Nutrient Management Strategies for Two Different Soils in the Wet Zone of Sri Lanka

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Abstract

Combined use of organic amendments (OA) with mineral fertilizer is a feasible method of nutrient management to deal with soil fertility decline, soil organic matter depletion, crop growth and yield reduction. To study the effect of different nutrient management strategies on different soils, a greenhouse experiment was set-up in a complete randomized design (CRD). Organic amendments, cattle manure-saw dust (CS) incubated for two months and bio-char (BC) produced from saw dust. Soil samples were collected from fields in Wagolla (WG) and Peradeniya (PD). Site-specific fertilizer recommendation was developed for each soil. Shoot and root biomass of one month old maize (*Zea mays*) was measured in OA+mineral fertilizer added soils , soil+fertilizer-only (SF) and soil-only (S) treatments. Each soil was different in available plant nutrients and nutrient fixing ability. Shoot biomass ranged from 1.11 to 3.17g/plant and from 0.89 to 2.04g/plant in WG and PD soils, respectively. Root biomass varied from 1.08 to 1.99g/plant and from 0.81 to 2.13g/plant in WG and PD soils, respectively. Shoot and root biomasses were significantly higher ($P<0.05$) when soil was mixed with fertilizer alone or OA + fertilizer compared to soil-only treatment. The CS+SF treatment showed the highest shoot biomass in both soils and significantly high root biomass in PD soil. In BC+SF treatment shoot and root biomass was reduced by 13% and 25%, respectively compared to SF. Difference in nutrient management strategies and soil characteristics affected soil's capacity to support crop growth. Plant growth support capacity of soil was enhanced by CS +SF combination.

Key words: Bio-char, Biomass, Fertilizer, Maize, Saw dust.

Introduction

Use of organic amendments and mineral fertilizers in combination has beneficial effects on soil properties and crop growth (Chivenge *et al.*, 2011). Simultaneous use of organic and mineral nutrient resources has its drawbacks; positive results may not be obtained always. Plant nutrient availability in soil can be hindered by diverse mechanisms and by alteration of soil properties influencing nutrient availability.

Studies have been conducted in Sri Lanka on the effects of organic amendments of differing quality on the productivity of different crops. In a study conducted using different OA in combination with mineral fertilizer, conflicting results were obtained; *Gliricidia* improved growth and yield significantly, coir dust addition caused a significant yield drop and application of cow dung or rice straw did not produce noticeable yield increase (Kendaragama, 1999). Hence improvement in crop performance with the incorporation of organic amendments cannot be expected at all times. Effects of different organic amendments on plants vary depending on many factors; climate, soil type, soil environment, composition and quality of organic amendment (Chivenge *et al.*, 2011).

The objective of the study was to determine the effect of different nutrient management strategies on two different soils using a greenhouse experiment.

Materials and Methods

Soil samples were collected from a field (110m^2) in Wagolla located in the Low-country Wet Zone (LCWZ) and a field (380 m^2) in Peradeniya located in the Mid-country Wet Zone (MCWZ). The soil order is Ultisol. Samples were collected using the grid random sampling method and a representative composite sample was prepared for each site. Soils were air-dried and sieved through a 2 mm sieve.

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Soil pH was measured in soil: water suspension (1:2.5) and the organic matter (OM) content by digestion with acid dichromate followed by titration with ferrous ammonium sulphate. Cation Exhange Capacity (CEC) was analysed using an ammonium acetate buffer solution at pH 7. Soil texture was determined by the pipette method and all analyses were performed in triplicates.

Organic amendments used were cattle manure-saw dust at 2:1 ratio (incubated two months prior to application) and bio-char. Incubation was carried out at room temperature and aerobic condition to facilitate partial decomposition of the material through the activity of mesophilic microorganisms. Saw dust was from *Alstonia macrophylla*. Bio-char was prepared using saw dust by slow pyrolysis method at the Department of Soils and Plant Nutrition of the Rubber Research Institute of Sri Lanka.

Site-specific fertilizer recommendations were developed for each soil based on soil nutrient analysis and sorption studies followed by a greenhouse study using maize as test crop. A separate greenhouse experiment was set-up in triplicates in a CRD using maize (Hybrid variety - *Sampath*) as the test crop. Plastic pots were filled with 200g soil mixed with mineral fertilizer at rates developed for each soil and organic material at the rates of 1% (w/w). Soil mixed with mineral fertilizer alone (SF) and soil-only (S) were also included as treatments. Four seeds were planted per pot and thinned out for two plants after one week. Plants were harvested after one month and oven dry weight of shoots and roots were measured.

