Improved fallow and live-staking of yam using *Gliricidia sepium* in Papua New Guinea

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Abstract

A novel agroforestry system using the leguminous tree *Gliricidia sepium* (Gliricidia) as improved fallow and live stake for yam (*Dioscorea* spp.) is being evaluated in several locations in Papua New Guinea. The trees are established from pole cuttings directly into degraded grasslands, 8-12 months before planting yam. Gliricidia poles are planted on a 2 x 2 m grid, each tree supporting four yam vines. Data from four trial sites harvested in 2003 showed no difference in yield attributable to staking system, while NPK fertilizer increased yield by 50% (from 18.6 to 27.9 t/ha) on two Bogia District sites, but not on two Markham Valley sites. While positive responses attributable to nutrients contributed by Gliricidia leaf mulch are not yet evident, these preliminary results indicate that, when regularly pruned, the trees do not compete to the detriment of the crop, and can reduce management inputs for weeding and staking. The system may alleviate many of the problems associated with shortened fallows, including weed intensity, decline in soil nutrient availability and organic matter content, and shortage of staking materials. Further benefits to farmers include softer soil texture, and shading of workers at planting and harvest. The trials are continuing to evaluate medium-term impacts on soil and crop. Further long term experiments are needed to assess the system fully.

Media summary

A legume-based agroforestry system provides PNG yam growers with a viable alternative to slash-and-burn.

Key words

Short fallow stabilization, Dioscorea esculenta, Dioscorea rotundata.

Introduction

Probably the oldest staple food crop in the Pacific, yam has great cultural significance for many subsistence farmers today. In areas with a seasonal drought, the storability of yam is vital, making it the dominant staple food. However, even in the most remote areas, land pressure has reduced the length and quality of fallows, with grasslands increasingly dominant and resulting shortages of timber for building, for fuel, and for yam stakes. Farmers report declining yields of yam. Traditional burning of fallows, while giving a flush of available nutrients, is believed to exacerbate the cycle of decline under short fallows, through loss of volatile nutrients and soil organic matter.

The current study sought to address declining yields of subsistence yam crops. Given that purchased fertilizers are unlikely to be widely adopted, an improved fallow system was sought which would contribute nutrients to the crop and discourage burning, while not increasing the farmers' workload with the maintenance of "unproductive" plants. A legume-based planted fallow would reduce the need for burning by controlling weeds, and the retention of fallow species into the cropping cycle would provide a conspicuous reason not to burn.

Budelman (1990a and 1990b) compared three leguminous trees (*Leucaena leucocephala*, *Gliricidia sepium* (Gliricidia) and *Flemingia macrophylla*) in Ivory Coast for their suitability as live-stakes for *Dioscorea alata*. Gliricidia was found to have suitable architecture of both tops and roots, providing sturdy support without excessive shading, and minimizing competition within the crop root zone. Otu and Agboola (1994) subsequently reported positive results of Gliricidia live-staking of *D. rotundata*. The tree is widely distributed in Papua New Guinea. Being planted from large pole cuttings, it is easily established even among grasses. Some farmers in NW Madang Province were found to have recently adopted Gliricidia fallowing to reclaim grassland for gardening by shading out the understorey. Beginning with these farmers, and later extending to collaborators in other provinces, trial plots of a Gliricidia live staking system were established. The current paper presents initial findings from this evaluation.

Methods

Medium-term agroforestry trial sites have been established at a number of locations, identified following a survey of selected yam-growing areas. Locations include Bogia district in NW Madang Province, the Markham Valley in Morobe Province, and Kiriwina Island in the Trobriand Group, Milne Bay Province (data not yet available from the latter). At each location, 4 trial sites were established, usually under management of different collaborating farmers. Each site contained four plots constituting a single replicate of a 2 x 2 factorial experiment, with and without Gliricidia live-staking, with and without mineral fertilizer. Preliminary pot experiments (data not presented) were used to identify nutrient deficiencies in the soils to estimate fertilizer requirements.

