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Intercropping trials of four crops in bamboo plantations

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Abstract—The growth, yield and land equivalent ratios were assessed for pigeon pea, soybean, turmeric and ginger intercropped with *Bambusa bambos*, in Tamil Nadu, India. Pigeon pea and soybean appear to provide most benefits in terms of productivity.

Key words: Bamboo plantations; pigeonpea; soybean; turmeric; ginger; yield; LER.

INTRODUCTION

Agroforestry is an alternative land use system under situations of shortages of fuel, fodder and timber where there is no separate land available to increase the area under forest to meet requirements. It also helps overcome the ill effects of degradation of natural forests [1]. Bamboo is basically a household species and is very useful to farmers. The availability of natural bamboo resources have decreased due to over exploitation, gregarious flowering, shifting cultivation practices and extensive forest fires [2]. The present crisis in sustained availability can be ensured only by raising elaborate bamboo plantations [3]. In India, bamboo plantations are normally raised at spacings of 6 × 6 m to meet the increasing demand for bamboo products. Research has increased rapidly in recent years to cultivate agricultural crops in bamboo plantations [4–7]. There is a great need to identity suitable agricultural and horticultural crops, which can grow well with bamboo in plantation conditions.

In the present study, intercropping of agricultural crops (pigeonpea, soybean, turmeric and ginger) in established bamboo plantations was tested. The growth, yield and land equivalent ratio (LER) of the agroforestry systems are discussed. The above ground interaction investigated showed variable results from species to species [8, 9] but little information is available on belowground interaction [10]. The present investigation aimed to assess this in relation to the production of new culms in bamboo.

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MATERIALS AND METHODS

The study area was located at Kallipathy, Tamil Nadu, India and lies between 11°28′, and 12° latitude and 76°59′, and 77°47′ longitude. Altitude was 540 metrés above sea level. This area has red soil, with pH between 7.4 and 7.8. Soil nitrogen, phosphorus and potassium were 3800 kg/ha, 360 kg/ha and 3600 kg/ha respectively. The mean temperature and rainfall is 31°C and 600 mm, respectively.

Planting arrangements bamboo plantations

Seedlings of *Bambusa bambos* were planted at 6 × 6 m spacing in a 3 ha area with 250 seedlings per ha. Almost every seedling, produced culms during the first year of transplantation. On an average, 5 culms emerged in the first year, increasing to 17 at the 6th year and then culm recruitment decreased to 7 at 10 years. In the plantations, all culms above 3 years were harvested. Pruning was done on the remaining culms.

To estimate the total above ground biomass, three culms were randomly selected and felled. After felling, fresh weight was estimated in the field and sub-samples were brought to the laboratory and were oven dried at 103°C to a constant weight. From the oven dry weight of the sample, the total above ground biomass was calculated by multiplying the total number of bamboo's with the average dry weight of the sample.

Intercropping (design and installation). Intercropping was carried out using 4 diverse crops:

(1) Pigeonpea: (*Cajanus cajan*)

Pigeonpea (*Cajanus cajan*) is a hardy pulse of tropical grassland and arid regions. It accounts for about 4% of the total pulse production in the world. The crop usually prefers a fairly moist climate during its vegetative development. The crop prefers a light and moist soil in which the roots can develop freely. ICPL-88034, a short duration pigeonpea was sown in a bamboo plantation, 1 : 1 rows at 3 × 3 m spacing with 1111 plants/ha during June. Only 45% of plants established.

(2) Soybean: (*Glycine max*)

Soybean (*Glycine max*) may grow under varying climatic conditions either as a pure crop or as an intercrop. The best results are obtained on fertile loam and sandy loam soils. M.A.C.S 58 was sown in bamboo plantations 1 : 1 rows at 3 × 3 m spacing (1111 plants/ha) during June. Only 35% of plants established.

(3) Turmeric: (*Curcuma longa*)

Turmeric is obtained from the underground rhizome of the plant. The crop requires a warm and moist climate, and well drained fertile sandy or clayey, medium

black, red or alluvial loams. It is a shade loving plant and can be grown in association with a variety of trees [11]. For planting, both round and finger-like rhizomes are cut into a 3 to 4 cm long pieces, each having at least one sound bud. The rhizomes were planted at 1 × 2 m spacing (5000 plants/ha). The crop was sown in April. Only 40% of plants established.

