Evaluating the properties of paddy-grown soil after biofertilizer application

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ABSTRACT

This experiment evaluated the soil properties of paddy crop at clay loam soil in Kilinochchi by using different fertilizer sources, including two types of biofertilizer, Azolla, in a symbiotic relationship with *Anabaena* and *Azotobacter* sp and Urea. The experiment was devised in a randomized complete block design of seven treatments, each with three replications. Three treatments were incorporated according to fresh Azolla, *Azotobacter* sp compost, and Urea. Combinations of Azolla with *Azotobacter* sp, Azolla with Urea, and *Azotobacter* sp with Urea were treatments of the experiment, while the control treatment was maintained without any source of fertilizer. The results revealed that the soil chemical properties were significantly different among treatments ($p<0.05$). Sole application of *Azotobacter* sp treated soil showed the highest available phosphorus content (31.773 ppm) and soil porosity (2%). The highest exchangeable potassium (301.63 ppm) was recorded in *Azotobacter* sp and urea combined treated soil. The combined Azolla and urea application showed the lowest bulk density (1.0004 g/cm^3) in an experiment. It was concluded that the application of biofertilizer as sole and combined with chemical fertilizer increased soil properties. Biofertilizer could be used as an alternative source for chemical fertilizer to the soil in paddy cultivation with reduced hazardous effects on the environment..

Keywords: Azolla, *Azotobacter* sp, Biofertilizer, Symbiotic relationship, Urea.

INTRODUCTION

Sri Lanka mainly depends on agriculture for economic growth. Paddy cultivation is one of the main productions in the agriculture sector of Sri Lanka. Paddy production in Sri Lanka has increased considerably during the last three decades due to the cultivation of high-yielding varieties, greater use of plant nutrients, and a greater extent of irrigated area for cultivation. As the high-yielding varieties are highly fertilizer responsive, proper fertilizer application is needed to obtain respective yield levels. The supply of three major nutrients, namely, Nitrogen, Phosphorous, and Potassium, are essential for cultivation. Among these nutrients, Phosphorous and potassium are the most limiting nutrient for paddy production; therefore, these nutrients are generally applied in the most considerable quantity and estimated that about 50% of all phosphorus and potassium needed for crop production are applied as chemical fertilizers (Claus-Peter, 2011).

Modern agriculture involves the usage of chemical fertilizer with the essence of increasing the world's food production. Continuous application of chemical fertilization leads to decay of soil quality and fertility, and thereby the accumulation of heavy metals in plant tissues resulted in poor yield, nutritional value, and edibility (Farnia and Hasanpoor, 2015). Organic fertilizers improved soil productivities and microbial activity in the soil. A particular group of organic fertilizers includes outcomes based on plant growth-promoting microorganisms identified as 'biofertilizers'. These biofertilizers comprised efficient strains of nitrogen-fixing or phosphate solubilizing microorganisms such as fungi and bacteria. Microorganisms could easily convert complex organic material into simpler compounds in order for plants to easily absorb them. (Bhattacharjee and Dey, 2014). The biofertilizers are Azolla, *Azotobacter* sp, and Azospirillum (Rahimi et al., 2016). *Azotobacter* sp can be applied by seed dipping and seedling root dipping methods (Shridhar, 2012). Mainly Azolla is utilizing intercropping with paddy crop (Murtaza et al., 2009).

In Sri Lanka, overuse of chemical fertilizer (e.g. Urea) for paddy cultivation causes yield reduction and environmental pollution. Therefore, the present study was conducted to assess the impact of biofertilizers and Urea as sole and in combination on the soil properties of widely cultivated paddy crops to quantify their phosphorous and potassium supply efficiency for environmentally friendly paddy cultivation with a higher yield. Against this backdrop, the present investigation contemplated the objectives; to estimate the effectiveness of biofertilizer and Urea on chemical and physical soil properties and identify the better fertilizer source for paddy crops for maintaining the soil fertility in clay loam soil.

METHODOLOGY

The experiment was conducted in a wirehouse using polyethene bags during the *Yala* season from July to September 2020 at Paranthan, situated in the Kilinochchi district, Sri Lanka. Seven treatments, including sole and combination of nitrogen sources and control, were replicated three times in Randomized Complete Block Design. According to the experiment, 100% recommended rate (Department of Agriculture, 2013) nitrogen to paddy crop was given by sole fresh Azolla incorporated with soil as organic manure, *Azotobacter* sp as compost material, and Urea in treatments T1, T2, T3 and by combining Azolla + *Azotobacter* sp, Azolla + Urea, and *Azotobacter* sp + Urea in treat-

