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Early Growth Performance of Leguminous Alley Shrubs in the Highland Region of Rwanda

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EARLY GROWTH PERFORMANCE OF LEGUMINOUS ALLEY SHRUBS IN THE HIGHLAND REGION OF RWANDA

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ABSTRACT

Early growth performance of some leguminous shrubs was studied in the Buberuka Highland and Central Plateau regions of Rwanda. The dominant altitudinal ranges for the two agro-ecological zones are 1800 - 2400 m and 1500 - 1900 m, respectively. Beans grown in association with Sesbania sesban enhanced the growth of the shrub in the Central Plateau region. At both sites, growth of Sesbania was retarded by intercropped pea. Growth of Sesbania increased significantly during the dry season in June and July. Biomass and height after one years' growth of Sesbania were higher in the Buberuka Highlands than in the Central Plateau region. Growth performance of the shrubs is ranked as Sesbania sesban > Leucaena leucocephala > Calliandra calothyrsus > Markhamia lutea in the Buberuka Highlands. Farmyard manure generally increased the growth rates of the shrubs, but this was not significant in all cases. Calliandra and Leucaena were most responsive to liming. The response of Leucaena to liming decreased with manure application, but no definite trend was observed for Calliandra, Sesbania and Markhamia. Sesbania and Markhamia were least influenced by application of lime. Their respective Lime Response Indices were 0.35 and 0.46. The average growth rates for Sesbania and Leucaena at selected locations ranged between 26.4 and 62.2 cm/month and between 13.1 and 27.4 cm/month for the respective shrubs.

INTRODUCTION

The elevation of Rwanda's highlands ranges from 1500 m to over 2500 m (ISNAR, 1983). Slopes on most farms exceed 30% with a high farmer-to-land ratio. Rainfall combined with steep, denuded slopes results in soil loss, run-off and soil fertility degradation. Terraces with grasses planted along contours constitute the principal erosion control measure, but terraces have generally fallen into disrepair. Thus, soil productivity continues to decline in this densely populated region.

Inter-row cropping of leguminous trees with food crops, i.e., alley cropping, is a practice recommended for control of soil erosion on sloping lands (Young, 1984; ISNAR, 1983). Specifically, Zimmerman (1986) and Ross (1984) proposed such an approach for solving land degradation problems in Haiti and Indonesia under conditions analogous to those of the highland regions of Rwanda. Alley cropping can also provide fuel wood and forages in addition to erosion control (Robins, 1985). Farmers readily accept alley cropping because it is a good approximation to the natural bush fallow system.

Two research needs must be addressed to implement alley cropping in Rwanda: 1) identify shrubs suited to the local environment and 2) develop management practices to enhance survival and growth of agro-forestry shrubs. This paper presents data on the following:

1. the growth performance of Sesbania sesban (Sesbania) inter-cropped with peas, beans, potatoes and wheat in two agro-ecological zones,
2. the growth performance of Sesbania, Calliandra calothyrsus (Calliandra), Leucaena leucocephala (Leucaena) and Markhamia lutea (Markhamia) as affected by lime and manure application and
3. the growth performance of Sesbania and Leucaena in selected micro-ecozones.

The research was conducted in the operational zone of the Farming Systems Research Program (FSRP) in the northeastern highlands of Rwanda. Our methodology of involving farmers in the applied research program is described in Appendix A. Appendix B gives a summary of the various institutions visited and contacted that were of assistance in increasing our understanding of erosion control and soil fertility management techniques. Two agro-ecological zones were delineated in the project region: the Buberuka Highlands and the Central Plateau area (ISAR, 1985). Environmental information for these zones is given in Table 1.

Study 1

Background. The objective of this study was to determine the effect on shrub growth of beans, peas, wheat and potatoes grown in association with Sesbania. The food crops chosen dominate local cropping systems, and exploratory surveys showed that leguminous shrubs appeared to have poorer growth performance when intercropped with grain legumes such as peas and beans than when intercropped with cereals such as maize, sorghum or wheat.

Widespread acceptance of agro-forestry depends on the ease of establishment and subsequent management of companion shrubs. The easiest and cheapest way to promote agro-forestry among farmers is to interplant shrubs with common food crops on their farms. The primary aim of this study was to identify food crops and shrub combinations that would be compatible during shrub establishment. A secondary objective was to investigate shrub performance in the two major agro-ecological zones. A third objective was to obtain base-line crop yield data for future evaluations.

Methodology. At each location, eight rows of 4-month-old Sesbania seedlings were planted 0.5 m apart within rows. Rows were 40 m long, and alleys were between 2 and 8 m in width. The 40-m-long block of Sesbania was divided into 5 plots. Food crops (peas, beans, potatoes and wheat) and the control treatments were assigned randomly to the plots and repeated twice. Five shrubs were tagged in each plot, and heights were measured at monthly intervals until the food crops were harvested. About 100 plants per location were sampled for biomass and height assessments one year after establishment.

Study 2

Background. This study developed from observations made while conducting exploratory surveys among the farmers of the region. Southern Rwanda is characterized by a relatively low altitude and warm environment and is particularly favorable to growth of most leguminous shrubs, including Leucaena and Calliandra. However, these shrubs are seldom found in the project research area, a fact that supports a commonly held view that Leucaena and other leguminous shrubs do not grow well at high altitudes. However, in one location observed in the exploratory survey at an altitude of 2000 m, Leucaena exhibited good growth performance. Further enquiry revealed that manure had been applied to the site, prompting our question, "Could manure be used to offset the negative altitudinal effect on the growth of Leucaena and other leguminous shrubs?"

