Cowpea Yield Performance in an Alley Cropping Practice on an Acid Infertile Soil at Ebini, Guyana

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Abstract: The yield performance of cowpea var. Minica # 4 (*Vigna unguiculata* L.) on an Arenic Paleudult (Acrisol) was evaluated in an alley cropping experiment with *Gliricidia sepium* (Jacq.) Kunth ex Walp., *Leucaena leucocephala* (Lam.) de Wit and a treeless control during a short- (November-December 2004), and long-(May-June 2005) rainy season at Ebini, Guyana. The alley cropping treatments had no significant effect on cowpea plant height, pods per plant, pod weight per plant and grain weight. During the short-rainy season, values for cowpea plant height and number of pods per plant were higher compared to those for the long-rainy season, and number of pods per plant was positively correlated with pod weight. During the long-rainy season, pod weight and grain weight were correspondingly higher. Plant height vs. number of pods per plant; number of pods per plant vs. pod weight; and, number of pods per plant vs. grain weight, were all positively correlated. Cowpea could yield the same or more when associated with managed fast growing, nitrogen (N)-fixing trees or treeless plots. This alley cropping practice has the potential to reduce the use of fossil-fuel generated fertilizers and reduce the potential production of an important greenhouse gas (GHG).

Keywords: Humid tropics, sandy soils, agroforestry system, *Gliricidia sepium*, *Leucaena leucocephala*, Minica #4, pruning.

INTRODUCTION

The Intermediate Savannas (5^0 30” N, 58^0 00” W) of Guyana are located approximately 160 km south of the Atlantic Ocean behind the low-lying coastal plains. The climate is a transitional tropical wet and dry with mean annual rainfall of 2250 mm, temperature of 26 ^{0}C, and relative humidity of 80% [1]. Dry evergreen forests dominated by wallaba (*Eperua falcata* Aubl.) and dakama (*Dimorphandra conjugata* (Splitg.) Sandwith), surround the native savanna vegetation consisting of grasses (*Trachypogon plumosus* (Humb. & Bonpl. ex Willd.) Nees) and sand paper trees (*Curatella americana* L.). Soils of agricultural importance are loamy, siliceous, isohyperthermic, very acid, highly leached, and excessively permeable, of low natural fertility and exchange capacity [2].

Current efforts to develop the Intermediate Savannas for agricultural land-use are based on the perceived threat to the fertile, low-lying and populous coastal belt from sea level rise and increasing urbanization, and the need for alternative lands for commercial agriculture. Three decades of soil and crop research in the Intermediate Savannas have led to the development of cereal and grain legume crop rotation models. However, achieving economic crop yield on the soils of the Intermediate Savannas requires soil tillage, annual soil pH amelioration, fertilizers, and large scale cropping. For small farmers, the cost of these inputs is prohibitive.

Gliricidia sepium (Jacq.) Kunth ex Walp. and *Leucaena leucocephala* (Lam.) de Wit are fast growing, nitrogen (N_2)-fixing trees for low-input tropical agroforestry systems with annual crops. The benefit of these tree species in agroforestry systems is increased when they are managed by pruning. Pruning management of the trees to reduce competition with companion crops for light and nutrients, to optimize supply of nutrients for crop growth, and to conserve the service attributes of trees which have developed under humid tropical conditions [3-7]. On an Arenic Paleudult soil in the Intermediate Savannas of Guyana, cowpea (*Vigna unguiculata* (L.) Walp.) and maize (*Zea mays* L.) had a greater yield in a three-year field trial when fertilized with leaf prunings of *G. sepium* and *L. leucocephala* compared to added chemical fertilizers [8].

The present study investigated the performance of cowpea in an alley cropping system with *G. sepium*, *L. leucocephala* and no-tree control on an acidic infertile Arenic Paleudult at Ebini, Guyana, to test the hypothesis that the introduction and management of fast growing, N_2-fixing trees on smallholder farms provide an opportunity to reduce requirement for costly soil and crop inputs without concomitant loss in crop yield.

MATERIALS AND METHODS

Study Site

The study was carried out at the Intermediate Savannas Field Research Unit (ISFRU), of the National Agricultural Research Institute (NARI), Ebini, Guyana. The ecological

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zone is a transitional wet and dry savanna, approximately 28 m above sea level. The main soil type is an acid infertile Arenic Paleudult (Acrisol) soil [2]. Meteorological variables (average ± SD) are monthly precipitation 178±76 mm; rain days 15±4 days; monthly mean temperature 26.7±0.74 ^{0}C; and daily sunshine hours 5.5±1.0 hours [1].

