EVALUATION OF TOTAL N, P, K AND ORGANIC MATTER CONTENTS OF SOIL AMENDED WITH PADDY HUSK CHARCOAL COATED UREA AND COMPARISON OF THE YIELD OF PADDY.

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Abstract

Rice production in Sri Lanka has increased considerably during the last three decades as a result of cultivation of high yielding varieties, increase in the area of cultivation under irrigation and heavy use of plant nutrients. Most of the high yielding varieties which are extensively grown throughout the country require recommended levels of fertilizers in order to obtain their potential yields. Therefore, effective and efficient way of fertilizer application is important. Coated fertilizers are widely used to improve the efficiency of fertilizer application. However, the conventional coated fertilizers such as sulphur coated urea and urea super granules are not popular among the rice farmers in Sri Lanka owing to high cost of the coated fertilizers. One of the most sustainable solutions is application of paddy husk charcoal as a coating material to N fertilizer so as to gradually release nitrogenous compounds and making them available for plants. Objectives of this study were to evaluate total N, P K and organic matter of soil amended with paddy husk charcoal coated urea and to compare the yield of paddy production. A field experiment was carried out at *Kalugamuwa* farmer field in *Yala* 2010 and *Maha* 2010/2011. The field was divided into three blocks of equal size (30 m x 5 m) and each block was further subdivided into four plots (5 m x 5 m) and treatments were arranged in randomized complete block design. Treatments were application of (1) chemical fertilizer only, (2) urea coated charcoal only (1/3 of recommended urea) (3) chemical fertilizer and paddy straw compost (compost obtained from anaerobic digestion of paddy straw) and (4) paddy straw compost and urea coated charcoal only. The highest mean grain yield of 12.59kg/plot was obtained with the application of chemical fertilizer followed by charcoal coated urea with compost, chemical fertilizer and charcoal coated urea only for *Yala* season. Paddy husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching losses of urea. In addition, coating is less costly and helps reducing the fertilizer cost (70% of urea cost) and contribute to mitigate atmospheric pollution as well as pollution of water bodies.

Keywords: Charcoal, slow releasing N fertilizer, Coated fertilizers, Efficiency of fertilizer application

1 Introduction

Agriculture plays an important and strategic role in the performance of Sri Lankan national economy. Agriculture sector contributes nearly 12 percent to the National GDP of Sri Lanka (CBSL, 2010). Rice production in Sri Lanka has increased considerably during the last three decades as a result of cultivation of high yielding varieties, increase in the area of cultivation under irrigation and heavy use of plant nutrients. Presently, Sri Lanka produces 4.3 million tons of rough rice and national average yields of 4.5 T/ha (Department of Census and Statistics, 2011).

At present, urea is the most dominant form of nitrogen fertilizer (60-70%) used in Sri Lanka. In 2008, over 430,000 MT of urea was imported and used either as a straight or in mixed form (NSF, 2011). Introduction of heavy subsidy scheme for chemical fertilizers by the government, the demand for urea has increased. In 2009, total annual cost of subsidy programme for rice is Rs. 26, 935 million (expenditure on fertilizer imports Rs. 55,000 million) (NSF, 2011). In addition, the government of Sri Lanka has initiated a new fertilizer subsidy programme for all other crops. At present, there is a substantial increase in the quantity imported under the subsidy scheme due to enhanced demand for fertilizers by all crop sectors. In mixing both urea and biochar in soils causes a slow release of inorganic fertilizer and increase nitrogen use efficiency (Basnayake, 1994), thus reducing the cost of importations of nitrogen based fertilizers per unit area of cultivation. Paddy husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching losses of urea. And it also helps to reduce the phosphate and potassium leaching (Gamage, et. al, 2011 and 2012). Although there are few methods available for paddy husk reuse, a significant amount of paddy husk remains unused and burned in open fields, causing serious environmental and health problems. The concept of manufacturing biochar using paddy husk is practicable in Sri Lanka, where more than 40% of the farmers are engaged in paddy cultivation. (Department of Census and Statistics, 2008). It is the best solution for managing the agricultural wastes while providing a useful product for increasing agricultural productivity and protecting the environment. Thus, objective of this study was to evaluate paddy husk charcoal coated urea as a slow releasing fertilizer and compare the total N,P, K, organic matter in soil and yield of paddy production.