Soils in the project area are highly acidic (pH 3.5 - 5), which also is a potential limitation to legume performance. A second question the exploratory survey brought to our attention was, "Could the moderate application of lime mined from a local source improve the growth rate of leguminous shrubs?"

Methodology. In 1986, four leguminous shrubs (Sesbania, Calliandra, Leucaena and Markhamia) were planted at 0.5 m x 4 m spacing within and between rows, respectively, forming the main plots. Sub-plots were manure treatments at 0, 2.5, 5.0 and 10.0 tons/ha. Potatoes were initially used as the test food crop. Shrub row length was 30 m, and there were two repetitions. Treatments were modified slightly during the second growing season as follows: the four leguminous shrubs constituted the main plots; sub-plots were lime at 0 and 0.75 ton/ha, and sub-sub plots were manure applications at 0, 5.0 and 10.0 ton/ha. There were 2 replications, and the test crop was changed to maize. Five shrubs in each sub-sub plot were tagged and measured at monthly intervals during the two growing seasons.

Study 3: Background and Methodology

Following a farmer field day, 15 sites covering selected micro-ecozones in the research area were chosen for multi-locational testing of Sesbania and Leucaena. The trials were placed on farmers' fields and had the following configuration: row length along the contour, 20 m; shrub spacing within rows, 0.5 m. Shrub spacing between rows was determined by the formula $D = 100/S$ (Young, personal communication) where D = alley width (m) and S = % slope. Shrubs were planted in October 1986, and growth measurements were taken from January to April 1987.

RESULTS AND DISCUSSION

Food Crop Yields

Food crop yields at both sites were poor and reflected the low base-line soil productivity in the experimental plots (cf. Table 1). Crop yields were higher in the Buberuka region than in the Central Plateau area. Damage to pea and wheat plots by birds at the Central Plateau site made statistical analysis meaningless. Nevertheless, yield differences between the sites for wheat, potatoes and peas were large. Yields were 44 kg/ha (beans); 662 kg/ha (peas); 1018 kg/ha (wheat) and 9375 kg/ha (potatoes) in the Buberuka Highlands as opposed to the Central region where less than half the above yields were recorded. Average yields for the same food crops elsewhere in the country are 1000 kg/ha (beans), 1900 kg/ha (wheat) and 15,000 kg/ha (potatoes) (MINAGRI, 1985).

The following inferences can be drawn from these preliminary results: potatoes and wheat are more adapted to the high-altitude, cold-environment Buberuka Highlands than the relatively low-altitude, warm Central Plateau environment. In terms of high returns from invested labor, farmers in both regions stand to benefit more by planting potatoes instead of beans on the poor soils commonly encountered. The fact that beans exhibited high sensitivity to low soil fertility may indicate farmers' preference to use their limited quantities of manure on beans rather than on their potato fields. Apparently, the shrubs did not adversely affect food crop yield at this initial stage.

Performance of Shrubs

The initial growth of Sesbania as affected by the associated food crops is shown in Fig. 1. Initial growth of Sesbania in the Central Plateau region was slightly better than in the Buberuka Highlands zone, but the difference in growth between the two sites was not significant. At both sites, no significant difference in height of Sesbania was observed after the first month. There was a significant difference in height of Sesbania grown in the pea and bean plots after the second month in the Central Plateau region. At the end of the third month in the same region, no significant difference was observed between the Sesbania in the bean and control plots, but the height of Sesbania in those plots was significantly different from that of the Sesbania in the other plot. The above trend continued to the end of the fourth month. In the Buberuka Highlands, no clear differences in the height of Sesbania in the food crops were observed until after the fourth month. At this time, Sesbania in all the food crops grew better than those in association with peas.

Growth at both sites started slowly during the first two months after establishment and thereafter increased markedly. The accelerated growth rate following root establishment was observed even during the dry season (June and July). If this proves to be the normal growth pattern, it would be advantageous with respect to producing dry season fodder as well as organic material and nitrogen for the subsequent seasons' crops. Shrubs planted alone performed better than those grown in association with food crops, but acute land scarcity in the research area will make that option unacceptable to most farmers.

Additional testing should be done to confirm these preliminary results and to determine whether the effect is present in other than the establishment phase. Beans, however, seem to enhance growth of Sesbania in the Central Plateau region in contrast to an earlier observation made in the Buberuka Highlands (Graf and Yamoah, unpublished). This finding implies that in the low-altitude, high-rainfall Central Plateau area, good establishment of Sesbania can be obtained by intercropping with beans instead of with peas, potatoes or wheat. For the Buberuka Highlands region, the initial companion food crop may be a matter of choice (keeping in mind the possibility that peas might retard shrub growth).

Figures 2a and 2b show the frequency distribution of biomass and height for Sesbania in the two major ecozones. Biomass production (woody stems, small twigs, leaves) in the Buberuka Highlands region was 3.4 kg/plant/year compared to 2.8 kg/plant/year in the Central Plateau. Sixteen percent of the shrubs yielded 4.4 to 6.4 kg/plant fresh matter per year (Fig. 2a). The mean fresh matter yield per plant in this region was 3.4 kg/year, which is equivalent to 8500 kg dry matter/ha/year for a 0.5 x 4.0 m alley formation having a density of 5000 plants/ha. Therefore, the amount of dry organic material actually incorporated into the soil is about 3000 kg/ha/year.