The Gliricidia alley-cropping system described by Budelman (1990b) was modified to more closely resemble traditional Melanesian yam garden systems. Gliricidia stakes (approximately 2.5 m in length) were planted on a 2 x 2 m grid, 8 to 12 months prior to planting yam (Figure 1a). Before planting yam, a pig-proof fence was constructed around the block. In the control plot, fallow vegetation was cleared and the plot burnt. On other plots, weeds were uprooted but left on the plot as mulch.

a) **b)** **c)**

Figure 1. a) Eight-month-old Gliricidia trees in an experimental plot being cleared for yam planting; b) Preparing holes for yam planting, showing arrangement of four yams around each tree, and pig-proof fence in background; c) Applying fertilizer to two-month-old *D. esculenta* growing on Gliricidia live stakes.

Yam planting setts (small whole tubers of *D. esculenta*, or sprouted minisetts (30-50g) of *D. rotundata*) were selected for uniformity and distributed evenly among the four plots according to size. Each plot contained 25 datum plants surrounded by 24 guard plants (Figure 2). Yams were planted on a 1 x 1 m grid, so that each Gliricidia tree, where present, was surrounded by four yams (Figure 1b). Plots without Gliricidia trees received traditional staking with a dead 2 m pole at each mound. Fertilized plots received Triple Superphosphate (150 kg P/ha) buried under the planting hole before planting, Potassium Chloride (80 kg K/ha) and Urea (74 kg N/ha) half at two-three months and half at approximately five months after planting. Gliricidia trees were pruned near the base of all branches after emergence of the yam vines. Pruned branches were leant from each mound to the tree to guide the vines (Figure 1c). All prunings were left in the plot as mulch. Subsequent pruning was required at approximately two-month intervals. After yam vines began to senesce, the trees were left unpruned through harvesting and the dry season until after emergence of the subsequent yam planting.

