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COMPARATIVE STUDIES ON GROWTH AND PRODUCTIVITY OF *SESBANIA* AND *LEUCAENA* IN THE CENTRAL PLATEAU AGROECOLOGICAL ZONE OF RWANDA[1]

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INTRODUCTION

Agroforestry is primarily valued for its potential in controlling soil erosion on steep slopes (Young, 1984; Lundgren and Nair, 1985; Zimmerman. 1986). Its application is particularly important in the Central Plateau region of Rwanda where soil erosion and fertility loss limit continuous agricultural production.

Besides erosion control, farmers in the region welcome agroforestry for wood, stakes, fodder and green manure production for soil fertility management. Previous research results have demonstrated the use of *Sesbania, Leucaena* and *Calliandra* for agroforestry in similar agroecological zones in Rwanda and parts of East-Central Africa (Balasubramanian and Sekayange, 1988; Yamoah et al., 1989a; ICRAF, 1986; KREDP, 1985; Oduol and Akunda, 1988; Eylands and Yamoah, 1990).

Application of manure enhanced early growth of the above-named species in the Buberuka Highlands of Rwanda (Yamoah et al., 1989a). Productivity of *Leucaena* was increased by application of phosphatic fertilizers and inoculation with vesicular-arbuscular mycorrhiza fungus in India (Byra-Reddy and Bagyaraj, 1989).

Sesbania is the preferred species among farmers in the Rwanda highlands because of its initial rapid growth. However, research in lower elevations of Rwanda has proven the superiority of *Leucaena* over *Sesbania* in terms of survival for long-term productivity (Balasubramanian and Sekayange, 1988).

This study presents data on growth, biomass, nutrient yields and stake production of *Sesbania* and *Leucaena* in the Central Plateau agroecological zone of Rwanda. It forms part of the collaborative research effort between the Eastern Africa Agroforestry Research Network (AFRENA) and the Farming Systems Research Project (FSRP).

MATERIALS AND METHODS

The study was conducted in the Central Plateau region, which is one of the 12 agroecological zones in Rwanda. The biophysical features are altitude, 1600; rainfall, 1500 mm/yr; temperature, 22 C; and soils, Oxisols (USDA Soil Taxonomy). The experimental design was Randomized Complete Block (RCB) with two treatment factors and three replications. First factor was shrub species, namely *Sesbania sesban, Leucaena leucocephala, Leucaena diversifolia* (provenance, Rwanda) and *L. diversifolia* (prov. Kenya). Ten tons/ha fresh manure and 30-30-30 NPK fertilizer/ha were applied at planting and 4 months later. Four-month-old tubed seedlings were planted in April 1988, and height measurement of tagged plants began after 3 months. Plants were spaced 1 x 1 m on a plot of 20 m^2. During the first cutting after 10 months, plots were divided into two. Half were cut back to a height of 1 m for *Sesbania* or 0.5 m for *Leucaena*. The other half were cut after 6 months to the same height. Regeneration from the previous cutting was pruned and weighed. The

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following data were collected: biomass, stakes, diameter at cutting height and leaf analysis for NPK using standard analytical procedures. Differences between treatments were compared with MSTAT software at LSD of 0.05.

RESULTS AND DISCUSSION

Height

Height of the shrubs is shown in Fig. 1. *Sesbania* was superior to the *Leucaenas* throughout the 16-month growing period. Mean height of *Sesbania* during first cutting at 10 months was more than 3.5 m whereas the *Leucaenas* were about 2 m or less.

Compared to the *Leucaenas, Sesbania* showed rapid initial growth followed by a decreased growth rate after 10 months. Rapid initial growth of *Sesbania* relative to other woody species in Rwanda has been reported (Balasubramanian and Sekayange, 1988; Yamoah et al., 1989a; Westwood, 1986). Among the *Leucaenas*, the *diversifolias* grew faster than the *leucocephala*.

Diameter

Data on the stem diameter of the shrubs are presented in Fig. 2. *Sesbania* had bigger stems than the *Leucaenas* at 10 months after planting (MAP). For the *Leucaenas*, the *diversifolias* produced bigger stems than the *leucocephala*. At 16 MAP, *L. diversifolia* (prov. Rwanda) had about the same stem diameter as *Sesbania*.

Increase in stem diameter between 10 and 16 months was greater for the *Leucaenas* than for *Sesbania*. This indicates a decrease in growth rate of *Sesbania* after the tenth month compared to the *Leucaenas*.