2 Materials and Methods

2.1 Experimental site

The pyrolyzer was designed, fabricated and developed at the mechanical workshop, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya and it was installed and evaluated the performances at Meewathura Research Farm, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya. Quality of the produced charcoal was analyzed at Soil and Water Engineering Laboratory, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya.

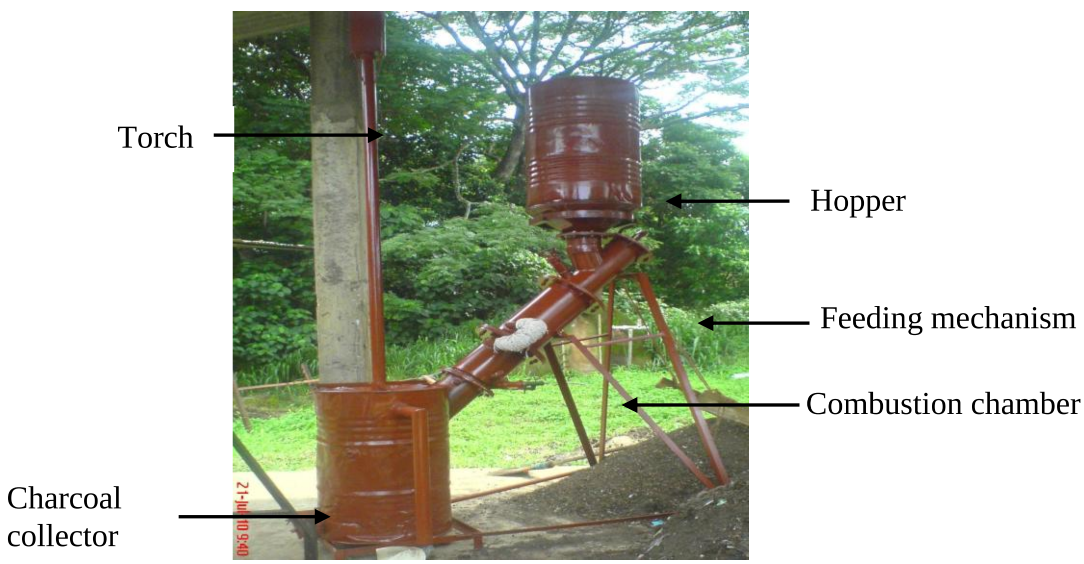


Plate 1: The pyrolyzer

2.2 Preparation of slow releasing nitrogen fertilizer

Production of 1kg of fertilizer having a ratio of Char: N (2:1) requires 30-50g of dried manioc starch (Preferable process manioc boiled dried ground) amount to 3-5% of the mixture. So as to enhance the binding quality that is strength. Sodium hydroxide can be added about 3% of the weight of starch. Cassava was boiled, dried in the oven at (80ºC) and ground to produce cassava flour. Carbon powder and urea mixed thoroughly and with the help of cassava gum, granules of 1.0cm diameter were formed. The gum was prepared by adding hot water into 2g of cassava flour. After making carbon coated urea balls, they were kept in a descicator for about three days.

2.3 Preparation of farmer land for experiment

An experiment was conducted during *Yala* season 2010 and *Maha* 2010/2011 The location selected for the experiment was farmer field at Kalugamuwa, Kandy, Sri Lanka as it was easy for sample collection, water management and daily supervision of the experimental plots. The study area comes under the mid country wet zone (MCWZ) of Sri Lanka. The major rice growing soils in the region comes under low humic glay and as such imperfectly drained soil of the red yellow podzolic soil was selected for this experiment.