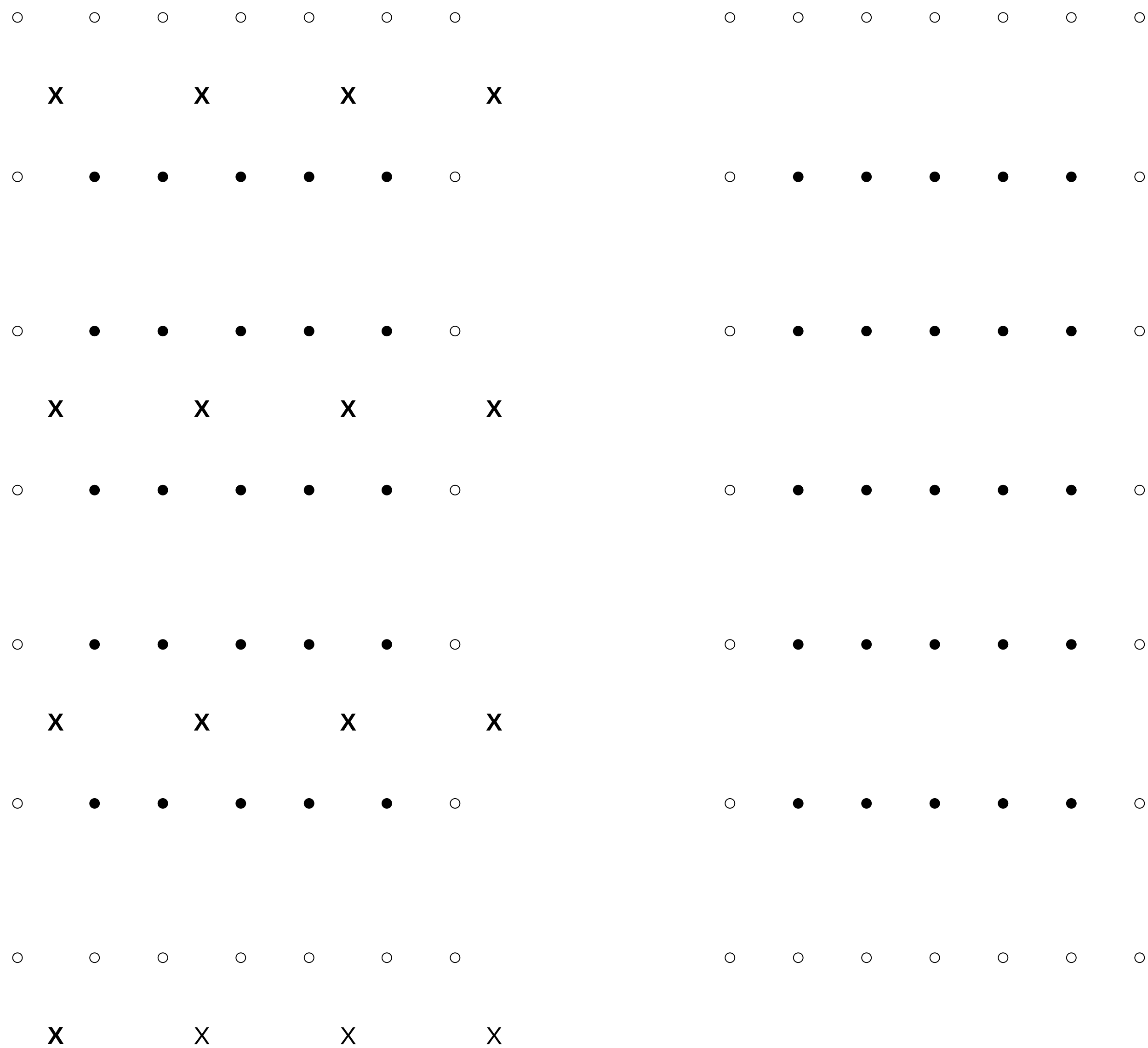

Figure 2. Layout for two of four plots at each site. One pair of plots was fertilized, and a similar pair unfertilized. X Gliricidia tree, • yam datum plant, ○ yam guard plant.

At approximately three months, yam leaves (blades from the 6th and 7th node from an active tip) were sampled from each plot for analysis of nutrient content. At harvest, tuber number and weight of marketable (>250g) and unmarketable tubers were recorded for each datum plant.

Results and Discussion

The yam yields presented in Figure 3 are from four sites harvested in 2003. Some planted sites were not harvested due to damage, hence data are available from only two sites each from the two locations planted in 2002. At all sites, there was no significant change in tuber yield between traditionally-staked and live-staked plots. The Bogia district sites (Dugumor village) both recorded a significant positive response to fertilization, but the Markham sites (Bubia research station) did not. Mid season leaf analyses (data not presented) did not show significant differences attributable to treatments.