Dry matter yields from Gliricida Sepium, Cassia simea and Flemingia congesta pruned two years after establishment in Nigeria were 3120 kg/ha, 10,666 kg/ha and 1955 kg/ha for the respective shrubs (Yamoah et al., 1986). Leaf dry weights of 2300 kg/ha and 2467 kg/ha for Gliricida and Leucaena, respectively, using an alley spacing of 0.5 x 2 m after a year's growth have also been reported at the

International Institute of Tropical Agriculture (IITA, 1979). In the Central Plateau region, however, 72% of the leguminous shrubs gave fresh matter yield of < 3.4 kg/plant, 25% gave between 3.4 and 4.4 kg/plant, 1% gave between 4.4 - 5.4 kg/plant, and none yielded above 5.4 kg/plant (Fig. 2a). The relatively low fresh matter production in this region could be attributed to the poor base-line soil fertility status (cf. Table 1).

For poor soils in the Central Plateau with percent base saturation of 17% and pH of 4.3, application of manure and lime may be necessary to enhance the growth rates of the shrubs in the establishment phase. On a per-hectare basis, the dry leaf weight in this zone comes to 2100 kg, which compares favorably with the data for Gliricida and Leucaena cited in Nigeria above (IITA, 1979). With respect to shrub height, 86% of the plants in the Buberuka Highlands attained 3.4 m or more after one year whereas only 5% of the shrubs in the Central Plateau region attained the same height. Ninety-four percent of shrubs in the Central Plateau region attained a height of less than 3.4 m (Fig. 2b). The initial growth rate of shrubs in this environment, however, was slightly greater than that in the Buberuka region (Fig. 1). Mean heights for shrubs in the Buberuka and Central Plateau regions were 4.1 m and 2.7 m, respectively.

Application of moderate quantities of farmyard manure increased growth rates of all shrubs tested (Fig. 3). The increase, however, was not significant in all cases. Growth of Calliandra and Sesbania increased by 20% when tested with manure. According to Fig. 3, 5 tons of manure/ha appears to be the optimum level of application for the leguminous shrubs tested, but this was not significantly different from 2.5 tons/ha. Hill (1970) reported that Leucaena grew faster when nitrogen fertilizer was applied during the establishment phase. The advantage of alley cropping partly depends on the rapid initial growth of the shrubs. Consequently, it is recommended that manure be added to infertile soils to enhance shrub establishment.

Shrub height with four different rates of manure application at three and four months after planting (MAP) for four leguminous shrubs is given in Table 2. There were significant growth differences between some species, particularly noted between Sesbania and Leucaena and between Markhamia and Calliandra. Sesbania exhibited the fastest growth followed by Leucaena. Markhamia, although native to the region, gave the poorest growth performance.

Table 3 gives shrub height as affected by two lime and three manure application rates at five, six, seven and eight months after planting. Lime at 0.75 ton/ha increased growth of all shrubs. Significant differences in shrub height occurred throughout the 8-month period. The effect of the interaction between lime and manure was also statistically significant. The progressive difference in height between Calliandra and Markhamia at this growth stage was interesting. For instance, mean heights of the two shrubs at 3 MAP were 15.9 cm and 16.1 cm, respectively. By the end of the eighth month, the mean respective heights without liming were 140.0 cm and 41.0 cm. This represented average growth rates of 17.5 and 5 cm/month for Calliandra and Markhamia, respectively.

The term Lime Response Index (LRI) is used to further highlight the effect of liming on the growth rates of the shrubs (Fig. 4). Lime Response Index, as used here and explained in Fig. 4, represents the difference in shrub mean height with and without liming at 8 MAP divided by height at 3 MAP. According to the above analysis, LRI is highest for Calliandra, followed by Leucaena, Markhamia and then Sesbania. These results suggest that Sesbania is more tolerant to acid soils than the other species tested. This assertion, however, should be verified by further research. LRI decreased with the quantity of manure applied in the case of Leucaena, but no definite trend was observed with the other shrubs. Also, whereas the LRI values for the other shrubs increased from 5 MAP to 8 MAP, that of Sesbania showed a decrease. Perhaps the lime requirement for the fast-growing Sesbania is important following the first few months after application. But for the other shrubs with slow initial growth, the benefit from liming increases over time when their roots may have adequately proliferated. This also needs to be tested through further research.

The growth performance of Sesbania and Leucaena in selected micro-ecozones is portrayed in Figures 5a and 5b, respectively. There are significant differences in growth of Sesbania among some of the sites (Fig. 5a). For example, the height of Sesbania at site 7 in April 1987 was more than twice the height of the same species at site 1 for the same period.

Sites 1, 2 and 3 belong to the Central Plateau, and sites 4, 5, 6 and 7 belong to the Buberuka Highland region. Within the same major agro-ecological zone, the shrub still performed differently, depending on the micro-ecozones in which the shrub was planted. General observation revealed better plant growth in

the bottom soils than in the upper and middle slope areas. Evidence in support of this was the growth difference between the shrubs at site 2 (bottom soil) and sites 1 and 3 (upper to middle slope soils), Fig 5a. The shrub varieties at site 7 showed an exceptional growth rate; the site borders the volcanic soils in the project area, which are classified in the USDA system as Andepts (ISAR, 1985). These are generally recognized as more fertile soils than the intensively used Ultisols on which the shrubs in sites 4, 5 and 6 were placed. The growth rates for Sesbania reported in this study are in conformity with the 5-month average height of 177 cm obtained by Westwood (1986) in a similar agro-ecological zone in Rwanda.