Table 1: Impact of treatment on soil chemical properties at 30 days

Treatment		Soil available phosphorus (ppm)	Soil exchangeable potassium (ppm)
T1	Azolla	2.9895 ± 0.1858^{ba}	85.610 ± 1.6141^{a}
T2	*Azotobacte* sp	2.8483 ± 0.1915^{ba}	94.487 ± 1.9050^{a}
T3	Urea	2.1891 ± 0.1383^{b}	38.800 ± 1.0567^{c}
T4	Azolla + *Azotobacter* sp	3.1190 ± 0.3003^{ba}	60.591 ± 1.3979^{b}
T5	Azolla + Urea	3.8488 ± 0.1734^{a}	63.012 ± 2.3030^{b}
T6	*Azotobacter* sp + Urea	2.8130 ± 0.2791^{ba}	65.433 ± 0.5283^{b}
T7	Control	2.1068 ± 0.0347^{b}	41.221 ± 1.3979^{c}
	Treatment Pr>F	0.0997	<0.0001

Table 2: Impact of treatment on soil chemical properties at 45 days

Treatment		Soil available phosphorus (ppm)	Soil exchangeable potassium (ppm)
T1	Azolla	29.329 ± 1.1101^{a}	129.21 ± 10.3146^{b}
T2	*Azotobacter* sp	31.773 ± 0.1806^{a}	162.7 ± 10.9654^{b}
T3	Urea	27.074 ± 0.5874^{ba}	121.77 ± 7.8031^{cb}
T4	Azolla + *Azotobacter* sp	22.241 ± 1.4040^{b}	154.02 ± 2.8131^{b}
T5	Azolla + Urea	26.765 ± 0.2097^{ba}	240.85 ± 5.2208^{a}
T6	*Azotobacter* sp + Urea	26.362 ± 0.4470^{ba}	301.63 ± 9.4818^{a}
T7	Control	6.103 ± 0.6528^{c}	54.78 ± 5.7613^{c}
	Treatment Pr>F	<0.0001	<0.0001

ments T4, T5, and T6 respectively and control without fertilizer in treatment T7. The poly bags were filled with clay loam soil, and nitrogen sources were added to the treatments as basal fertilizers three days before sowing. Sprouted rice seeds were transferred to each polybag. After 12 days, seedlings were thinned out to maintain six healthy and uniform seedlings per bag. The water level was maintained inside the poly bags after seedlings emerged to ensure the proper growth of seedlings. The water level was gradually increased with increasing plant height by adding the required quantity of water into the bags. Triple superphosphate (TSP) and Muriate of potash were applied to all the bags based on the recommendation of the Department of Agriculture (2013). Hand weeding was done at two weeks intervals. After 30 and 45 days, the soil sample was analyzed for soil chemical properties, soil available phosphorus and soil exchangeable potassium and soil physical properties, bulk density of soil, and soil porosity by using a Spectrophotometer, Flame photometer, and Pycnometer methods.

RESULTS AND DISCUSSIONS

Soil available phosphorus content

The result of the impact of biofertilizers and Urea as the sole and in the combination shows a significant influence on available phosphorus concentration at 30 days (Table 1) and at 45 days (Table 2) after sowing as the *p*-value is less than 0.05. The initial available phosphorus content of the soil was 4.28 ppm. The result pertaining to 30 days shows (Table 1) that the concentration of available phosphorus is notably reduced than initial phosphorus concentration. Azolla and Urea combination and significantly highest reduction is observed in only urea treatment and is comparable with control. The reduction is significantly lower in treatment of Urea was recorded poor phosphorus amount in soil among the treatment, and it was nearly same phosphorus concentration of treatment of control. Considerably high phosphorus amount in soil was found in the soil of treated with biofertilizer as the sole and in combination condition and among them; high phosphorus concentration was received by treatment of Azolla and Urea. This may be due to the unavailability of readily available phosphorus by the treatments the plant may obtain phosphorus from the native soil phosphorus. This statement agrees with Carrillo et al. (2018) report that their lack of mobility and low solubility reduces the availability of phosphorus fertilizer as it is fixed by soil phosphorus compounds. Fixed phosphorus is not lost; it becomes slowly available to crops over several years depending on soil and phosphorus compound type. However, among the treatments, the Azolla and Urea combination may release phosphorus quickly than other treatments. This may be due to the composition and release rate of this combination. The solubilizing effect of chemical compounds has impacted the availability of phosphorus for plant uptake at the early stage (Ali et al., 2016). Azolla and *Azotobacter* sp combination may release some phosphorus from them as Azolla and *Azotobacter* sp have nutrients including phosphorus through their mineralization by decomposition. Dawar and Singh (2002) found that soil cultures were as good as the nutrient medium by biofertilizers addition.

