Gliricidia Sepium as a Source of Green Manure for Improving the Productivity of Tropical Smallholder Farming Systems

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Abstract

Adopting agro forestry systems is a possible remedy for improving tropical smallholder farming systems located on degraded lands. *Gliricidia sepium,* which has the possibility to enhance soil fertility as well as to provide nutrients to crops over time, can be introduced in to these systems. Many studies have examined the impact of *Gliricidia sepium* on crop productivity under alley cropping systems. However, due to lack of studies on the use of green manures on enhancing the sustainability of tropical smallholder farming systems, a field study was carried out to determine the benefits of adding *Gliricidia sepium* green leaf manure to home gardens and adjacent cultivated fields located on sloping, moderate and flat terrains in the Meegahakiula region of Sri Lanka. Thirty households including home gardens and their adjacent cultivated fields were selected along the terrain. Field experiments were conducted using three treatments including NPK+*Gliricidia*, *Gliricidia* only and the control over the 2007/8 *Maha* and 2008 *Yala* seasons using maize and mung bean as the test crops, respectively. Soil sampling was done up to a depth of 60 cm considering the rooting depths of the selected crops to analyze soil quality and plant samples at crop maturity. Inclusion of green manure improved the soil properties significantly in home gardens in all categories irrespective of the slope. Yield increments were greatest in the eroded steep category due to Gliricidia green leaf manure while the beneficial impact was greater in maize than in mung bean. The incorporation of *Gliricidia sepium* as a source of green manure for sustaining crop yields in major and minor seasons in degraded lands in the tropics was clearly evident from this study.

Key words: *Gliricidia sepium*, Home gardens, Terrain

Introduction

Low nutrient holding capacities, high acidity, low organic matter, poor soil structure and low water-holding capacity are constraints in tropical crop productivity. These constraints are in some cases exacerbated by over exploitation through continuous cropping and low nutrient application rates (Mafongoya et al. 2006). Especially, variation of soil fertility is one of the critical issues related to crop production in Asian countries. The main constraint for improving agricultural productivity in these countries is to build up and maintain soil fertility despite low incomes. Nutrient rich leguminous green manures have the ability to sustain soil and crop productivity on the highly weathered soils sited in humid and sub humid tropics. They are known to enhance nutrient uptake and improve soil physiochemical and biological properties. *Gliricidia sepium* is one of the most promising multipurpose tree species which has the ability to replenish soil fertility of degraded lands in the tropical region. According to a study done by the Coconut Research Institute of Sri Lanka, inclusion of *Gliricidia* had shown elevated levels of organic carbon, N and P compared to non treated plots. With the continuous lopping of *Gliricidia* as a renewable forestry, such plant nutrients are expected to be high in the surface layer of soil (Gunathilake, 2005).

Meegahakiula is a typical example of tropical smallholder upland farming systems, associated with soil degradation and low productivity. The region is characterized by high-gradient slopes ranging from 40 – 80 % thus being highly vulnerable for soil erosion. Two farming systems were identified in the region: home gardens where intensive management practices are adopted and cropping fields which had been

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managed under shifting cultivations with annual food crops and tobacco for many years. Due to lack of studies on the use of green manures on enhancing the sustainability of such tropical smallholder farming systems, this study was carried out to determine the benefits of adding *Gliricidia sepium* green leaf manure to home gardens and adjacent fields located in Megahakiula region of Sri Lanka.

Materials and Methods

The experiment was conducted for one year spanning two planting seasons (2007/8 *Maha* and 2008 *Yala*) in the Meegahakiula region of Badulla district of Sri Lanka (IM_{1c} agro ecological zone), at 81°02.740' E and 7°07.485' N at an altitude of 327 above MSL. The experimental site was located in a region where Red-Yellow Podzolic Soils (Mahawalatenna Series; USDA: Ultisols - Udults - Rodudults, Tropudults) and Mountain Regosols predominate (Panabokke, 1996). The average rainfall of the region is greater than 1300 mm per annum at 75 % probability level. Based on the elevation the land was divided in to 3 gradient categories as flat (gradient < 10 %), moderate (gradient 10 - 30%) and steep (gradient > 30 %). In total, 30 home gardens and 30 cropping fields representing 10 from each gradient category were selected in order to obtain an equal representation from each category. This selection represented 40 % of the total smallholder farms located in the region. Selected home gardens and cropping fields were planted with maize (*Zea mays* L.) (Variety Ruwan - OPV) during the 2007/08 *Maha* season (spacing 60x30 cm) and *Vigna radiata* (variety - MI 6) during the 2008 *Yala* season on plots at a spacing of 15 cm along the rows and 45 cm apart between the **rows**. An experimental plot of 30x30 m was marked in each site and it was divided to equal 3 parts to accommodate treatments (T_1- NPK + 3 mt fresh wt/ *Gliricidia*, T_2- Zero fertilizer + 3 mt / ha *Gliricidia and* T_3 *- zero fertilizer + zero Gliricidia*).