Stakes

Sesbania produced more stakes than the *Leucaenas* at 10 MAP (Fig. 3). Among the *Leucaenas*, the *diversifolias* provided more than the *leucocephala*.. However, at 16 MAP, *L. diversifolia* (prov. Rwanda) outperformed *Sesbania* for stake production (Fig. 3). Relative increase in mean number of stakes between 10 and 16 months was higher for the *Leucaenas* than for *Sesbania*. Correlation between mean number of stakes and shrub height was significant (r=0.74*), but the degree of association was not as strong as that between stake number and biomass (r=0.99**).

Bean is a major food crop in the region, and yield potential of climbing bean is higher than that of bush bean varieties. Production of climbing beans is constrained by nonavailability of stakes. *Sesbania* produces an average of 5 stakes/plant within 10 months, thus making its growth more attractive to farmers than that of *Leucaena*.

Biomass

Biomass is an important parameter for evaluating shrubs because it has a direct relationship with nutrient yield, stake and fodder production. Ten-month biomass of *Sesbania* was higher than that of the *Leucaenas* (Fig. 4). Biomass production 6 months later was slightly higher for *L. diversifolia* (prov. Rwanda) than for *Sesbania*. *L. leucocephala* gave the lowest biomass during the two cutting periods. Biomass for the *Leucaenas* showed an increase over time, but that of *Sesbania* registered a decrease. The behavior of *Sesbania* in this region is contrary to experience gathered in the Buberuka Highland region of Rwanda (Yamoah and Burleigh, 1990). In the Buberuka Highlands, *Sesbania* throws out many branches after cutback, which raises its biomass yield. In general, *Sesbania* rarely survives after cutback at low elevation agroecological zones in Rwanda (Balasubramanian and Sekayange, 1988).

Addition of biomass at 10 MAP and coppice 6 months later gave total biomass of the shrubs for two cuttings in 16 months. Comparing the above with biomass obtained from a single cutting of *Sesbania, L. leucocephala, L. diversifolia* (prov. Rwanda) and *L. diversifolia* (prov. Kenya) in 16 months we got 3.78, 1.89, 3.24 and 3.14 kg/5 plants for two cuttings and 3.8, 1.94, 4.08 and 3.22 kg/5 plants for a single cutting in 16 months for the respective shrubs. Apparently, biomass for the two cutting regimes did not differ

significantly. From a practical standpoint, it is advisable to cut twice to minimize intercrop shading during shrub establishment (Yamoah and Burleigh, 1990).

Stem diameter is a better index of biomass production (r=0.92**) (Fig. 5) than shrub height (r=0.75*) on the infertile soils in the region. On poor soils, shrubs, particularly *Sesbania*, show spindly growth with chlorotic leaves.

Effect of NPK and Manure

Nitrogen, P and K application significantly increased shrub height, stem diameter, biomass and stake production relative to control (Fig. 5). Manure use was consistently superior to use of NPK. Manuring and NPK affected biomass production more than the other parameters measured. Since nutrient yield, stake and fodder production largely depend on shrub biomass, it is important to use starter manure to catalyze shrub growth during establishment. This practice also reduces the time it takes for farmers to realize the benefits of agroforestry technology, especially on degraded soils. Interaction between fertilization and shrub species was not significant for the measured parameters.

Nutrient Contribution of Shrubs

Table 1 gives concentration of nutrients in biomass of shrubs. Nutrient concentration among the shrubs differed significantly. *L. diversifolia* (prov. Kenya) had the highest N content (4.0%) and *Sesbania* the lowest (2.85%). Phosphorus content ranged between 0.17% (*L. leucocephala* prov. Kenya) and 0.12% (*Sesbania*). *Sesbania* had the highest K content (1.61%) and *L. leucocephala* the lowest (1.00%). Application of manure and fertilizer significantly increased percent K but not N and P in the biomass. This is probably due to luxury consumption of K (ASA, 1968). Thus, under circumstances in which biomass is exported outside the farm for use as animal feed or fuelwood, one risks impoverishing the soil of K in the long term.

Tables 2 through 4 show yields of the major nutrients by the species. As expected of leguminous shrubs, N production was more than that of P and K. The low P yield attests to the fact that we cannot rely on the shrubs to recycle P in this acid and P-deficient soil. Mean Al saturation and available P of soils in this region are 46% and 2.4 ppm, respectively (Yamoah et al, 1989b). High doses of starter P and lime may be necessary for long-term yield sustainability (Buol et al., 1988).