The result (Table 2) revealed that at 45 days, the phosphorus availability is higher than 30 days. Among the treatments, the significantly highest value is observed in

Table 3: Impact of treatment on soil physical properties

Treatment		Soil bulk density (g/cm^3)	Soil porosity (%)
T1	Azolla	1.07298 ± 0.0149^{ba}	1.99719 ± 0.00529^{a}
T2	*Azotobacter* sp	1.06832 ± 0.0307^{a}	2.01668 ± 0.00417^{a}
T3	Urea	1.15992 ± 0.0158^{ba}	1.99972 ± 0.00655^{a}
T4	Azolla + *Azotobacter* sp	1.05842 ± 0.0103^{ba}	2.00178 ± 0.00076^{a}
T5	Azolla + Urea	1.00038 ± 0.0120^{ba}	1.99638 ± 0.00111^{a}
T6	*Azotobacter* sp + Urea	1.06663 ± 0.0123^{ba}	2.00017 ± 0.00101^{a}
T7	Control	1.1037 ± 0.0071^{ba}	1.98892 ± 0.00434^{a}
Treatment Pr>F		0.3431	0.6887

sole *Azotobacter* sp and is on par with sole Azolla treatment. Among the treatments, the significantly lowest value is recorded in *Azotobacter* sp and Azolla treatment. The time is taken to decompose organic matter will affect the release of organic acids for the solubility of available phosphate, which may cause the unavailability of phosphate (Felton et al., 2004).

Soil exchangeable potassium

It was found that there were significant ($p<0.05$) differences between treatments in the sole and a combination of biofertilizer and Urea on the soil exchangeable potassium content at 30 days (Table 1) and 45 days (Table 2). The initial value was 50.10 ppm.

At 30 days (Table 1), soil exchangeable potassium content was significantly higher than initial potassium content except for treatment of Urea and control. The lowest value of potassium content was recorded in the treatment of Urea. The highest soil potassium content was found in the *Azotobacter* sp treatment; soil potassium may increase as the biofertilizer contained potassium. The values obtained at 45 days (Table 2) are higher than 30 days among the readings. Biofertilizers such as microorganisms are fertilizers and accelerate those microbial processes. Which directly give nutrition to plants and augment the availability of nutrients to soil (Boraste et al., 2009).

Significantly higher potassium content is recorded in sole Azolla and *Azotobacter* sp at 30 days (Table 1) and in treating Urea with Azolla and *Azotobacter* sp at 45 days (Table 2). That result increases potassium concentration in soil due to the addition of topdressing fertilizer as TSP to treatments. Potassium chemical fertilizers are increased the exchangeable form of content (Finck, 1982). Biofertilizer is one of the organic matters which contained and stored nutrients, including potassium; therefore, the soil is enriched with potassium from the biofertilizer by decomposition. Chemical supplements induced this activity as Urea. Rekha et al. (2009) stated the biofertilizer consortia applied to the soil, which in turn released soluble potassium from potassium-bearing minerals through the decomposing and microbial activity.

Soil bulk density

The result (Table 3) pertaining to the impact of biofertilizer and Urea as sole and in combination on soil bulk density at the end of the experiment is not significantly different among treatments as the *p*-value is higher than 0.05. The initial bulk density was 1.6094 g/cm^3. Azolla and *Azotobacter* sp insole and treatment are combining them recorded lower value than control and insole urea treatment. Organic matter is proved to be better due to favourable effects on the physical properties of soil (Murtaza et al., 2009). However, bulk density is reduced in all treatments than an initial record of soil bulk density. Organic amendments will reduce the bulk density due to the improvement in aggregation and microbial activity. The bulk density of amended soil was lower than initial soil, which supported soils receiving organic amendments to show a decrease in dry bulk density (Edmeades, 2003).

Soil porosity

The results (Table 3) revealed no significant influence on soil porosity by the treatments in paddy gown soil as the *p*-value is higher than 0.05. The initial record of soil porosity was 0.0495%. According to the result (Table 3), porosity is higher in all treatments than initial soil. It may be due to the effect of internal characteristics of organic amendments on porosity. There is no significant difference among treatments with *Azotobacter* sp as the sole and recorded the highest porosity in combination. Increased porosity with the application of organic manures in soil was also supported by the findings of Asadu and Unagwu (2012) in the case of wheat. Manure amended with soil increased the porosity of the soil (Iwai et al., 2013).

CONCLUSION

The biofertilizer application produced better soil bulk density and porosity and can increase the soil available phosphorus and soil exchangeable potassium content when treated with combined 50% urea. Therefore, biofertilizers can be used as an alternative source of chemical fertilizer in paddy cultivation.

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