Field was divided into three blocks in equal size (30 mx5 m) and each block was further sub divided into four plots (5 m x 5 m) and treatments were arranged in randomized complete block design. Prior to land preparation paddy stubble of the previous crop were cut off at the ground level and removed from the field. Land preparation was then started with soaking the field followed by ploughing the soil. Two weeks after the first ploughing, second ploughing was done. The harrowing and leveling of the field were carried out in another two weeks time. At the same cannel system was made along the bunds of the experimental plots in order to supply and control the water level in the plots independently to restrict the mixing of fertilizer from one plot to another. Treatments are as follows; 1. Application of chemical fertilizer only, 2. Application of urea coated charcoal only 3. Application of chemical fertilizer and paddy straw compost only and 4. Application of paddy straw compost and urea coated charcoal only. Four treatments of the experiment were randomly assigned to the plots of each block so that each treatment occupied in one plot of the each block. Farmers are using mineral fertilizer at the rates recommended by the Department of Agriculture. In Sri Lanka, about 20 improved rice varieties are cultivated in different agro-climatic regions. Bg 358 was used for the experiment. Sprouted seeds of the variety Bg 358 were raised in nurseries prepared in close proximity to the experimental site. Seedling of 18 days old were removed from the nursery and transplanted in the plots with two plants per hill at the range of 15 cm X 15 cm. Surface water inside the plot was maintained to the level of 5cm continuously until rice plant matured in all the plots for two seasons (IPCC, 1996). Weed control for the plots was done manually. Herbicides or insecticide were not added to the treatments.

Phosphorus and potassium were applied to the soil for all the plots at the rates of 218.75 mg and 93.75mg immediately before transplanting. Urea at the rate of 31.25 mg per plot was applied as basal dressing to the nitrogen treated plots. For the treatment 2 and 4 urea at the rate of 10.41 mg (uera: charcoal- 1:2). Urea at the rate of 125 mg, 187.5 mg and 93.75 mg per plot was applied at 2,5 and 8weeks after planting. For the treatment 2 and 4, urea at the rate of 41.66 mg, 62.5 mg and 31.25 mg per pot was applied at 2,5 and 8weeks after planting. Potassium at the rate of 93.75 mg per plot was applied at 7 weeks after planting. Rice straw compost was applied at 2, 5 and 8 weeks (three times) for the treatment 3 and 4 during the cropping season. Soil samples were collected randomly from plots before land preparation and composite soil sample was prepared. Soil texture, pH, EC, Eh, organic carbon, available P, total N and exchangeable K were determined using standard soil analytical methods. Soil samples were collected once a week after basal dressing. The sampling was done once a week for three months period. Number of tillers per hill was counted at the maximum tillering stage (45 days after planting). Before harvesting number of panicles per hill was counted. At the time of harvesting 10 randomly selected rice plants were uprooted from each plot and roots were thoroughly washed and kept inside a oven at $80^{o}C$ for 72 h to for dry weight determination of both below and above ground biomass. At maturity plots were harvested discarding the boarder rows and grain yield of each plot was recorded at 14% moisture content.

2.4 Statistical Analysis

Differences between the treatments were tested by analysis of variance (ANOVA) technique using SAS.

3.0 Results and Discussion

3.1 Physico-chemical properties of biochar and soil

The composition and characteristics of biochar were as follows; moisture content 6%, pH 8.7, carbon content 18.72%, total nitrogen 0.58%, P 0.12% , K 0.20%, volatile matter 6%, ash 5%, fixed carbon. 65%, Electrical conductivity 214 (µs/cm), salinity 0% and Bulk density 390 (kg/m^3). The characteristics of soil were: pH 5.2, carbon content 0.6%, total nitrogen 0.17%, P 0.099% , K 1.307%, Electrical conductivity 213 (µs/cm), salinity 0% and Texture is sandy loam. The characteristics of paddy straw compost were: pH 6.4, organic carbon content 23.76%, total nitrogen 0.98%, P 0.6%, K 1.32% and sand 9.55%.