(4) Ginger: (*Zingiber officinale*)

Ginger is an important spice crop of the humid tropics. Being a shade-loving plant, ginger is grown in association with a wide variety of trees [11]. Ginger rhizome bits were planted at 1 × 2 m spacing (5000 plants/ha). The crop was sown in May and only 30% of plants established.

In all the intercropping trials, three replicates were maintained and one block kept as a control. Growth and yield studies were conducted after first harvesting. Production of culms and above ground biomass of culms was also investigated.

Parameters emphasized

The land equivalent ratio (LER) is a convenient method for measuring biological productivity. It is defined as the land area in a monocropping system that would be required to produce the same yield as one ha of intercropping. It is calculated as follows

$$\mathrm{LER} = \mathrm{C1/CS} + \mathrm{T1/TS},$$

where C1 and T1 are crop and tree yields under intercropping and CS and TS are yields in the mono system respectively [12].

In the agrisilvicultural model, a set of 15 clumps was selected randomly and marked with paint for the assessment of monthly production of culms. Every month, the number of newly sprouted culms and their survival were recorded over a period of one full year.

RESULTS AND DISCUSSION

Based on one year of observations, the data in Table 1 show that, for all crops, yield in pure stands was higher then in intercropping models. This has also been reported previously [4–7].

The average annual recruitment of bamboo culms was found greatest in pure stands as compared to intercropped stands. Under ground root competition for moisture, nutrients and space are relatively more important factors in agroforestry systems than is above ground competition. The productivity of bamboo was assessed by the number of new culms produced annually. At a given site, the production of new culms mostly depended on the degree of congestion, clump age, rainfall of the previous year and the nature of competition.

Table 1.
Growth and yield of monoculture and intercropped agricultural crops

	Pigeonpea/bamboo		Soybean/bamboo		Turmeric/bamboo		Ginger/bamboo	
	Pure	Intercropped	Pure	Intercropped	Pure	Intercropped	Pure	Intercropped
Total number of plants planted (ha)	1111	1111	1111	1111	5000	5000	5000	5000
Average yield obtained form single plant (kg)	0.63	0.59	1.53	1.26	0.86	0.21	0.20	0.13
Yield/ha*	700	600	1700	1400	6050	4300	1000	650

* Values are means of three replicates.

Table 2.
Production of culms and the accumulation of above ground of biomass in monoculture and intercropped bamboo stands

	Bamboo/pigeonpea		Bamboo/soybean		Bamboo/turmeric		Bamboo/ginger	
	Pure	Intercropped	Pure	Intercropped	Pure	Intercropped	Pure	Intercropped
Total number of clumps/ha	250	250	250	250	250	250	250	250
Average annual production of culms/clump	17	10	13	7	11	8	147	9
Total culm production/year/ha	4250	2500	3250	1750	2750	2000	3500	2250
Average above ground biomass/culms/kg	9.0	5.5	11.15	8.2	9.0	6.0	8.5	7.0
Total accumulation of above ground biomass/ha/kg	38 250	13 750	36 230	14 350	24 750	12 000	29 750	15 750

* Values are means of three replicates.

Table 3.
Land equivalent ratio of agrisilvicultural models

Model	Pure agricultural crops yield (kg/ha)	Pure bamboo yield (kg/ha)	Intercropping		LER
			Agricultural crop yield (kg/ha)	Bamboo yield (kg/ha)	
Bamboo/pigeonpea	700	38 250	600	13 750	1.2
Bamboo/soybean	1700	36 230	1400	14 350	1.2
Bamboo/turmeric	6050	24 750	4300	12 000	1.1
Bamboo/ginger	1000	29 750	650	15 750	1.1

The average annual recruitment of bamboo culms is shown in Table 2. The number of culms produced was less than in pure bamboo stands. This may be mainly due to competition with the root systems of agricultural crops [13, 14]. Also, the unit area above ground biomass accumulation was found to be lower in intercropped bamboo stands.

The LER was 1.2 in the bamboo/pigeonpea and bamboo/soybean models, but 1.1 in the bamboo/turmeric and bamboo/ginger models. This means that the productivity of one hectare under intercropping is equivalent to that of 1.2 ha or 1.1 ha under monoculture (Table 3).

The results of the study revealed that pigeonpea or soybean are most suitable for intercropping of bamboo plantations, and turmeric and ginger are a good second choice.

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