In general, Sesbania out-performed Leucaena in terms of growth rate. The best growth rates for Leucaena were noted at site 1 (Central Plateau) on bottom soils and site 5 (Buberuka Highland), which is the same kind of volcanic soil as site 7 for Sesbania. Average height for a 5-month Leucaena in Rwanda is 80 cm (Westwood, 1986). None of the farmers applied manure or fertilizer to the fields on which the shrubs were planted. The average growth rates in cm/month for the shrubs in our experimental trial sites are indicated above the bar graphs in Figures 5a and 5b. Clearly, Sesbania exhibits a faster growth rate than Leucaena. To illustrate, Sesbania scored an average growth rate of 62.2 cm/month as opposed to 27.4 cm/month for Leucaena at the same location. The average growth rates for the shrubs on the valley bottom soils (sites 2 and 7 for Sesbania and sites 1 and 5 for Leucaena) are superior to those of their counterparts on the upland and mid-slope soils (Fig. 5a and 5b). Both Leucaena and Sesbania showed significant growth over time, and these growth rates were consistently better on the pedologically favorable sites 7 and 2 for Sesbania and 1 and 5 for Leucaena.

CONCLUSIONS

This study has demonstrated that leguminous shrubs such as Sesbania, Leucaena, Calliandra and Markhamia thrive in the high-altitude areas of Rwanda. Sesbania showed the fastest growth rate, followed by Leucaena, then Calliandra and finally Markhamia. On the relatively fertile bottom soils, Sesbania and Leucaena grew almost twice as fast as those shrubs on the upland eroded hillsides. Manuring generally enhanced the growth rates of all the species at the establishment phase. Lime application improved the growth rates of Leucaena and Calliandra, but this benefit could not be said of Sesbania.

Our research demonstrated that it was best to establish the leguminous shrubs by interplanting them with food crops, but it is cautioned that association of Sesbania with pea may retard the growth of the shrubs in the early stages of growth.

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ACRONYMS USED

ISAR - Institut des Sciences Agronomiques du Rwanda.
PAP - Agro-pastoral Project, Rwanda
IITA - International Institute of Tropical Agriculture, Nigeria.
BGM - Bugesera, Gisaka, Migongo Districts of Rwanda
ICRAF - International Council for Research in Agro-forestry Kenya.
CIAT - International Center for Tropical Agriculture, Cali Columbia (Bean team in Rwanda).
USAID - United States Agency for International Development.
E/DI - Energy/Development International.
KREDP - Kenya Renewable Energy Development Project.
KWDP - Kenya Woodfuel Development Project.

LITERATURE CITED

1) Hill, G.D. 1970. Studies on the growth of Leucaena Leucocephala. Effect of clean weeding and nitrogen fertilizer on early establishment. Papua and New Guinea Agricultural Journal 22:29-30.

2) International Institute of Tropical Agriculture (IITA). Annual reports 1978-1982. Ibadan Nigeria.

3) International Service for National Agricultural Research (ISNAR). 1983. Agricultural research in Rwanda: Assessment and perspectives. A report submitted to the Government of Rwanda.

4) International Council for Research in Agro-forestry (ICRAF). 1985. Status Report, March 1985. Field Station Machakos, Kenya.

5) ICRAF. 1986. Status Report, March 1986. Field Station Machakos, Kenya.

6) Institut des Sciences Agronomiques du Rwanda (ISAR). 1985. Soil Association map for the Ruhengeri Prefecture, ISAR, Rubona Rwanda.

7) Kang, B.T., G.F. Wilson and T.L. Lawson. 1984. La culture en couloirs - un substitut d'avenir a la culture itinerante. Tech Bulletin, IITA, Ibadan, Nigeria.

8) Kang, B.T., G.F. Wilson and L. Sipkens. 1985. Alley cropping maize (Zea mays) and Leucaena (Leucaena Leucocephala, Lam de Wit) in southern Nigeria. Plant and soils 63:165-179.

9) Kenya Woodfuel Development Programme (KWDP). (1985) How to start a tree nursery. The Beijer Institute, Nairobi, Kenya.

10) Ministry of Agriculture, Livestock and Forestry (MINAGRI). 1985. Premier seminaire national sur la fertilisation des sols au Rwanda. MINAGRI, Kigali, Rwanda.

11) Mongi H.O. and P.A. Huxley (ed.). 1979. Soil research in agro-forestry. Proceedings of an expert consultation held at ICRAF in Nairobi March 26-30, 1979.

12) Nair, P.K.R. 1984. Soil productivity aspects of agro-forestry. ICRAF Science and Practice of Agro-forestry.

13) Robins, E. 1985. Communal afforestation. A report on the results of the socio-economic survey and status of the Afforestation Project. United States Agency for International Development (USAID), Rwanda.

14) Ross, M.S. 1984. Towards a farm model for sustainable, low-input agro-forestry systems in the humid tropics with reference to Indonesia. The International Tree Crops Journal 3(1984):49-61.

15) Westwood, S. 1986. Agro-forestry component of the CARE Gituza Project. (Mimeog.) CARE Rwanda.

16) Wilson, F.G. and B.T. Kang. 1981. Developing stable and productive biological cropping systems for the humid tropics. In Biological husbandry: A scientific approach to organic farming. B. Stonehouse, ed. London: Butterworth.