Data were statistically analysed using SAS 9.1. and the Duncan Multiple Range Test was performed to compare means for treatment effects.

Results and Discussion

Texture of both soils was sandy clay loam and OM contents of WG and PD soils were 2.1% and 1.7%, respectively. WG soil was slightly acidic with pH of 5.1 and pH of PD soil was 6.1 The CEC of WG and PD soils was 10.5 cmol(+)/kg and 16 cmol(+)/kg, respectively. Additional amount of each plant nutrient required to achieve its optimum level was different for each soil due to the difference in available nutrients and nutrient fixation capacity. Both WG and PD soils exhibited P fixation but K fixation was observed only for PD soil. Compared to the optimum nutrient treatment developed, WG soil showed noticeable reduction in plant dry matter of 41%, 39%, 31% and 27% in the absence of Mg, P, N and K applications, respectively. In PD soil the dry matter reduction of 28%, 18% and 11% was evident in minus treatments of K, P and Zn, respectively.

Amending soil with fertilizers alone or combination of OA and fertilizers resulted in significantly higher shoot and root biomass compared to no amendments (Table 1). Biomass of plants grown in soils revealed that two soils were significantly different in terms of the response to amendments ($P<0.05$).

Table 1. Shoot and root biomass of maize plants under different treatments in soils from Wagolla (WG) and Peradeniya (PD)

Treatment #	Shoot dry weight (g/plant)		Root dry weight (g/plant)	
	WG	PD	WG	PD
S	1.11^{b}	0.89^{b}	1.08^{C}	0.81^{C}
SF	2.69^{a}	1.78^{a}	1.99^{A}	1.54^{B}
CS+SF	3.17^{a}	2.04^{a}	1.59^{B}	2.13^{A}
BC+SF	2.57^{a}	1.64^{a}	1.71^{AB}	1.31^{B}

S-soil only, SF-soil+fertilizer, CS-cattle manure+saw dust, BC-bio char. Fertilizer (F) was developed separately for each soil based on soil nutrient analysis and sorption studies followed by greenhouse experiments. Means with similar letters in a given column are not significantly different. ($P>0.05$, n=3).

The highest shoot dry weight was observed in CS+SF treatment in both soils. Growth of aboveground vegetative plant parts is dependent on the available N in soil. The additional supply of nutrients and/ or the release of nutrients by the organic materials over time might have improved shoot biomass under CS combined with mineral fertilizers. Steiner *et al.* (2007) found that combination of organic materials with mineral fertilizers enhance plant growth and grain yield of rice and sorghum compared to mineral fertilizer only treatment and cattle manure addition increased soil nutrient concentrations and improved crop yield. The addition of high C/N material like saw dust to soil causes N immobilization. This was not observed in the present study as indicated by improved plant biomass with the addition of saw dust incubated with cattle manure. This may be due to the reduction of C/N ratio of saw dust by mixing it with cattle manure and the incubation process. It was observed that when cattle manure was mixed with high C/N materials rice straw and wood shavings at 2:1 ratio and incubated for two months, the C/N ratio reduced from 46 to 14 and from 37 to 16, respectively (unpublished data). Bio-char treatment reduced the shoot biomass compared to the SF treatment in both soils. N immobilization by bio-char might have resulted in biomass reduction. Lehmann *et al.* (2003) reported a significant decrease in N uptake by cow pea plants and lower N availability in both Anthrosol and Ferralsol soils when soil was amended with charcoal.

Dry weight of root was significantly increased in CS+SF treatment in PD soil. The availability of P in soil might have improved due to addition of saw dust. In the study of Gagnon and Simard (1999) the use of wood bedding in dairy manure compost reduced P immobilization during incubation. In WG soil BC application resulted in higher root biomass compared to CS addition. Lehmann *et al.* (2003) observed significantly high P availability in Anthrosol amended with charcoal than Ferralsol. The organic amendment CS combined with mineral fertilizer shows potential to improve plant growth. The observed effects in this study should be tested at field level to establish the possibility of using these strategies for improved crop performance in the future. Difference in soil characteristics and nutrient management strategies affected ability of soil to support crop growth. Cattle manure-saw dust combined with mineral fertilizer generally improved the capacity of soil to support plant growth.

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