Application of manure significantly increased nutrient yields of the shrubs, possibly through increase in biomass production. Pruning management, i.e. cutting once or twice in 16 months, did not influence nutrient yield. Compared to the other species, *Leucaena leucocephala* contributed fewer nutrients. The study concludes that good shrub establishment for long-term crop production with alley cropping systems in this agroecological zone warrants initial applications of manure, P and/or lime. A similar view was shared by Sanchez and Benites (1987) as regards establishment and subsequent functioning of agroforestry systems on acid soils in the Amazon region.

CONCLUSION

Since the benefits of alley cropping are realized in the long term, it is better to use *Leucaena* than *Sesbania* in the Central Plateau region of Rwanda. A mixture of the two in a hedgerow is another possibility due to the expressed need of farmers for stakes.

Leucaena diversifolia grew faster and was more productive than *Leucaena leucocephala*. On the infertile soils in this region, shrub contribution of P and K was insignificant. Starter manuring is required to catalyze growth and enhance productivity of the shrubs.

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Table 1. Nutrient content of alley shrubs

Species	%n	%P	%K
Sesbania	2.85	0.12	1.61
Leucaena 1	3.76	0.14	1.00
Leucaena 2	3.60	0.14	1.05
Leucaena 3	4.06	0.17	1.37
LSD (0.05)	0.43	0.03	0.20

Table 2. Nitrogen yield of alley shrubs (g/5 plants)

Species	Check	NPK	Manure	Mean
Sesbania	31	40	47	39ab
Leucaena 1	22	32	22	25b
Leucaena 2	41	52	45	46a
Leucaena 3	35	28	74	46a
Mean	32b	38ab	47a	39

Means followed by different letters differ at $P = 0.05$

Table 3. Phosphorus yield of alley shrubs (g/5 plants)

Species	Check	NPK	Manure	Mean
Sesbania	1.3	1.6	2.0	1.6a
Leucaena 1	0.8	1.2	0.8	0.9b
Leucaena 2	1.5	2.0	1.9	1.8a
Leucaena 3	1.5	1.2	3.2	2.0a
Mean	1.3b	1.5ab	1.9a	1.6

Means followed by different letters differ at $P = 0.05$

Table 4. Potassium yield of alley shrubs (g/5 plants)

Species	Check	NPK	Manure	Mean
Sesbania	18	20	28	22a
Leucaena 1	6	9	6	7c
Leucaena 2	14	12	14	13b
Leucaena 3	12	9	25	15b
Mean	12b	12b	18a	14

Means followed by different letters differ at $P = 0.05$

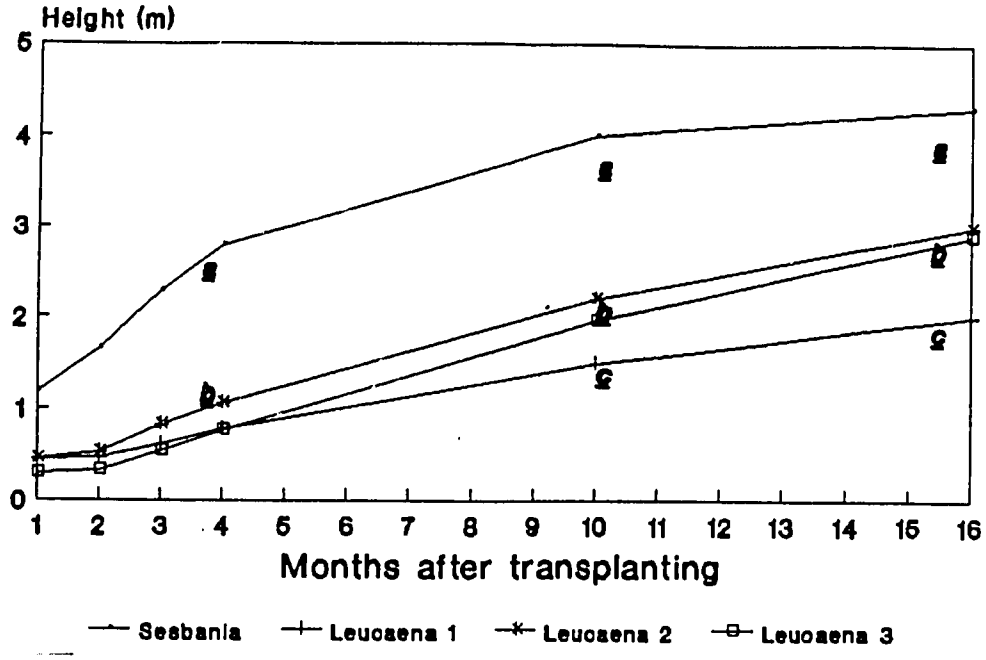

Fig. 1. Height growth of alley shrubs.