17) Yamoah, C.F. and R. Gross. 1986. Linking on-station research to on-farm testing: The case of agro-forestry and organic matter-based cropping systems for the Rwanda Farming Systems Improvement Project. (Mimeog.) FSIP, Kigali, Rwanda.

18) Yamoah, C.F., A.A. Agboola and G.F. Wilson. 1986. Nutrient contribution and maize performance in alley cropping systems. Agro-forestry Systems 4:247-254.

19) Young, A. 1984. Evaluation of agro-forestry potential in sloping areas. ICRAP working paper no. 27. ICRAP, Nairobi, Kenya.

20) Young, A. 1985. The potential of agro-forestry as a practical means of sustaining soil fertility. ICRAF working paper no. 34. ICRAF, Nairobi. Kenya.

21) Zimmerman, T. 1986. Agro-forestry: A last hope for conservation in Haiti. Agro-forestry Systems 4:255-268.

APPENDIX A: FARMER INVOLVEMENT IN FSRP RESEARCH

Farmers' participation in the overall FSRP agro-forestry research activities consists of three major components:

Component 1 - Information gathering and analysis (Diagnosis);
Component 2 - Technology testing and farmer orientation; and
Component 3 - Farmer training.

Component 1 - Diagnosis

Appendix B gives a summary of sources of information and resources tapped to date by the FSRP project and some discussion as to their respective contribution to our understanding of erosion control and soil fertility management in the FSIP mandate area.

Component 2 - Technology testing

Technology testing was composed of two stages:

Stage 1. The purpose of this stage was to ascertain the biological feasibility of selected agro-forestry species under the principal agro-climatic zones in the project area. Three sites were chosen for the start-up phase. The three sites were:

(i) the Buberuka Highlands,
(ii) the Central Plateau and
(iii) the Rugezi swamp.

The last site falls on a Histosol. Details of protocols are as reported in studies 1 and 2 above. During a field day, farmers were made aware of the proposed agro-forestry interventions, and cooperating farmers for stage 2 were then chosen to continue the research process (Yamoah and Grosz, 1986).

Stage 2. Participating farmers picked from stage 1 were plotted on the soils and land use map of the project area to ensure a fair representation of the observed micro agro-ecological zones. In all, 15 sites were used for the second stage multilocational testing. The leguminous shrubs under experimentation were Leucaena, Calliandra, Sesbania and Markhamia. Lack of adequate planting materials and initial slow growth rates of Markhamia and Calliandra limited their testing to the Buberuka Highlands and Central Plateau region only. Informal dialogue with cooperating farmers graded the value of alley cropping in the following order: supply of stakes > production of fuelwood > provision of fodder > erosion control device > soil fertility improver.

Component 3 - Farmer training

To accomplish this, a hands-on participatory workshop was held for some of the farmers who had field trials on their land during the 1986/1987 cropping season. The extension workers responsible for the administrative sectors in which these trials are located were also invited to the workshop. Farmers were trained in the following aspects of agro-forestry:

- Small scale nursery establishment using local materials (KWDP, 1985);
- Establishment of alley cropping on sloping lands using a procedure akin to the practice at ICRAF field station at Machakos, Kenya;
- Pruning methods and the use of pruned materials as green manure as well as support poles for climbing beans;
- Record keeping of growth of shrubs and rainfall as well as soil sampling techniques and yield assessment.

After the workshop, each farmer-researcher was asked to install five additional on-farm trials with neighboring farmers in collaboration with their extension worker and to monitor and evaluate these trials. Their task as research field-assistants involved coordination of trials, installation, follow-up and evaluation under the guidance and supervision of their extension workers. Thus both farmers and extension cadre were intimately involved in the research and extension process.

APPENDIX B: INFORMATION SOURCES AND RESOURCES ON SOIL FERTILITY MANAGEMENT AND EROSION CONTROL

Source	Information and/or resources employed
ISAR, Aboretum, Rwanda	- A catalogue of agro-forestry species for the different zones in Rwanda. - Supply of seeds of Sesbania, Leucaena and Calliandra. - Field observation of some agro-forestry species, namely Gliricidia, Leucaena, Calliandra, Sesbania, Euclyptus, Grevillia, Cidrella and Jacaranda.
Remarks: Growth of Cliricidia was rated only fair relative to the others.	
PAP, Nyabisindu with Rwanda	- Field inspection of agroforestry trials - Leucaena, Cidrella, Sesbania, Tephrosia.
Remarks: All the species demonstrated good growth performance.	
IITA, Ibadan Nigeria	- Review of publication on agroforestry, e.g. - Annual Reports 1980-1983 - Wilson and Kang (1981) - Kang et al. (1985) - Kang et al. (1984)
Remarks: Portray with supportive quantitative data the positive role of agroforestry landuse systems in soil fertility maintenance with concomitant increases in food crop yields; other attributes such as erosion control, supply of stakes and fuelwood are also mentioned.	
IITA, Farming Systems Project at BGM II	- Observation of alley cropping trials with Leucaena and Sesbania.
Remarks The growth performance of the shrubs was good.	
ICRAF, Nairobi	- Review of publications and reports on agroforestry technologies. For example: - Young (1984 and 1985) - Nair (1984) - Mongi and Huxley (1979) - ICRAF (1985 and 1986)

- Visited the Machakos field station where alley shrubs, especially Leucaena, reinforced with grasses are planted along contours at alley width of approximately 4 m to check soil erosion. Combination of the above practice with moderate terracing enhances its efficacy as erosion control device on slopes > 20%.