3.2 Rice growth

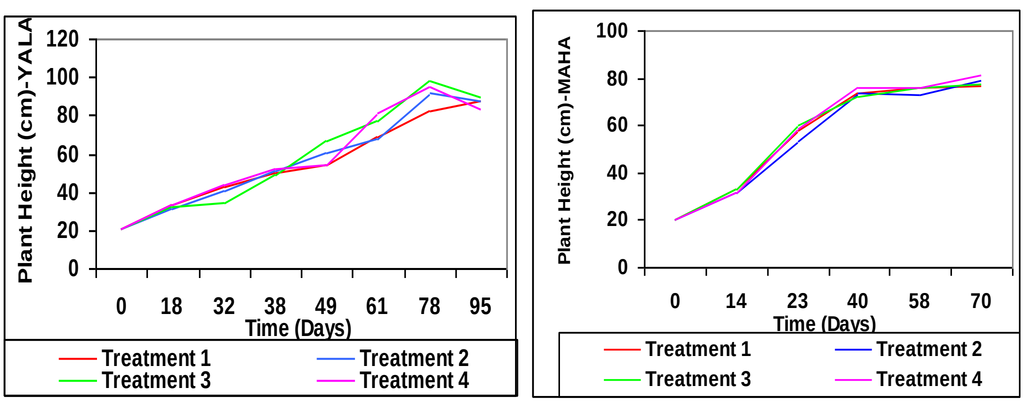


Figure 1 Relationship between plant height and time- (a)*Yala* (b) *Maha*

According to the mean separation, there was no significant difference of plant height in *Yala* season (Fig. 1a). According to the mean separation there were no significant difference of plant height in *Maha* season (Fig. 1b). Number of tillers of treatment 3 and 4 significantly different from 1 and 2 in *Yala* season (Table 1). Number of tillers significantly different from treatment 4, 1,3 and 2 in *Maha* season (Table 2). However, treatment 1and 3 are not significantly different. The total number of tillers per pot was higher in charcoal coated urea with paddy husk compost than chemical fertilizer treatments. One third of urea coated paddy husk charcoal apply for the treatment 4 and three times of paddy straw compost was applied during three months of growing season. Generally, the number of tillers is determined during the vegetative growth period and is mainly governed by tillers capacity of cultivars, planting density and the availability of mineral nutrition, particularly nitrogen (Yoshida *et al*., 1981). These results indicated that the importance of basal application of readily available nitrogen fertilizers (Ebid *et al*., 2007; Ghoneim *et al*., 2006).

Table 1 Effect of different treatment on the growth and yield parameters-*Yala* (2010)

Treatments	Number of tillers (Average value of ten hills)	Number of panicles (Average value of ten hills)	Yield per plot (kg)	Shoot weight (g)	Root dry dry weight(g)
1	$8.6^{b}\pm0.26$	$6.66^{b}\pm0.14$	$12.59^{a}\pm0.08$	$3.1^{b}\pm 0.1$	$5.0^{b}\pm0.1$
2	$8^{b}\pm0.4$	$7^{b}\pm0.4$	$10.18^{d}\pm0.02$	$3.0^{b}\pm 0$	$4.9^{b}\pm0.26$
3	$10.66^{a}\pm0.23$	$8^{a}\pm0$	$10.74^{c}\pm0.01$	$3.9^{a}\pm 0.4$	$6.0^{a}\pm0$
4	$11.33^{a}\pm0.64$	$8.33^{a}\pm0.18$	$11.48^{b}\pm0.59$	$4.1^{a}\pm 0.1$	$6.2^{a}\pm0.26$

Mean followed by the same letter at each column are not significantly different (p=0.05)

Table 2 Effect of different treatment on the growth and yield parameters-*Maha* (2010/2011)

