33 c
C = 2 mmhos cm^{-1} of saline soil	1.38 a
D = 2 mmhos cm^{-1} +biofertiliser + azolla compost	5.25 b
E = 4 mmhos cm^{-1} of saline soil	1.50 a
F = 4 mmhos cm^{-1} +biofertilizer + azolla compost	6.63 bc
G = 6 mmhos cm^{-1} of saline soil	1.50 a
H = 6 mmhos cm^{-1} +biofertiliser + azolla compost	2.63 a

*Numbers followedby the same letter are not significantly different according to Duncan's Multiple Range Test (confidence level 5%)

Available P

Observational data and statistical analysis in Table 2 shows that the biofertiliser consortium and azolla compost did not have any significant effect on available P, but increased the availability of P by 23.5% in 0 mmhos cm^{-1} and 3.9% in 6 mmhos cm^{-1}. This was due to available P in this soil being high and thus preventing the biofertiliser (especially phospahate solubilising microorganisms) from functioning optimally. Phosphate solubilising microorganisms increase solubilising phosphate in the P-deficient soil. This finding is in line with the study of Pereira and Castro (2014) who observed that phosphate solubilising bacteria

(*Pseudomonas* sp.) are able to increase available P concentrations in a P-deficient soil.

P availability in soil is influenced by several factors, including pH, Fe, Al and Ca cations and fertilisation intensity. The range of soil pH that supports the highest P availability is 6.0 to 7.0 (Hardjowigeno 2010). Based on the provisions of the Indonesian Soil Research Institute (2009), available P above 20 ppm is considered to be very high. Table 3 shows that all treatments can be categorised as high in available P.

TABLE 3
Effect of biofertiliser consortium and azolla compost on available P

Treatments	Available P (ppm)*
A = 0 mmhos cm^{-1} of saline soil (negative control)	67.50 a
B = 0 mmhos cm^{-1} of saline soil+ bio-fertlizer + azolla compost	83.39 a
C = 2 mmhos cm^{-1} of saline soil	103.83 a
D = 2 mmhos cm^{-1} +biofertilis+ azolla compost	83.56 a
E = 4 mmhos cm^{-1} of saline soil	115.63 a
F = 4 mmhos cm^{-1} +biofertiliser + azolla compost	89.55 a
G = 6 mmhos cm^{-1} of saline soil	116.90 a
H = 6 mmhos cm^{-1} +biofertilizs+ azolla compost	121.48 a

*Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test (confidence level 5%)

Plant Dry Weight

Observation data and statistical analysis in Table 4 show that there is an increase in dry weight of plants due to the biofertiliser and azolla compost application at various levels of salinity.

Table 4 shows that the highest dry weight value was achieved with treatment 0 mmhos cm^{-1} of saline soil with biofertliser and azolla compost at 0.213 gr / pot. Statistical analysis showed this treatment to be different to from the control. This shows that biofertiliser and azolla compost give the same yield and growth potential in 2 mmhos cm^{-1} salinity as in the case of a non-saline condition.

This study showed that the application of biofertiliser consortium and azolla compost have a positive effect on dry weight at all salinity levels. The treatment without the biofertiliser consortium and azolla compost resulted in less dry weight compared to the treatment with biofertiliser consortium and azolla compost in all treatments. The biofertiliser consortium and azolla compost could increase the dry weight of rice by 25.3% in 0 mmhos cm^{-1} salinity. The increase in dry weight at each salinity level ranged from 0.075 to 0.525 gr per pot or equivalent to 6 - 50%.

The increase in plant dry weight was due to phytohormone production by root colonising bacteria. These bacteria can stimulate plant growth, resulting in higher dry weight. Bacteria in the biofertiliser can provide additional phytohormones and stimulate growth to a certain degree of salinity (Egamberdieva

TABLE 4
Effect of biofertiliser consortium and azolla compost on plant dry weight

Treatments	Plant dry weight (gr/pot)*
A = 0 mmhos cm^{-1} of saline soil (negative control)	0.170 c
B = 0 mmhos cm^{-1} of saline soil+ bio-fertlizer + azolla compost	0.213 d
C = 2 mmhos cm^{-1} of saline soil	0.130 b
D = 2 mmhos cm^{-1} +biofertiliser + azolla compost	0.173 c
E = 4 mmhos cm^{-1} of saline soil	0.125 ab
F = 4 mmhos cm^{-1} +biofertiliser + azolla compost	0.133 b
G = 6 mmhos cm^{-1} of saline soil	0.100 a
H = 6 mmhos cm^{-1} +biofertiliser + azolla compost	0.153 bc

*Numbers followed wby the same letterare not significantly different according to Duncan's Multiple Range Test (confidence level 5%)

2012). Good plant growth will result in higher growth weight, and vice versa (Subowo 2015).

CONCLUSION

Our study showed that biofertiliser consortium and azolla compost had a positive effect on PSB population and dry weight of rice plants at some level of salinity but had no effect on available P. Biofertilizer and azolla compost fertiliser at 2 mmhos cm^{-1} gave an equivalent result in dry weight of rice plant and increased the population of PSB by 146% compared with 0 mmhos cm^{-1} without the addition of biofertiliser and azolla compost. A high level of salinity affected the PSB population resulting in a decline which eventually influenced plant dry weight. Further assesment on the increased availability of other soil macro- nutrients after the application of a biofertiliser consortium in saline soil is needed to obtain superior isolates.

ACKNOWLEDGMENTS

This research was funded by Academic Leadership Grant (ALG) from Universitas Padjadjaran. We thank to staff Laboratory of Soil Biology and Laboratory of Soil Fertility and Plant Nutrition Faculty of Agriculture, Universitas Padjadjaran for their cooperation We are also thankful to our students for supporting us during experiment.

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