The experimental plots were established in March 1997 to evaluate the performance of cereal (*Z. mays*) and grain legume (*V. unguiculata*) crops in alley cropping trials with *L. leucocephala* and *G. sepium* and treeless control treatments. *L. leucopephala* was established from seed and *G. sepium* from stem cuttings. Trees were planted at a row spacing of 6 m and an intra-row spacing of 1 m (1,666 trees ha^{-1}). Plot size was 15 x 6 m.

Between 1998 and 1999, trees were managed by periodic aboveground leaf pruning carried out at the beginning and middle of the two cropping seasons per year (a total of four leaf prunings per year). Leaf prunings were added to the alleys formed by rows of trees, and cowpea, maize and sorghum (*Sorghum bicolor* L.) were planted in the alleys and treeless control plots [8].

Experimental Design and Plot Management

- The effect of trees and treeless control treatments on cowpea yield performance was studied in a randomized complete block design with six replications during the two cropping seasons. The treatments were *L. leucocephala*, *G. sepium* and treeless control. Cropping seasons were from November-December 2004 (short rainy season) and May-June 2005 (long rainy season). Plots were fallowed in the interval between crops and ploughed prior to sowing. Cowpea var. Minica #4 was sown at a row spacing of 45 cm and an intra-row spacing of 4 cm, in the alleys and in treeless plots. Plots were fertilized with compound fertilizer 12:12:17:2 at 12 days after sowing (DAS) and with tree leaf prunings at 35 DAS. During the short rainy season, 52 kg *G. sepium* and 13 kg *L. Leucocephala* leaf prunings were applied *in-situ*, and during the long rainy season, the respective amounts were, 57 kg and 14 kg. Tree leaf prunings were not applied to treeless plots. On each pruning date, tree leaf fresh weight was measured before applying to plots. All plots were rain-fed irrigated and routine pest management practices were carried out. Cowpea was harvested at the grain stage.

Statistical Analysis

- Cowpea plant height, pods per plant, pod weight per plant and grain weight (~12% moisture content) per plot data were examined for homogeneity of variances and normality. Harvest data from the two cropping seasons were combined. The effects of alley cropping treatments on these variables were analyzed using a SAS/GLM (SAS Institute, Cary, North Carolina) procedure for randomized complete block design with six replicates. Mean comparisons were by the Ryan-Elinot-Gabriel-Welsch (REGWQ) test ($P<0.05$), which limits Type 1 experimental error. Pearson correlation procedures were applied to cowpea plant height and yield parameters. For all statistical analyses, the threshold probability level for determining significant differences was P>0.05.

RESULTS

There were no significant differences among the alley crop treatments for any of the variables measured. Numerical values for the cowpea plant height and yield parameters were higher in tree plots when compared to the treeless control treatment (Table **1**). When the cowpea data were analyzed by season, it was observed that plant height (Fig. **1**), and pods per plant (Fig. **2**) were higher during the short rainy season compared to the long rainy season. The reverse was true for pod weight (Fig. **3**) and grain weight (Fig. **4**).

Simple Pearson correlation procedures applied to the cowpea data revealed a positive correlation between number of pods per plant and pods weight per plant ($p=0.0900$) during the short rainy season (Table **2**). However, during the long rainy season, there were strong positive correlations between plant height and pod weight per plant ($p=0.0449$), number of pods per plant and pod weight per plant ($p=0.0006$), and number of pods per plant and grain weight per plot ($p=0.0017$) (Table **3**).

DISCUSSION

Results from this study confirm those of Simpson and Wickham [8] conducted under similar experimental conditions 4-5 years prior to this study. The inclusion of fast

Table 1. Effect of Alley Cropping Treatments with *G. sepium* and *L. leucucephala* and a Treeless Control on Cowpea Yield, Ebini During the 2004-2005 Cropping Season

Treatment	Plant Height (cm)	Pods / Plant	Pod wt. / Plant (g)	Grain wt. (kg)
G. sepium	33.4a	4.3a	295.2a	2.0a
L. leucocephala	32.1a	4.1a	289.9a	1.8a
Treeless control	31.7a	3.8a	281.9a	1.7a
Mean	32.4	4.1	289.0	1.8
F-value	0.21	0.16	0.06	0.81
Pr > F	0.9648	0.8562	0.9464	0.4552
C.V. (%)	20.58	58.41	34.05	33.37