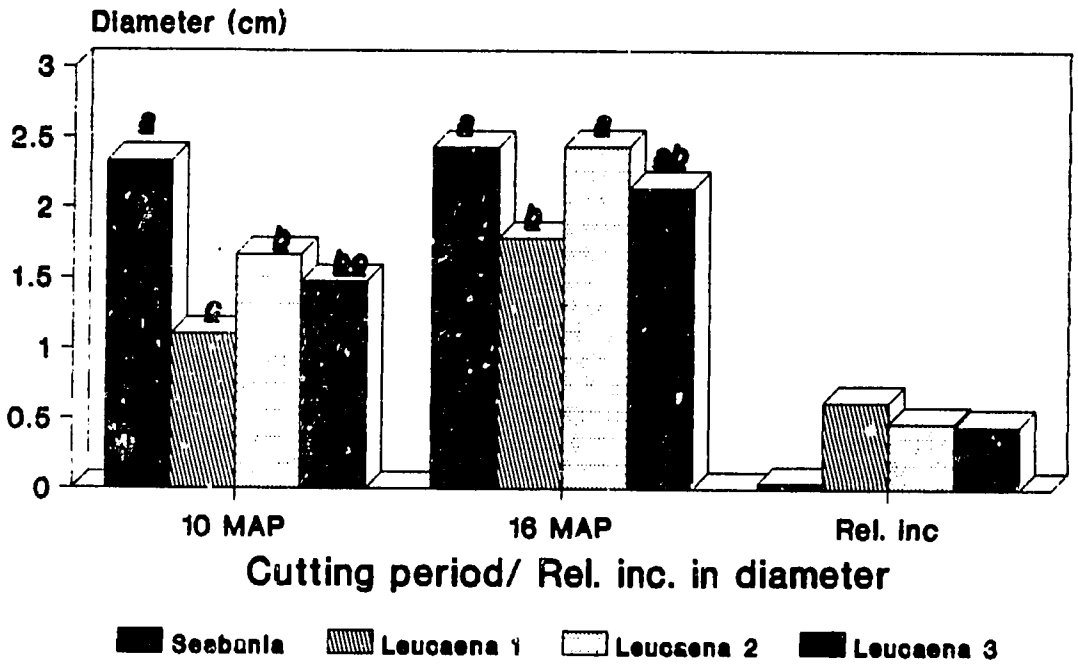

Fig. 2. Diameter of alley shrubs at 10 and 16 MAP (months after planting).

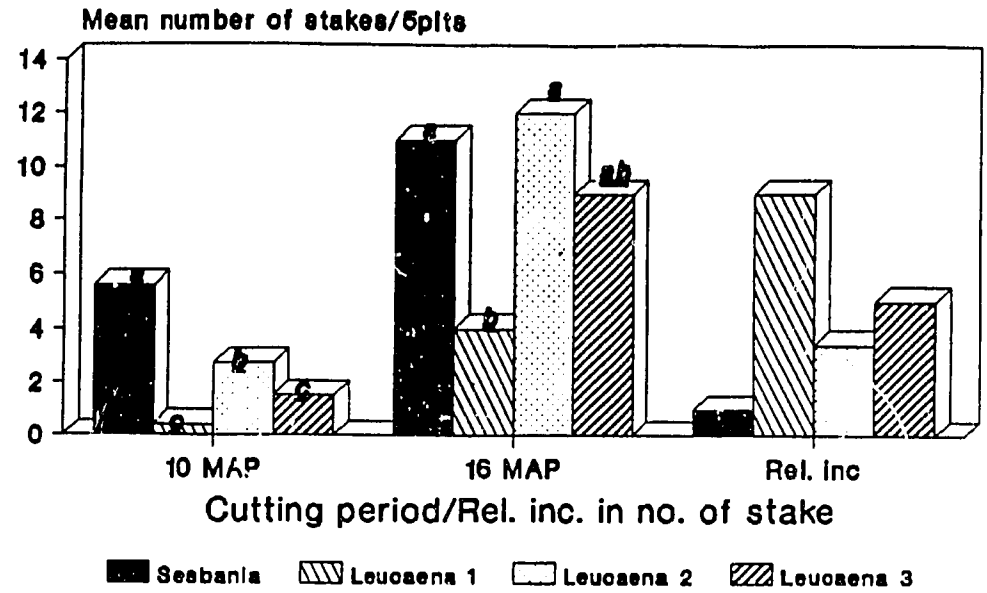

Fig. 3. Stake production of alley shrubs at 10 and 16 MAP (months after planting).