Remarks: The field work and documentation at ICRAF give good justification for the practice of agroforestry on sloping lands as generally observed in the region served by the FSRP.

CIAT, Bean Research Programme in Rwanda

- Initial growth trials on Sesbania, Calliandra and Leucaena at the high-altitude zone using the systematic design supplied by ICRAF.

Remarks: Growth performance was ranked as follows: Sesbania > Leucaena > Calliandra.

KREDP (E/DI) KWDP
Beijer Institute
Nairobi, Kenya

- Visited agroforestry trials, discussed and received documentation on various agroforestry practices at community level and establishment of simple nurseries for resource-poor farmers.

Remarks: The simple nursery method is being tried in Rwanda.

USAID,
Afforestation

- Received information pertaining to socio-economic aspects of agroforestry project in the FSRP area, Rwanda (Robins, 1985)
- Provided nursery facilities for raising seedlings.
- Observed growth performance of Leucaena, Grevillia, Cidrella, Eucalyptus, Sesbania macarantha and Sesbania sesban..

Remarks: Leucaena was rare among the species found in the area and generally showed poor growth performance except at one spot. Sesbania macarantha regenerated poorly relative to Sesbania sesban.

Table 1. Some environmental characteristics of the two major ecozones in the FSIP area.

Characteristic	Buberuka Highland	Central Plateau
Altitude (m)	1800-2650	1500-1700
Rainfall (mm)	1564	1166
Temperature (C)	15.1-16.7	17-22
Soil pH	4.8	4.3
Total N (%)	0.38	0.15
Organic carbon (%)	3.5	1.4
Clay (%)	60.8	36.1
CEC (meq/100 g)	22.8	15.7
Base saturation	47.4	16.8

Table 2. Effect of manure on growth of alley shrubs.

Shrub	Manure	Months after planting	
		3	4
	t/ha	----------Height (cm)----------	
Leucaena	0.0	47.7	57.8
	2.5	56.8	69.2
	5.0	57.7	67.4
	10.0	52.3	63.8
Markhamia	0.0	14.8	15.6
	2.5	16.5	17.3
	5.0	15.6	18.4
	10.0	17.5	16.7
Calliandra	0.0	14.6	19.5
	2.5	17.5	21.5
	5.0	17.8	26.9
	10.0	13.8	20.7
Sesbania	0.0	83.5	110.8
	2.5	81.3	119.0
	5.0	75.5	112.5
	10.0	81.8	122.8
LSD (0.05)	Shrubs with same manure	13.6	38..05

Table 3. Effect of lime and manure application on growth of alley shrubs.

Shrub	Lime	Manure	Months after planting 5	6	7	8
	t/ha	t/ha	Height (cm)			
Leucaena	0	0.0	58.3	86.7	125.2	180.0
		5.0	68.6	107.9	120.3	179.0
		10.0	62.0	89.4	125.0	148.0
	0.75	0.0	81.9	132.5	135.0	194.0
		5.0	72.0	107.4	125.3	214.0
		10.0	77.1	112.2	143.0	186.0
Markhamia	0	0.0	17.2	26.5	31.2	43.0
		5.0	19.4	27.7	32.3	45.3
		10.0	17.4	25.9	29.3	34.8
	0.75	0.0	26.5	36.7	37.1	47.5
		5.0	16.5	35.1	36.3	49.3
		10.0	21.3	34.3	35.3	48.8
Calliandra	0	0.0	25.1	43.6	78.8	141.0
		5.0	26.1	57.5	100.0	139.0
		10.0	25.5	45.3	75.0	141.0
	0.75	0.0	36.1	60.1	108.5	147.0
		5.0	33.8	61.3	104.5	153.0
		10.0	34.4	50.6	107.5	164.4
Sesbania	0	0.0	127.0	197.0	318.0	386.0
		5.0	136.2	217.0	336.0	390.0
		10.0	112.3	110.0	323.0	356.0
	0.75	0.0	221.0	292.0	383.0	402.0
		5.0	167.5	274.0	360.0	392.0
		10.0	199.5	276.5	376.0	424.0
LSD (0.05): Shrubs			93.0	48.0	93.1	63.4
Shrub x Lime			17.8	NS	NS	NS
Lime x Manure			9.8	10.3	9.5	10.6