In both seasons, *Gliricidia sepium* was added two weeks prior to the planting of maize and mung bean to increase the rate of decomposition. Application of *G.sepium* green leaf manure was based on the fresh weight (FW) and the application rate was 3 mt/ha. Plant samples were obtained at crop maturity to quantify total biomass and seed yields. At the same time soil samples were obtained by considering the rooting depth of maize at 10 cm intervals up to a 60 cm depth. Soil samples were oven dried and were analyzed for five chemical parameters: soil pH (pH meter), organic matter (Walkey and black method (van Ranst et al. 1999), total N (Kjeldahl (van Ranst et al. 1999), available P (Olsen and Sommers, 1982), and exchangeable K (Knudsen et al. 1982). Since home gardens and fields are nested within the slope

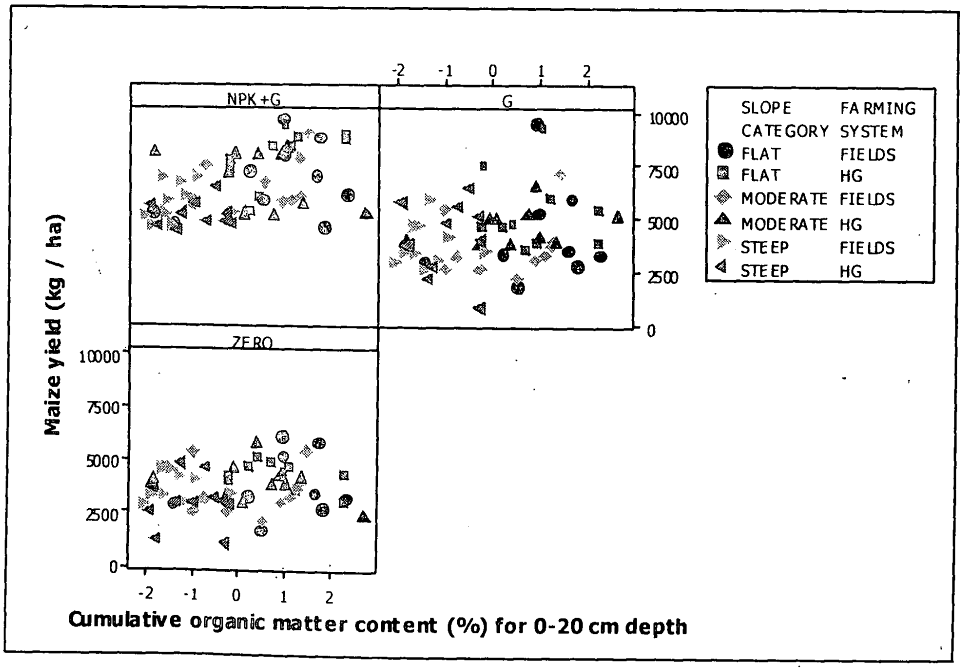

Figure 1: Relationship of seed yield of *Z. mays* in the major season with cumulative soil organic matter contents and the farming system

category, a nested ANOVA was used. The LSD (p=0.05) test was used to determine the significant difference among means. All data were analyzed using a General Linear Model (GLM) with the SAS (SAS Institute Inc, 1999) program.

