Plant and Soil

Extended Abstract

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On-farm spatial variability of Proso millet cultivation in Moneragala and Hambanthota districts of Sri Lanka

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1. Abstract

Proso millet (*Panicum miliaceum* L.) is a short duration minor millet cultivated in subsistence rain-fed farming systems in drier parts of Sri Lanka as a substitute for rice. It has been identified as an exemplar underutilised cereal crop for multiple security in future. The study was carried out to evaluate the present status of Proso millet cultivation in Moneragala and Hambanthota districts of Sri Lanka and to gather the indigenous knowledge of growers on Proso millet cultivation and use it in these districts, that will assist in agricultural decision making in the region. A field survey was conducted during March-June 2015 (*Yala* season) in Proso millet growing regions of Thanamalwila and Lunugamwehera divisional secretariat divisions of Moneragala and Hambanthota districts respectively. Above ground Proso millet plants of randomly selected 1 m^2 area were harvested from 41 farm fields at harvesting stage and yield analysis was performed. Daily rainfall data were collected from Thanamalwila Meteorological station. Results revealed that 96 % of the Proso millet fields were sown during a wet spell receiving at least 7 mm of rain in 2015 growing season, suggesting that rainfall distribution determines the Proso millet cropping pattern in the area. Proso millet farmers use high seed rate (2560 kg ha^{-1}) that leads to higher plant densities (61 to 601 plants m^{-2}) to control weeds and to recover the crop damages from excessive rainfall and animals. None of the fields were irrigated and no herbicide/pesticide was used while 4% of farmers fertilise their Proso millet fields with Urea. Yield varied from 470 kg ha^{-1} to 1956 kg ha^{-1} and the highest yield was from 351-400 plant m^{-2} category. Proso millet fields are maintained as low input agricultural systems. The study revealed some important information on Proso millet cultivation, its relationship to rainfall, yield and associated crop management practices in Moneragala and Hambanthota districts of Sri Lanka that will assist in agricultural decision making in the region.

Keywords: Dry seeding, high density, rainfall, yield

2. Introduction

Proso millet (*Panicum miliaceum* L.), a short duration minor millet that was reported among the first cultivated crops, is an exemplar underutilised cereal crop for multiple security in future where rainfall might be less reliable. It is the principal crop in drier parts of Sri Lanka, especially in Moneragala and Hambanthota districts during minor cultivation season, which is locally termed as '*Yala'* that falls during March to September, receiving a lesser amount of rainfall compared to the major cultivation season. These minor millets are cultivated in specialised agricultural niches (Seetharam et al. 2006) and found in one of the primitive agricultural systems known as *Chena*, grown as a rain-fed crop with low inputs.

Being a traditional crop among subsistence farmers, several different crop management practices can be observed in Proso millet fields. A knowledge gap exists for the Proso Millet grown in Sri Lanka by smallholders in mixed farming systems. Little is known about preferred geographic locations, climate resilience and other multiple avenues, but such knowledge could provide the basis for expansion of production under future climates. Exploitation of existing traditional knowledge and great potentials of Proso millet provides the platform for food and nutrition securities as a future crop that will directly contribute to the national development goals of Sri Lanka. Therefore, a study was carried out to evaluate the present status of Proso millet cultivation and to gather the indigenous knowledge of growers on Proso millet cultivation and use in Moneragala and Hambanthota districts of Sri Lanka.

3. Research Methodology

A field survey was conducted during March-June 2015 (*Yala* season) in Proso millet growing regions of Thanamalwila divisional secretariat (DS) division of Moneragala district and Lunugamwehera DS division of Hambanthota district. The study area was selected based on the grey literature and informal discussions with the Department of Agriculture Sri Lanka (DOASL). The study area belongs to Low Country Dry Zone (DL_{1b}) of the country. Fifty farmers were selected using random sampling technique. Researcher administered questionnaires were used to collect the data on sowing and harvesting dates, crop management practices and crop data. Above ground plants of randomly selected 1 m^2 area were harvested from 41 farm fields at harvesting stage during 23rd May to 4th June 2015. Three samples were collected from each field avoiding boundaries, foot paths, stones, water streams and big trees. Yield analysis was performed for the harvested plant samples. Daily rainfall data of the study period were collected from Thanamalwila Meteorological station of the Department of Irrigation Sri Lanka, which is the closest to the study area.