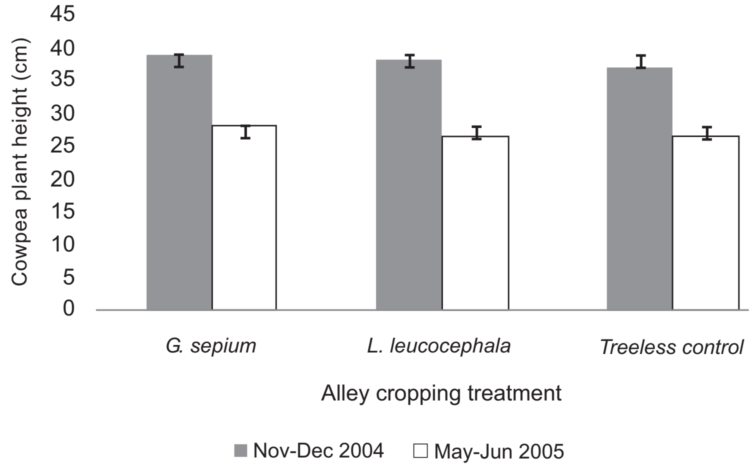

Fig. (1). The effect of *G. sepium* and *L. leucocephala* alley cropping and a treeless control on cowpea plant height in Ebini, Guyana.

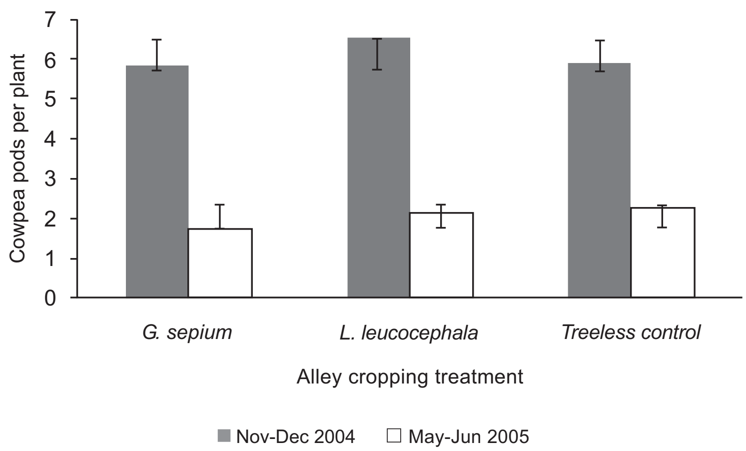

Fig. (2). The effect of *G. sepium* and *L. leucocephala* alley cropping and a treeless control on cowpea pods per plant in Ebini, Guyana.

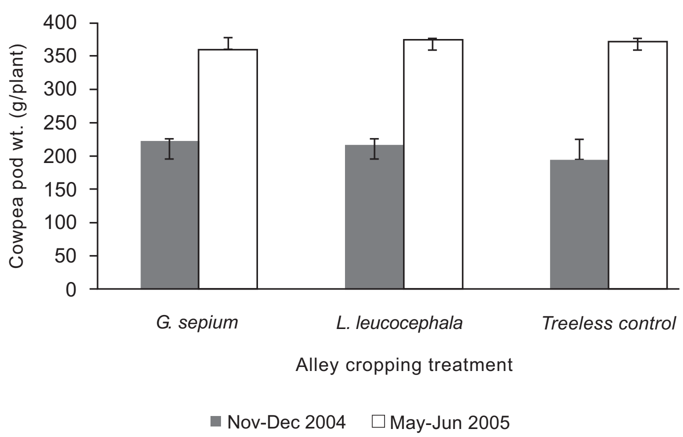

Fig. (3). The effect of *G. sepium* and *L. leucocephala* alley cropping and a treeless control on cowpea pod weight per plant in Ebini, Guyana.

growing, N_2-fixing trees did not reduce yield of the companion cowpea crop over two cropping seasons. The reason may be attributed to the management of trees by periodic aboveground pruning and plowing before the cropping season. This suggests that aboveground pruning reduced the competition for light and nutrients, the latter owing to the deleterious effect of aboveground pruning of alley cropping trees on tree fine roots [3-4]. The contributory effect of plowing on avoidance of root competition, while not investigated in this study, is plausible [9]. In earlier agroforestry experiments when tree management by pruning was not practiced, agroforestry systems with *Leucaena* and *Gliricidia* drastically suppressed cowpea grain and yield, and average cowpea yield in agroforestry systems was 30-50% of the treeless control [10].