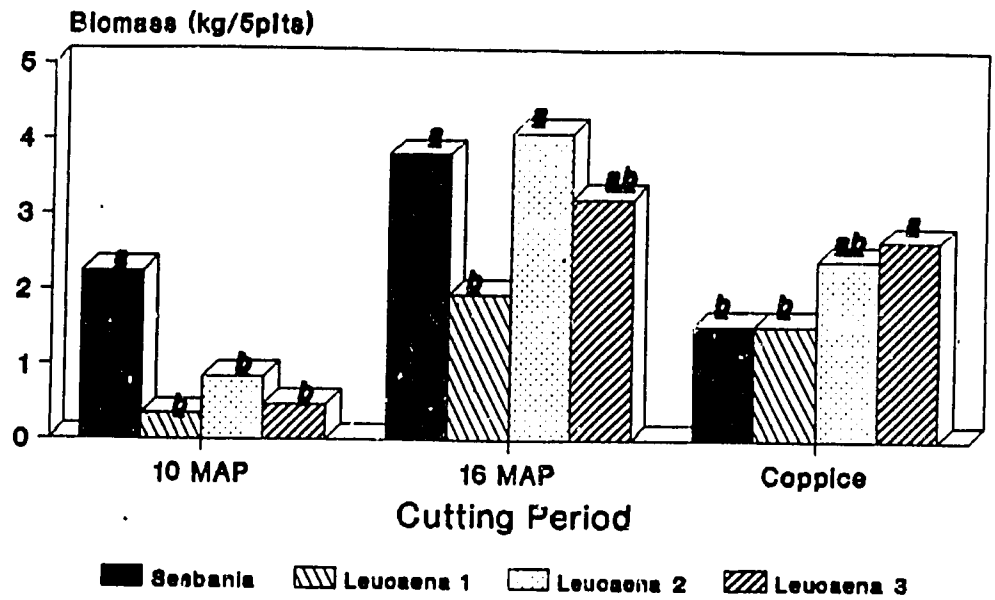

Fig. 4. Biomass yield of alley shrubs at 10 and 16 MAP (months after planting).

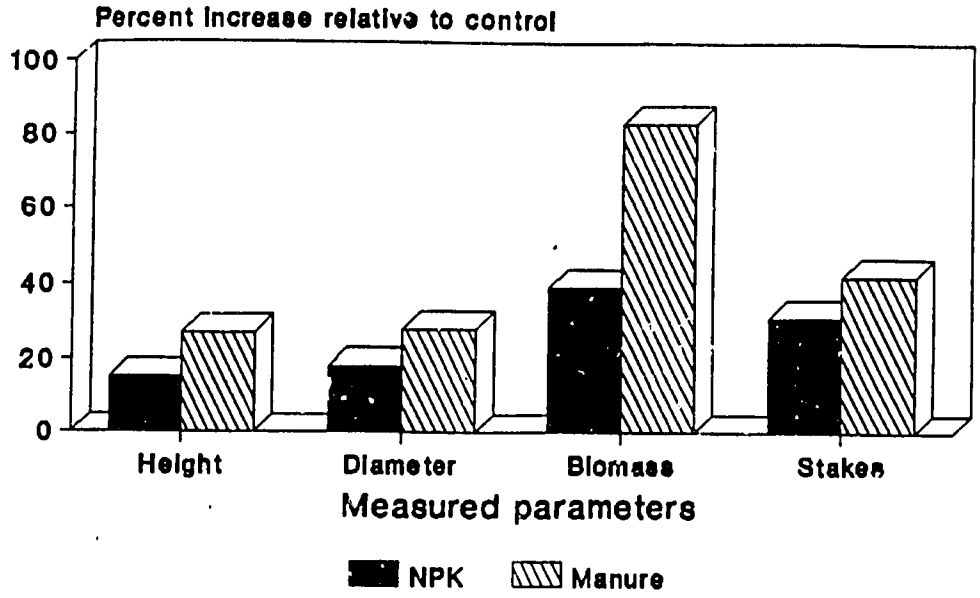

Fig. 5. Effect of manuring on productivity of alley shrubs.