4. Results

Rainfall distribution determines the cropping pattern of Proso millet in these districts. Survey data revealed that all Proso millet fields were sown between 23rd March and 10th April, where the area receives rainfall from First Inter Monsoons. Seventy two percent of the fields were sown in March while 96% were sown during a wet spell receiving at least 7 mm. Rest of the farmers (4%) sow seeds without any rain either on the same day or day before. This is called 'dry seeding' and allowed farmers to get a lot of arable land sown at the time of first rain and reduce timely land preparation after the first useful rain (Marteau et al., 2011). Crops were raised for 55 – 70 days and harvested during 23rd May5th June period. Broadcasting is the major Proso millet planting method and none of the farmers in the study area practiced row seeding. The seed rate was recommended by the Department of Agriculture Sri Lanka (DOASL-http://www.agridept.gov.lk/) is 5-6 kg ha^{-1} while farmers in the area broadcasted about 25-60 kg ha^{-1} seeds resulting highly unevenly distributed fields. Plant density varied from 61 to 601 plants m^{-2} with the mean of 217±94. The value is far above the recommended plant density (33-44 m^{-2}) by DOASL. Proso millet farmers in the study area prefer high plant density in order to control weeds and to recover the crop damages from excessive rainfall, animal (birds and elephants) associated damages etc. None of the fields was irrigated and no herbicide/pesticide was used during cultivation. Among farmers, 4% fertilise their Proso millet fields with Urea while others do not use any kind of fertilizers. Yield varied from 470 kg ha^{-1} to 1956 kg ha^{-1} with the mean of 1180 kg ha^{-1} and the values were lower than the potential yield of 4000 Kg ha^{-1} (DOASL). The highest yield was recorded from 351-400 plant m^{-2} category. Increment of plant density significantly ($p > 0.05$) decreased panicles per plant, seed number per panicle, harvest index and biomass partitioning to seeds. In yield components, panicle density (m^{-2}) and seeds number per panicle showed a positive significant ($p > 0.05$) relationship with grain yield (gm^{-2}) while panicles per plant, mass per grain (mg) and yield per plant (g) did not show a significant ($p < 0.05$) relationship with grain yield (gm^{-2}).

5. Conclusions

Farmers maintain high Proso millet plant density to control weeds and to recover the crop damages from excessive rainfall and animals. Increment of plant density decreased panicles per plant, harvest index and biomass partitioning to seeds. Proso millet cultivation found in low input subsistence farming systems of Moneragala and Hambanthota districts in Sri Lanka are well adapted to their climates. The study revealed some important information on Proso millet cultivation, its relationship to rainfall, yield and associated crop management practices in Moneragala and Hambanthota districts of Sri Lanka that will assist in agricultural decision making in the region.

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Extended Abstract

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The Effect of Amended Soil with Rice Husk biochar Coated Urea and Rice Straw Compost on Nutrient leaching

1. Abstract

Excessive application of fertilizer has caused the release of nutrients, such as nitrogen and phosphorus, from agricultural fields to aquatic systems. Leaching of nutrients from soils may deplete soil fertility, accelerate soil acidification, reduce crop yields, and most importantly impose a threat to environmental health. An option to reduce nutrient leaching could be the application of biochar to soils. Objective of this study was to produce rice husk biochar coated urea and rice straw compost as a slow releasing fertilizer and to compare the leaching losses of nitrogen, phosphorus and potassium using leaching columns. Leaching column studies were prepared using 1.2 m tall PVC pipes with a diameter of 15 cm and a sampling port was attached to the bottom end of the column-cap. Leachates (100 ml/leaching column) were obtained from two sets of (each has four leaching columns) leaching columns. The sampling was done once a week for 3 month period. The cumulative NO_3^--N leaching losses of eighty three days of different treatments were as follows; treatment 1 was 602.16 mg/L, treatment 2 was

423.28 mg/L, treatment 3 was 332.28 mg/L and treatment 4 control was

185.24 mg/L. Rice husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching losses of urea. It also helps reduce the phosphate and potassium leaching. The cyclic effect of phosphate release is an important finding which could be the central issue in defining microbial behavior in soils. The fluctuations of phosphate may have cyclic effects of 28 days. In addition, this coating and rice straw compost contribute to mitigate pollution of water bodies by inorganic fertilizers.