Treatments	Number of tillers (Average value of ten hills)	Number of panicles (Average value of ten hills)	Yield per plot (kg)	Shoot dry weight (g)	Root dry weight (g)
1	$9.33^{b}\pm0.39$	$6.1^{c}\pm0.17$	$6.66^{b}\pm0.36$	$3.1^{b\pm 0.08}$	$4.7^{b}\pm0.17$
2	$8^{c}\pm0$	$7.3^{b}\pm0.26$	$6.94^{b}\pm0.18$	$3.0^{b}\pm 0$	$4.8^{b}\pm0.08$
3	$9.4^{b}\pm0.45$	$7.6^{b}\pm0.1$	$7.77^{a}\pm0.06$	$3.8^{a}\pm 0.07$	$5.7^{a}\pm0.09$
4	$10.1^{a}\pm0.1$	$8.6^{a}\pm0.1$	$6.11^{b}\pm0.01$	$3.9^{a}\pm^{0.1}$	$6.0^{a}\pm0$

Mean followed by the same letter at each column are not significantly different (p=0.05)

3.3 Yield -*Yala* and *Maha* seasons

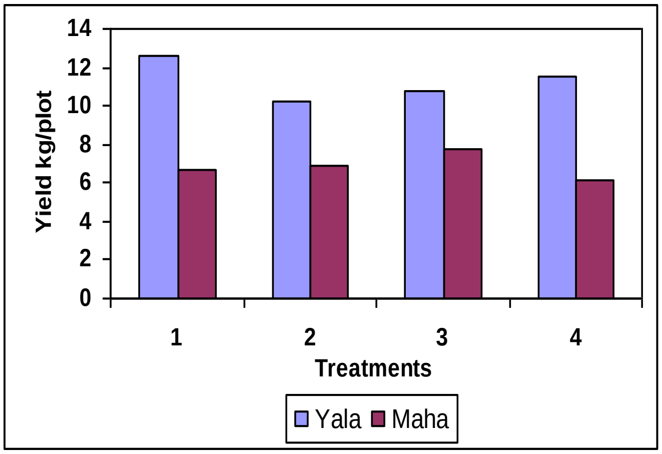


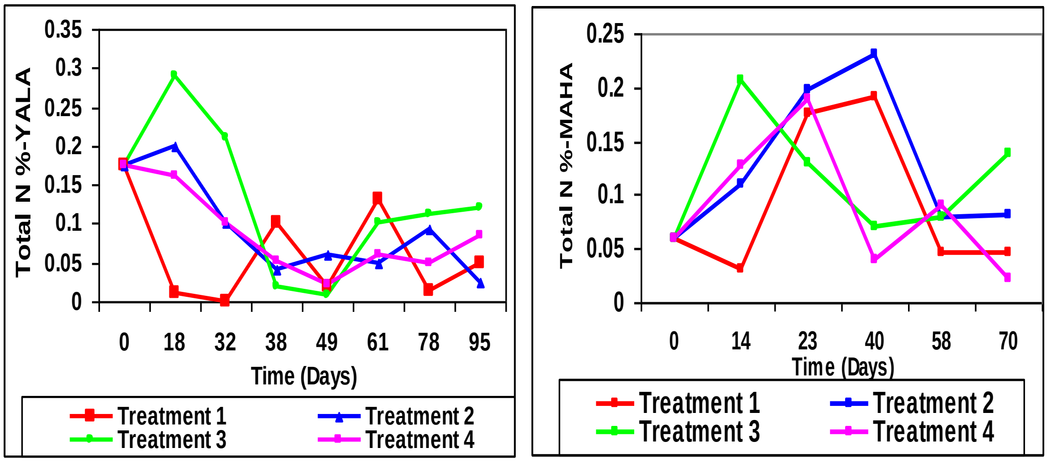
Figure 2 Relationship between yield and treatments- *Yala* and *Maha*