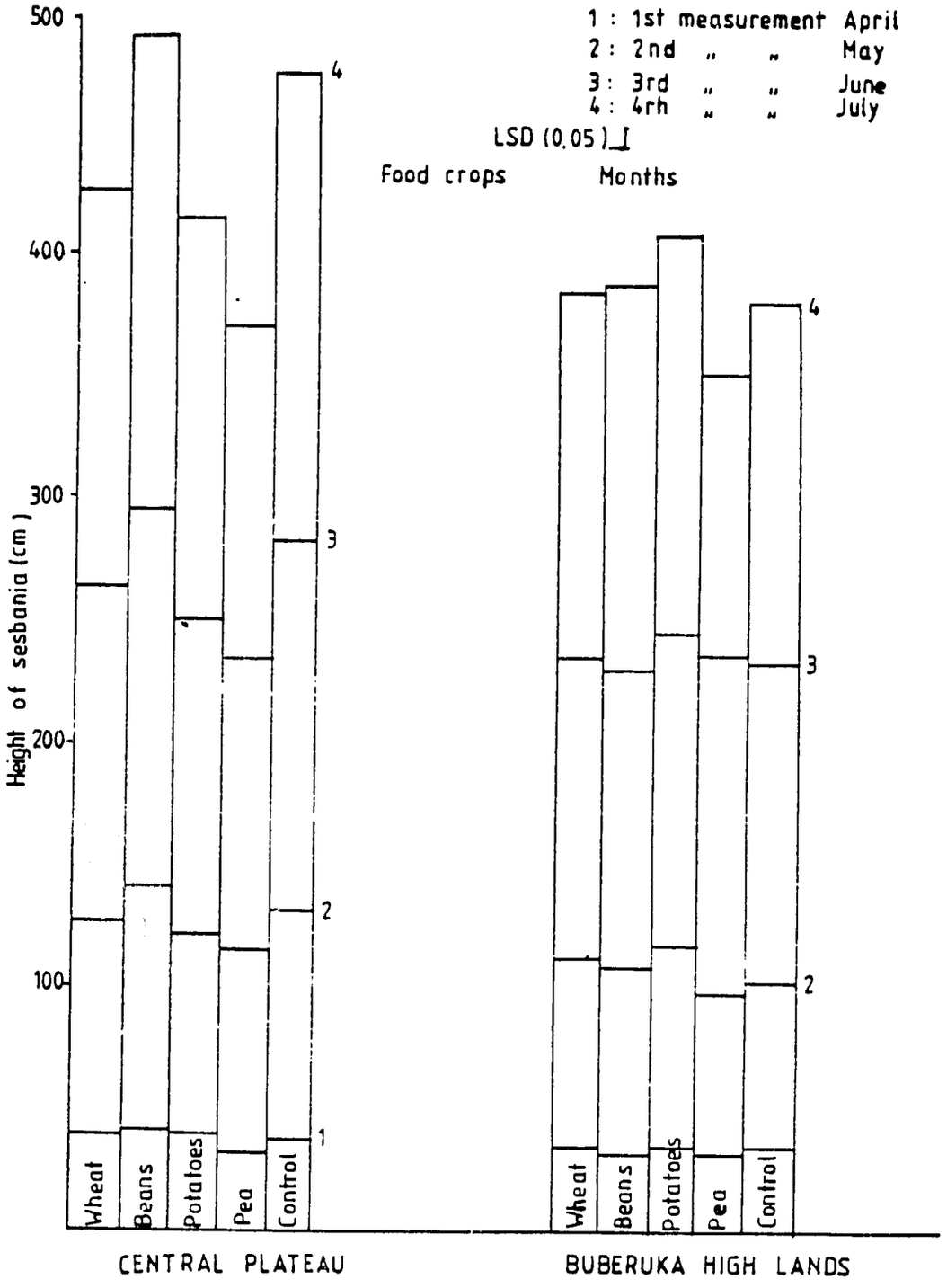

Fig. 1. Growth of Sesbania sesban as affected by food crops in two ecological zones in Rwanda.