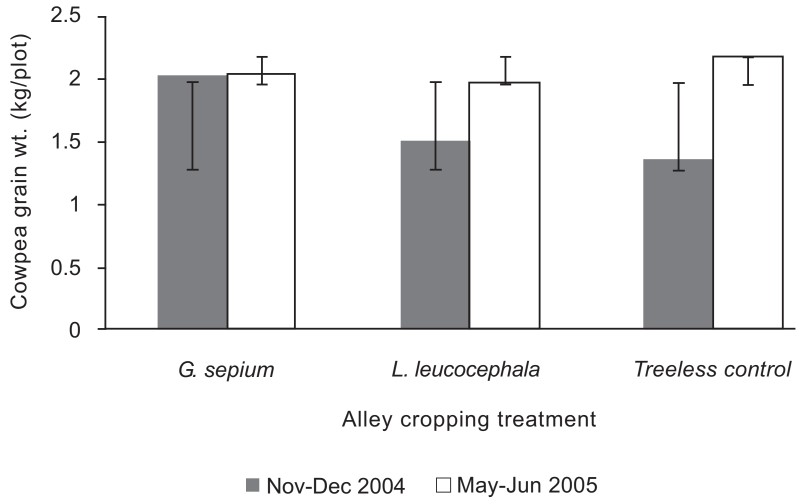

Fig. (4). The effect of *G. sepium* and *L. leucocephala* alley cropping and a treeless control on cowpea grain weight in Ebini, Guyana.

Table 2. Pearson Correlation Coefficients (n=18) for Cowpea Variables During the Short Rainy Season (November-December 2004), Ebini, Guyana

	Plant Height	Pods per Plant	Pod wt. / Plant	Grain Weight
Plant height		-0.07243 0.7752	0.35563 0.1475	0.23671 0.3443
Pods per plant	-0.07243 0.7752		0.41120 **0.0900**	-0.16368 0.5164
Pod wt. / plant	0.35563 0.1475	0.41120 **0.0900**		0.30169 0.2237
Grain weight	0.23671 0.3443	-0.16368 0.5164	0.30169 0.2237	

Table 3. Pearson Correlation Coefficients (n=18) for Cowpea Variables During the Long Rainy Season (May-June 2005), Ebini, Guyana

	Plant Height	Pods Per Plant	Pod wt. / Plant	Grain Weight
Plant height		0.15161 0.5481	0.47778 **0.0449**	0.36539 0.1359
Pods per plant	0.15161 0.5481		0.72792 **0.0006**	0.68432 **0.0017**
Pod wt. / plant	0.47778 **0.0449**	0.72792 **0.0006**		0.33057 0.1803
Grain weight	0.36539 0.1359	0.68432 **0.0017**	0.33057 0.1803	

Cowpea grain yield in this study was higher during the long rainy season compared to the short rainy season possibly because less photosynthates were allocated to vegetative growth (lower plant height) and comparatively more to grain production (higher pod and grain weights) [11]. Overall, cowpea grain yield ranging from 189-222 kg ha^{-1} for all treatments was lower than that reported by Simpson and Wickham [8], probably owing to better soil conditions for plant growth then, when plots were treated with di-ammonium phosphate at a rate of 100 kg ha^{-1}. This treatment was not repeated in 2004-05, when the present experiment was conducted.

When submitted to pruning schemes, fast growing N_2-fixing tree species like *G. sepium* and *L. leucocephala* can be introduced on smallholder farms on acid infertile Arenic Paleudults (Acrisol) under variable rainfall conditions without the grain yield reducing effect on the cowpea companion crop. This practice is attractive for its potential cost savings in terms of the additional need of inorganic fertilizer additions; especially given the remoteness of the Intermediate Savannas from fertilizer supply companies. Soil amelioration with di-ammonium phosphate would be important as it may provide suitable growth conditions for the cowpea crop. While *Gliricidia* is tolerant to soil acidity, *Leucaena* is not [12].

The numerically higher cowpea yields obtained from *Gliricidia*-amended plots, its ease of establishment from cuttings and production of higher amounts of biomass, make *Gliricidia* a more attractive alley cropping species than *Leucaena*. As such, we recommend *G. sepium* with cowpea agroforestry practice in order to maximize crop yield and minimize the need for external nitrogen fertilizers. This will also reduce the potential production of N_2O, a GHG with a significantly higher global warming potential than CO_2.

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