Numbers of panicles was higher in treatment 3 and 4 than other treatments in *Yala* season. However, the treatment 3and 4 was significantly different from treatment 1and 2 (Table 2). Numbers of panicles was higher in treatment 4 than other treatments in *Mala* season. However, treatment 2 and 3 were not significantly different from each other (Table 3). Treatment 1 has less number of panicles due to heavy raining and washed off the pollens of flowers. Grain yield, treatment effects are significantly different from each other in *Yala* season (Table 2). Treatment 1 has the highest yield followed by treatment 4, 3 and 2. However, Treatment 2 and 3 were not significantly different. Rice grain yield in *Maha* season, treatment 3 was significantly different from treatment 1, 2 and 4 (Table 3). After 3 months, soil N% for *Yala* as follows; treatment 1 (0.05%), treatment 2 (0.024%), treatment 3 (0.119%), and treatment 4 (0.085%) (Figure 3a). End of *Yala* season, treatment 3 has highest N% comparing to the other treatments. Figure 2 showed the relationship between yield and treatments in *Yala* and *Maha* season. One third of urea from the recommended fertilizer was used for the treatment 2 and 4. Therefore, reduce the two third of urea usage and save 70% fertilizer cost for the treatment 2 and 4. Paddy straw Compost was used three times for the treatment 3 and 4 only.

3.4 Shoot and root dry weight

There was a similar trend of root and shoot dry weight in *Yala* and *Maha* season. Both season showed that treatment 3 and 4 significantly different from treatment 1 and 2 (Table 2 and 3).

3.5 Time of fertilizer application and total N of soil

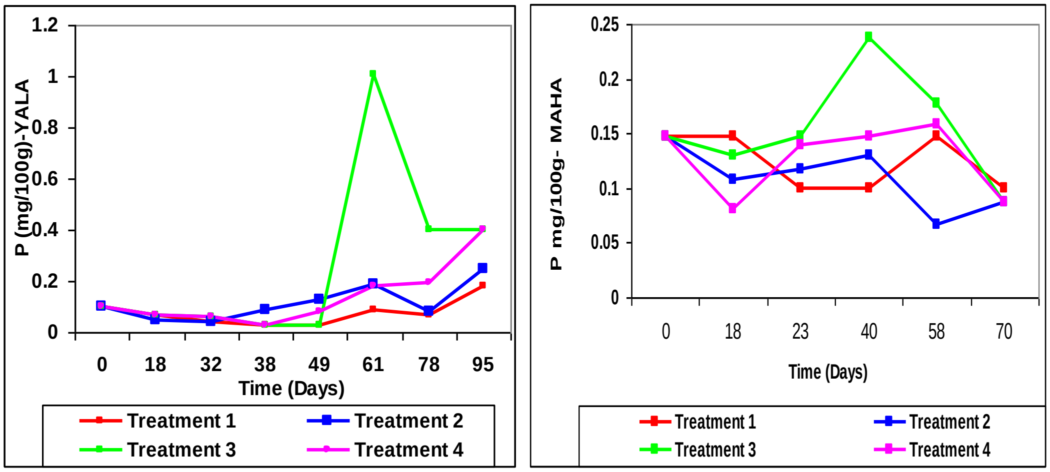


(a) (b)

Figure 3 Relationship between the time of fertilizer application and total N of soil-*Yala* (a) (b) *Maha*

According to the mean separation, there was no significant difference among treatments (Figure 3a and b). After 3 months of time soil N % for *Yala* as follows; treatment 1 (0.05%), treatment 2 (0.024%), treatment 3 (0.119%), and treatment 4 (0.085%). After 3 months of time soil N % for *Maha* as follows; treatment 1 (0.047%), treatment 2 (0.081%), treatment 3 (0.139%), and treatment 4 (0.083%). Total N of soil increment in treatment 4 for *Yala* was 0.035% with compare to the treatment 1. Total N of soil increment in treatment 4 for *Maha* was 0.036% with compare to the treatment 1. Most of the organic amendments supply low amounts of available N. In addition, the N from organic matter is also involved in other soil processes such as nitrification and denitrification. High C/N ratio of rice straw have a low N content and a high C/N ratio and expected to induce N immobilization during decomposition in soil (Ebid *et al*., 2007). Moreover, the addition of chemical fertilizer with composted paddy straw could facilitate decomposition in the short time. Addition of organic matter to flooded soil raises the NH_4^+ concentration of floodwater and leads to a pH increase (Sommer and Hutchings, 2001). Decrease in soil pH following organic materials can be partially attributed to the high release of organic acids.