Results and Discussion

Soil organic matter content (%) of the *Gliricidia* treated plots showed a significant increment ($p < 0.05$) over the non treated plots in both farming systems. Cherr et al. (2006) reported that the application of *Gliricidia* green leaf manure improves the fertility of the soils by increasing the SOM content. However, the mean organic matter content (%) declined significantly ($p = 0.0001$) with increasing inclination irrespective of the farming system and the treatments. This is an important implication indicating the impoverishment of the soil through continuous crop production on these lands. *Gliricidia* treated plots of the (NPK + G) home gardens in the flat, moderate and steep gradient categories contained 39 %, 28 % and 28 % more organic matter content than the control (Zero) respectively. However, there was no significant difference ($p > 0.05$) between the two systems of farming in each category in terms of organic matter increment.

Total soil nitrogen content (mg N / g soil) followed the similar pattern as that of organic matter. *Gliricidia* treated plots of both farming systems showed significantly high amounts of total N over the non treated plots ($p < 0.05$). Phombeya (1999) has shown that the application of *Gliricidia* Green Leaf Manure (GGLM) may result in the almost immediate release of N. If inorganic fertilizer is added, it may release up to 60 % of its N content within three weeks and 70 % within 24 weeks. The mean total N content declined significantly with increasing inclination in both home gardens ($p < 0.0001$) and fields ($p < 0.0001$). The increment of total soil N content over the control in *Gliricidia* treated plots of the home gardens in the flat gradient category was greater (41 %) than the increment achieved by the fields of the same category (15 %). However, in other two gradient categories the increment of total soil N in *Gliricidia* treated plots over the non treated plots was similar irrespective of the farming system. The total soil N increment in the *Gliricidia* treated plots (NPK + G) of the moderate and steep home gardens was 28 % and 27 % while it was 23 % and 24 % for fields of those two gradient categories respectively.

Seed yield of maize (*Zea mays* L.) during the major cropping season (2007/8 *Maha*) decreased significantly ($p<0.0001$) with the increasing inclination in both systems of farming. *Gliricidia* treated plots of the home gardens and fields in the flat gradient category produced 6 % and 11 % more yield of maize respectively over the control. Furthermore, the yield increment over the control in G000liricidia treated plots in the home gardens and fields of the moderate gradient category was 18 % and 16 %, respectively. Importantly, *Gliricidia* treated plots of the steep gradient category showed the greatest yield increment (22 %) than the home gardens (6 %) in the same gradient category. During the minor cropping season (2008 *Yala*) mung bean yield decreased significantly with the inclination ($p < 0.05$). The lowest yield increment in *Gliricidia* treated plots over the control was recorded in the flat gradient category (9 % and 8 % for home gardens and fields respectively). In contrast, the highest yield increment was observed in the *Gliricidia* treated plots of the fields of moderate and steep gradient categories over the control (34 % and 23 % respectively). Comparatively low yield increment was observed in the *Gliricidia* treated plots of the home gardens in the moderate and steep gradient categories over the control (5 % and 8 % respectively).

As explained earlier addition of *Gliricidia sepium* improved the soil properties, especially soil organic matter content. Therefore, a new variable was developed using organic matter content of the surface soil layer (0 - 20 cm). Principle Component Analysis (PCA) was used to define the new variable to explain the importance of soil organic matter in determining maize and mung bean yields.

One principle component was defined using a correlation matrix with an Eigen value of 1.63 and the cumulative proportion of variance was 82 %. The clustering was done using the gradient category and the type of farming system. Farms producing higher yields arise from the home garden group in each treatment. Application of *Gliricidia sepium* (NPK + G and G only) improved the soil organic matter content and thus contributes to higher seed yield of maize over the control (Zero). Therefore, these farms are clustered in the high organic matter area of this graphical representation (Figure 1). Home gardens in the flat gradient category produced greater seed yields of maize with the application of NPK + G and G only treatments over the control. In contrast, the fields in the steep gradient category produces greater seed yield of maize with the adoption of NPK + G and G only treatments when compared with the home gardens in the same gradient category and clustered together. This was not evident during the minor season.

Application of *Gliricidia sepium* as a source of green manure has increased the yields of maize and mung bean in both home gardens and fields especially in the flat gradient category. On the other hand the yield increments were greatest in the eroded steep category when compares to the other two categories. The incorporation of *Gliricidia sepium* as a source of green manure for sustaining crop yields in major and minor seasons in degraded lands of the smallholder farming systems was clearly evident from this study.

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