Keywords: Leaching, mitigate, rice husk charcoal, slow releasing fertilizer

2. Introduction and research problem/issue

Nutrient retention of a soil is one of the important aspects pertaining to the fertility of a soil. The use of nitrogenous fertilizers is one of the major reasons for the increased agricultural productivity. Unused N in the soil profile is either removal through leaching, de-nitrification or volatilization. Nitrate leaching which causes contamination of ground water has become a major concern worldwide. Rising nitrate concentration in groundwater has been detected in developing countries such as India and Sri Lanka where agricultural production has been intensified through application of urea above the recommended levels (Mikunthan and de Silva, 2008). Specially, non-point source pollution of nitrate in ground water is a major problem in many areas of Sri Lanka in both hard rock and limestone aquifers. As a result, nitrates concentrations ingroundwater exceeds the drinking water standard in these areas. A great deal of emphasis has been focused on the groundwater quality aspects in the dry zone of Sri Lanka (Christensen and Dharmagunawardena, 1986).

Phosphorus transported from agricultural lands to surface waters can promote eutrophication. It refers to an abnormally high growth of algae and aquatic weeds in surface waters. As organic material decays, natural oxygen levels decline, which leads to changes in fish population or fish deaths. Other common problems associated with eutrophied water bodies include less desirable or restricted recreational use, unpalatable drinking water, and increased difficulty and cost of drinking water treatment. Eutrophic surface waters may also experience massive blooms of cyanobacteria, which can kill livestock and pose health hazards to humans (Brady, 2002). The excessive reuse of the groundwater resources with considerable application of organic and inorganic fertilizers lead to a deterioration of the quality and quantity of water(Nadarajah, 2002).

Biochar is a form of charcoal produced through the heating of natural organic materials like crop wastes, organic fraction of municipal wastes, chicken litter, timber etc. under low or without oxygen conditions. In mixing both urea and rice husk charcoal in soils causes a slow release of inorganic fertilizer and nitrogen retains (Basnayake, 1994), thus reducing the cost of importations of nitrogen based fertilizers per unit area of cultivation. Objective of this study was to determine the behavior of rice husk charcoal coated urea as a slow releasing fertilizer and measure the leaching losses of nitrogen, phosphorus and potassium.

3. Research Methodology

Two sets of leaching columns were prepared using 1.2 m tall PVC pipes with a diameter of 0.15m. Gas measuring and leachate recirculation orifices were made at the top of the column. Gas collection was done by using of the polythene tubes. A sampling port was attached to the bottom end of the column-cap. There was a container connected to the system to maintain a constant height of liquid (5cm). Four PVC pipes of 1.2 m high and 0.15 m diameter were used to make leaching columns. A 40 mm thick layer of precleaned, washed, and dried gravel with a particle size of 5-7.5 cm was used as the filter medium. Rice soil was taken from the MegodaKalugamuwa, Kandy, Sri Lanka. Production of 1 kg of fertilizer having a ratio of char: urea (2:1) requires 3050 g of dried manioc starch. Carbon powder and urea were mixed thoroughly and with the help of cassava gum, granules of 1.0cm diameter were formed.

Three layers of rice soils (each 5kg) were packed in the column with the bulk density of 1.3kg/m^3, but the same order of layers as in the field. Every column was filled with 15 kg of rice soils as a substrate and the columns were saturated with water for 2 weeks. Four treatments were used for the columns, namely; inorganic fertilizer only (Urea, TSP and MOP) (Treatment 1), rice husk charcoal coated urea, TSP and MOP only (Treatment 2), rice straw compost, (Treatment 3) and no fertilizer as a control (Treatment 4). According to the Department of Agriculture (2009) recommendations, fertilizer for 3 1/2 months variety was used for the columns except control. Same amounts of N, P and K were applied for the each column surface area. A soil sample was obtained before loading fertilizer onto the column, to evaluate the soil physicochemical parameters. The 100 ml leachates were obtained from the leaching columns. The sampling was done once a week for 12 weeks period. The treatments were set up in a completely randomized design. Analysis of variance (ANOVA) was performed and differences in mean values determined using t-test at $p<0.0001$ and employing ANOVA, and least significance difference procedures (SAS Institute (2011) SAS/STAT User's Guide (Version 9.2). Statistical Analysis System Inst, Cary).