3.6 Time of fertilizer application and total P of soil



(a) (b)

Figure 4 Relationship between the time of fertilizer application and total P of soil-(a) *Yala* (b) *Maha*

According to mean separation, there is no significant difference among treatments (Figure 4a and b). After 3 months of time soil P for *Yala* as follows; treatment 1 (0.1794 mg/100g), treatment 2 (0.2494 mg/100g), treatment 3 (0.399 mg/100g), and treatment 4 (0.399 mg/100g). After 3 months of time soil P for *Maha* as follows; treatment 1 (0.099 mg/100g), treatment 2 (0.087 mg/100g), treatment 3 (0.087 mg/100g), and treatment 4 (0.087 mg/100g). Soil P increment in treatment 4 for *Yala* was 0.2196 mg/100g soil with compare to the treatment 1. Total P of soil increment in treatment 1 for *Maha* was 0.012 mg/100g of soil with compare to the treatment 4.

3.7 Time of fertilizer application and total K of soil

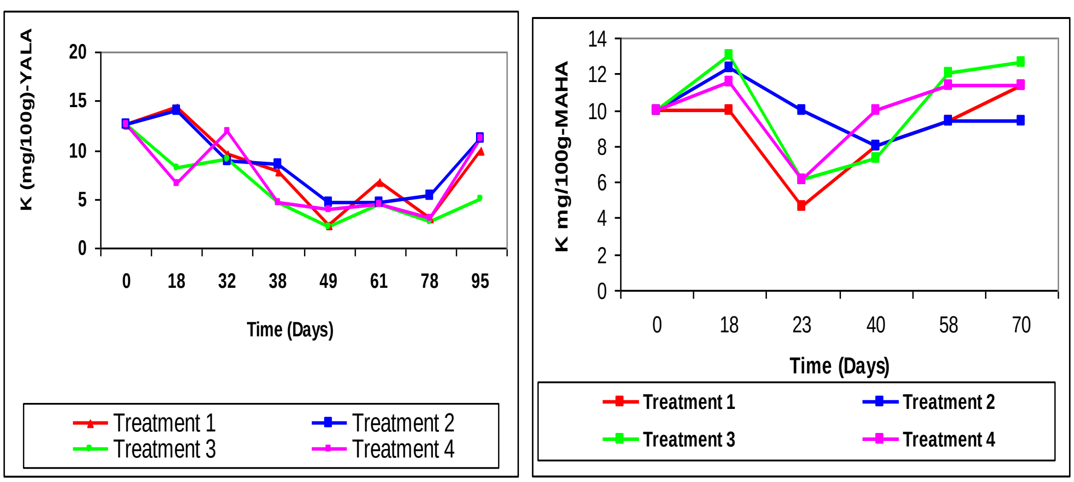
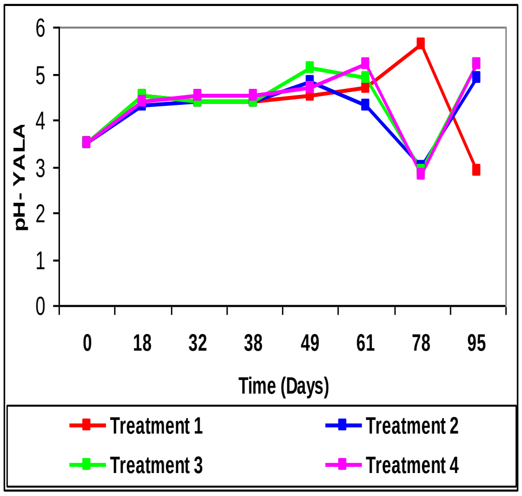


Figure 5 Relationship between the time of fertilizer application and total K of soil-(a)*Yala* (b) *Maha*