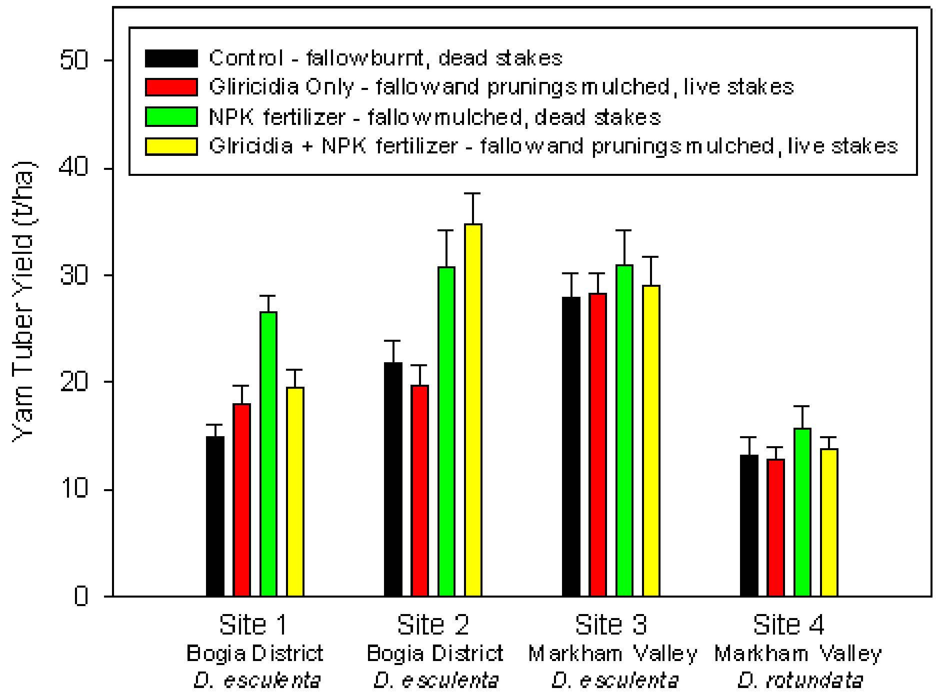

Figure 3. Yield of tubers from four trial sites harvested in 2003. Error bars are standard errors for each plot mean based on individual plant yields.

Other observations from the trials indicate several advantages of the agroforestry system. Yam establishment was more successful under Gliricidia partial shade, especially for *D. rotundata* where pre-sprouted minisetts were planted. Weeds were fewer and easier to remove on mulched plots than on the control plots. Under traditional staking, broken or fallen stakes are a common problem, which was not encountered with live stakes. At harvest, the Gliricidia plots were easier to dig, due to higher soil moisture. At garden establishment, soil under Gliricidia fallow was also observed to be easier to work than under *Imperata cylindrica* grass fallow.

Ongoing studies are monitoring nematode populations during sequential cropping under each treatment, assessing changes in soil organic matter and nutrient content, and quantifying the nutrient input from tree prunings. In more recently established sites (data not presented here), a cover crop of *Dolicus lablab* was sown under the Gliricidia. The effects of this treatment on crop nutrition and weed management are also being evaluated.

It is anticipated that the trees may be maintained for at least six years, depending on location, before growing too big to be manageable in the crop system. A typical cropping system may have the following sequence: one year of planted fallow with newly established Gliricidia and Lablab, followed by one or two crops of yam, and one year of cropping with mixed vegetables which tolerate some shade (such as taro and sweet potato) and those which may benefit from the trees' support (tomato and cucumber). The trees would persist through a second one year fallow underplanted with Lablab or other legume, before returning to yam. During this second fallow, the unpruned trees may produce useful pole-wood for fencing and other light construction. The trees may be removed following the yam harvest before planting mixed crops preferring full sun, and those crops which may be maintained for more than one year (such as banana, aibika and pineapple). Gliricidia trees may be established among the latter as the garden is running down, to begin the cycle again.

The system represents little change in the traditional cropping sequence, but a major change in the management of soil and weeds. The high requirements for labour and staking materials limit the scale of yam production for many farmers, and both these costs are considerably reduced in the proposed system. Partial shading improves working conditions during planting and harvest, and the managed fallow and mulching reduces weed infestation. Improved crop performance may be achieved through protection during establishment, nutrient inputs and soil moisture retention from legume mulching, and over time organic matter accumulation improving soil texture, pH buffering, nutrient availability and water-holding capacity. Further long-term experiments are needed to quantify these effects.

Conclusions

The data represented are preliminary results from medium-term experiments, where management procedures are still being optimized, and which might be expected to show cumulative benefits over several years. Hence the results are encouraging, as they indicate that yam (*D. esculenta* and *D. rotundata*) may yield equally well with Gliricidia live-stakes as with traditional staking. Better management of pruning operations to reduce shading may improve yam performance further.

Achieving change in crop management by traditional farmers is difficult at best. However, traditional management appropriate to long-fallow slash-and-burn systems becomes inappropriate as cropping intensifies. The change needed is quite profound: for Melanesian farmers, a good garden is a clean garden, cleared of all soil-covering by burning and weed removal. The Gliricidia live-staking system has potential to offer subsistence farmers enough incentives to move away from traditional practices.

Acknowledgement

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