4. Results and findings

The cumulative NO_3^--N leaching losses of eighty three days of different treatments were as follows; treatment 1 was 602.16 mg/L, treatment 2 was 423.28 mg/L, treatment 3 was 332.28 mg/L and treatment 4 control was 185.24 mg/L. According to the cumulative addition of nitrogen to the columns except the control, leaching loss of NO_3^--N percentages is as follows; treatment 1 was 65.7%, treatment 2 was 41.2%

and treatment 3 was 21.8%.The efficiency of the urea-N in rice culture is very low, generally around 30–40%, in some cases even lower (Choudhury and Khanif 2001, 2004). According to the results of mean separation, the results of all of the treatments are significantly different from each other ($p<0.0001$). Treatment 1 has the highest value of NO_3^--N leaching and 2, 3 and 4 comes in descending order.

The cumulative leaching losses of P of eighty three days of different treatments were as follows; treatment 1 was 10.98 mg/L (0.66%), treatment 2 was 8.39 mg/L (0.19%), treatment 3 was 8.7 mg/L (0.14%) and treatment 4, control was 7.2 mg/L. According to the cumulative addition of phosphorous to the columns except the control, leaching losses of P percentages as follows; treatment 1 was 0.66%, treatment 2 was 0.19% and treatment 3 was 0.14%. Considering, P there are significant treatment effects cumulative leaching losses of P of eighty three days of different treatments were as follows; treatment 1 was 10.98 mg/L (0.66%), treatment 2 was 8.39 mg/L (0.19%), treatment 3 was 8.7 mg/L (0.14%) and treatment 4, control was 7.2 mg/L. According to the cumulative addition of phosphorous to the columns except the control, leaching losses of P percentages as follows; treatment 1 was 0.66%, treatment 2 was 0.19% and treatment 3 was 0.14%. Considering, P there are significant treatment effects. The fluctuations of phosphate may have cyclic effects of 28 days . The rate increased gradually to a peak and then reduced to lower values. It can be mathematically expressed as logistic growth equations, applicable for microbial growth and decay. The microbial cyclic effects have been recorded by Madhi et al., (2011) and Sharma et al., (2013).

The cumulative leaching losses of K of eighty three days of different treatments were as follows; treatment 1 was 346.64 mg/L, treatment 2 was 262.36 mg/L, treatment 3 was 296.48 mg/L and treatment 4 control was 231.94 mg/L. According to the cumulative addition of potassium to the columns except the control, leaching losses of K percentages as follows; treatment 1 was 19.26%, treatment 2 was 5.05% and treatment 3 was 17.78%. According to the mean separation treatment 1 has the highest K followed by 3, 2 and 4. However, the treatment 3 and 2 are not significantly different and again 2 and 4 are also not significantly different.

Treatments 4 and 3 have the higher pH than treatment 1 and 2. There are also relationships between fertilizer application and NO_3^- -N and PO_4^{3-}-P leaching and pH. The relationship between soil pH and nutrient uptake efficiency is that fertilizer use and crop response are expected to change as a function of soil pH (Silveira, 2013).

According to the Table 1 shows that the cumulative leaching losses of nutrients kilogram per hectare (soil depth was 20cm).

Table 1: Leaching losses of the nutrients

Nutrient	Treatment 1	Treatment 2	Treatment 3	Treatment 4
NO_3-N (kg/ha)	$30.10^a \pm (0.31)$	$21.64^b \pm (0.51)$	$16.64^c \pm (0.21)$	$9.26^d \pm (0.11)$
PO_4-P (kg/ha)	$0.549^a \pm (0.21)$	$0.419^b \pm (0.45)$	$0.435^b \pm (0.16)$	$0.360^b \pm (0.39)$

K (kg/ha)	4.357[a]± (0.95)	3.294[b]± (0.32)	3.709b[c]± (0.21)	2.915[c]± (0.98)

Mean followed by the same letter at each column are not significantly different (p=0.05), each value represents the mean of two replicates. SD is given in parenthesis

5. Conclusions, implications and significance

Rice husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching loss of NO_3^--N, $PO^{3-}{}_4$-P and K. It is possible to reduce proportionality the amount of urea applications, considering both ammonia volatilization and NO_3^--N leaching losses. It can be amount up to 60% to 70% in saving of urea applications, thus retaining adequate nitrogen in soil for plant uptake as reported. The cyclic effect of phosphate release is an important finding and it could be the central issue in defining microbial behavior in soils. The fluctuations of phosphate may have cyclic effects of 28 days. Charcoal coated urea increased the pH value of the soil. It can be used as a soil amendment and as an organic fertilizer, but adjustment of pH is required at high application rates.

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