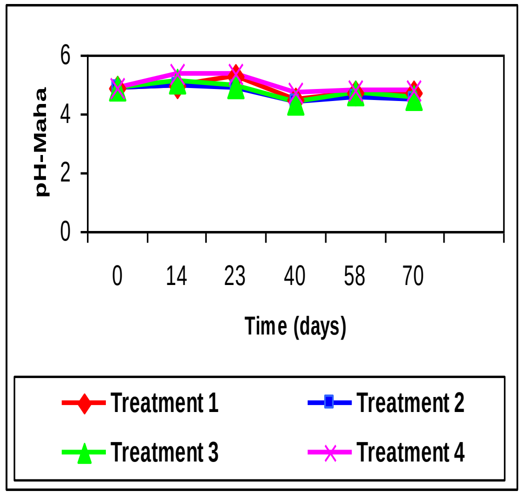
According to the mean separation there is no significant difference among treatments (Figures 5a and b). After 3 months, soil K for *Yala* as follows; treatment 1 (10 mg/100g), treatment 2 (11.17

mg/100g), treatment 3 (4.9 mg/100g), and treatment 4 (11.17 mg/100g). After 3 months, soil K for *Maha* as follows; treatment 1 (11.33mg/100g), treatment 2 (9.33mg/100g), treatment 3 (12.66 mg/100g), and treatment 4 (11.33 mg/100g). Soil P increment in treatment 4 for *Yala* was 1.17 mg/100g soil with compare to the treatment 1.

3.8 Soil pH



(a)



(b)

Figure 6. Relationship between the time of fertilizer application and pH of soil-(a)*Yala* (b) *Maha*

According to the mean separation there is significant difference among treatments in *Maha* season and no significant treatment effect in *Yala* season (Figure 6a and b).

3.9 Soil Organic matter

According to the mean separation there is significant difference among treatments in *Maha* season and no significant treatment effect in *Yala* season (Figure 7a and b).

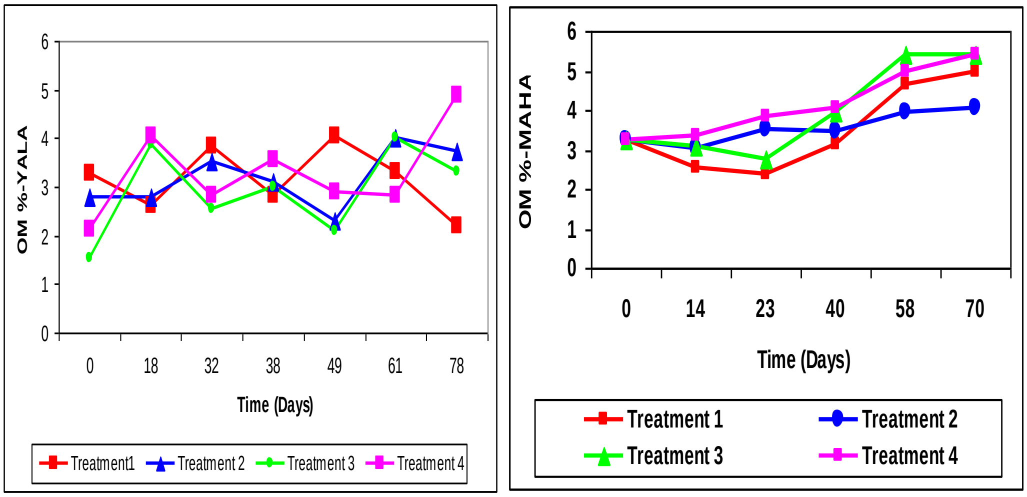


Figure 7. Relationship between the time of fertilizer application and organic matter of soil – (a)*Yala* (b) *Maha*

4.0 Conclusions

Paddy husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching losses of urea. And it also helps to reduce the phosphate and potassium leaching. Charcoal coated urea also increased the pH value of the soil for the desire level. Charcoal can be used as a soil amendment and organic fertilizer, but adjustment of pH is required at high application rates. In addition, this coating is less costly and helps reducing the fertilizer cost.

5.0 Acknowledgement

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