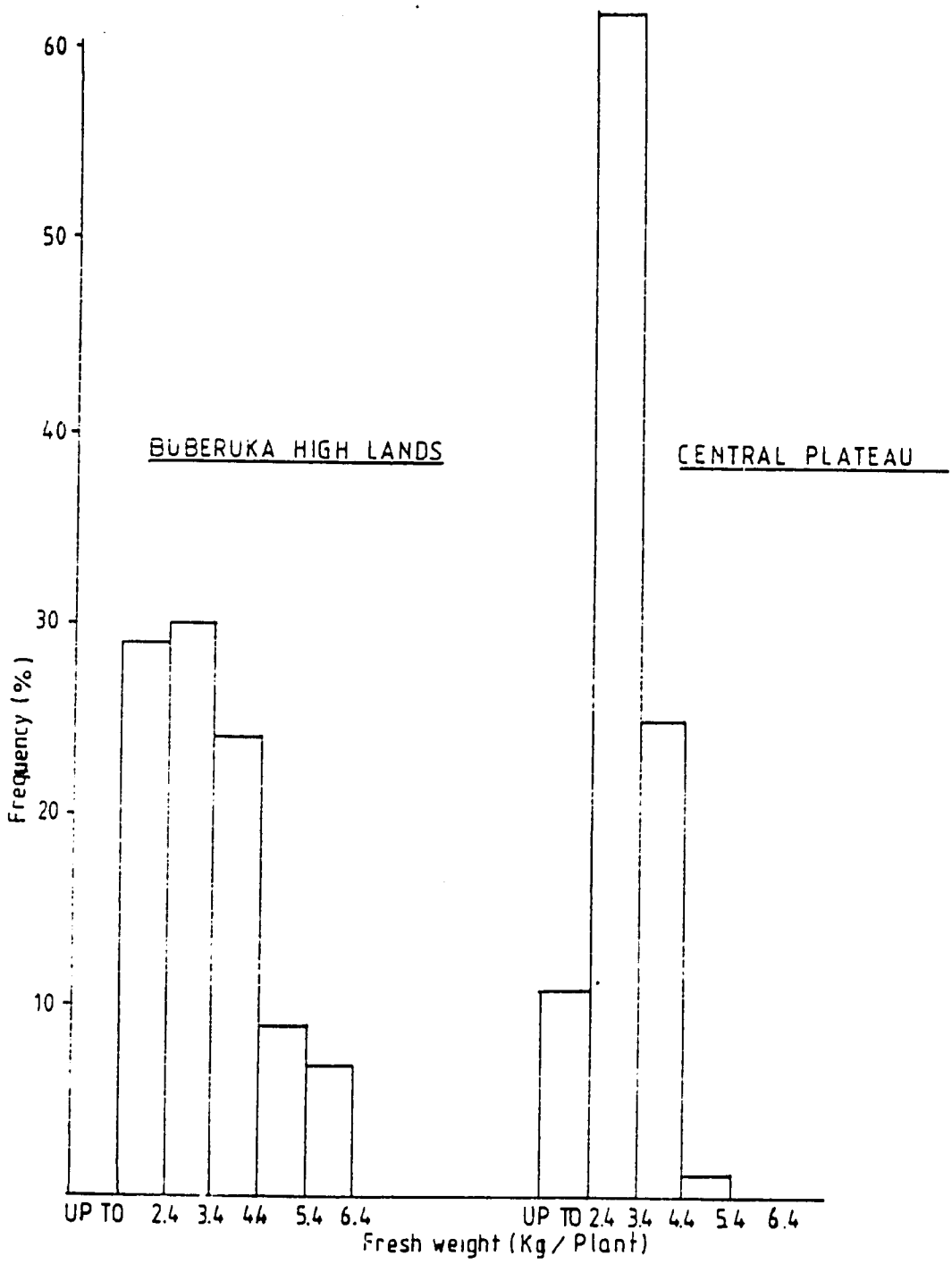

Fig. 2a. Frequency distribution of biomass for Sesbania sesban one year after establishment in two ecozones in Rwanda.

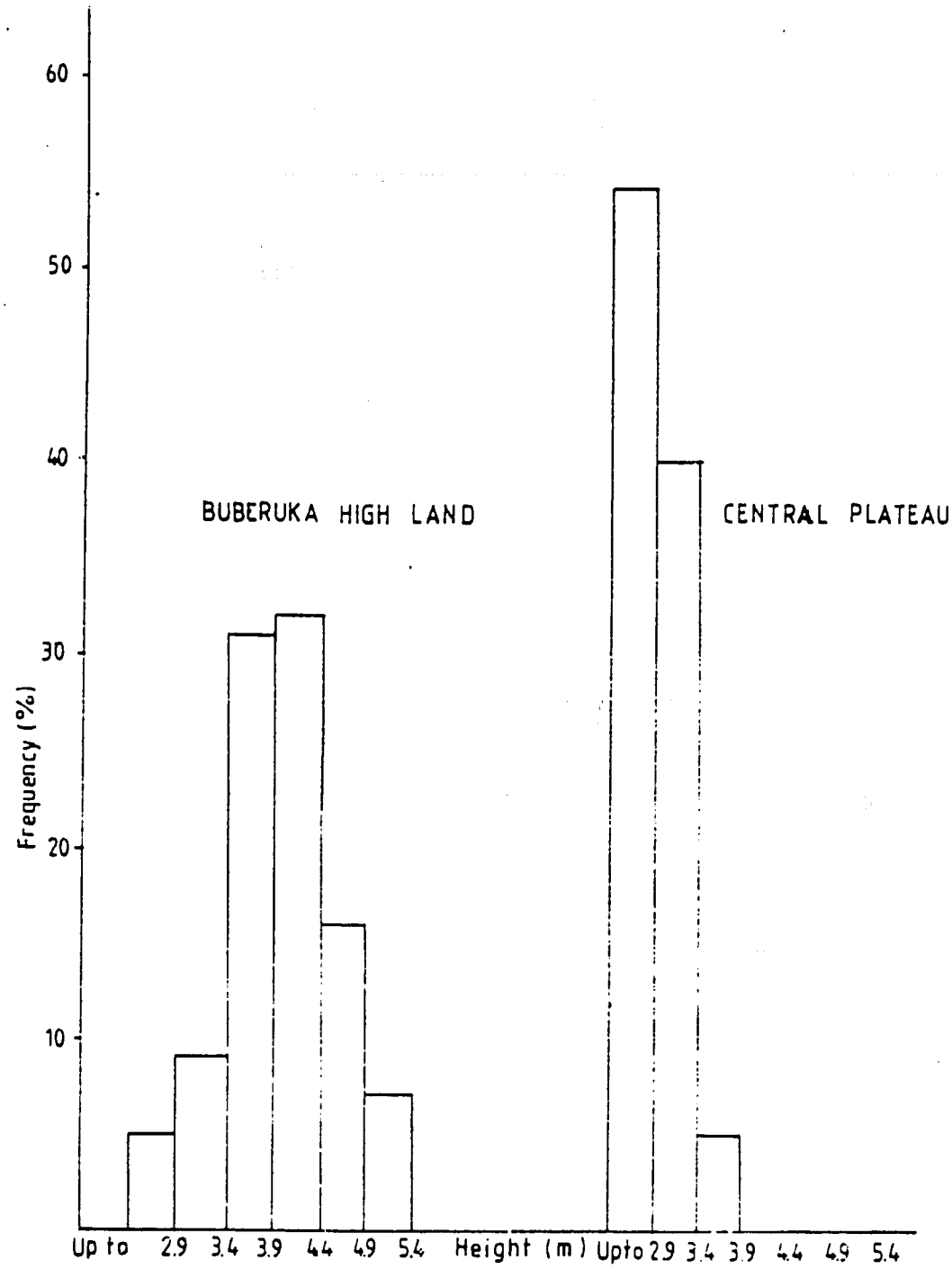

Fig. 2b. Frequency distribution of height of Sesbania sesban one year after establishment in two ecozones in Rwanda.

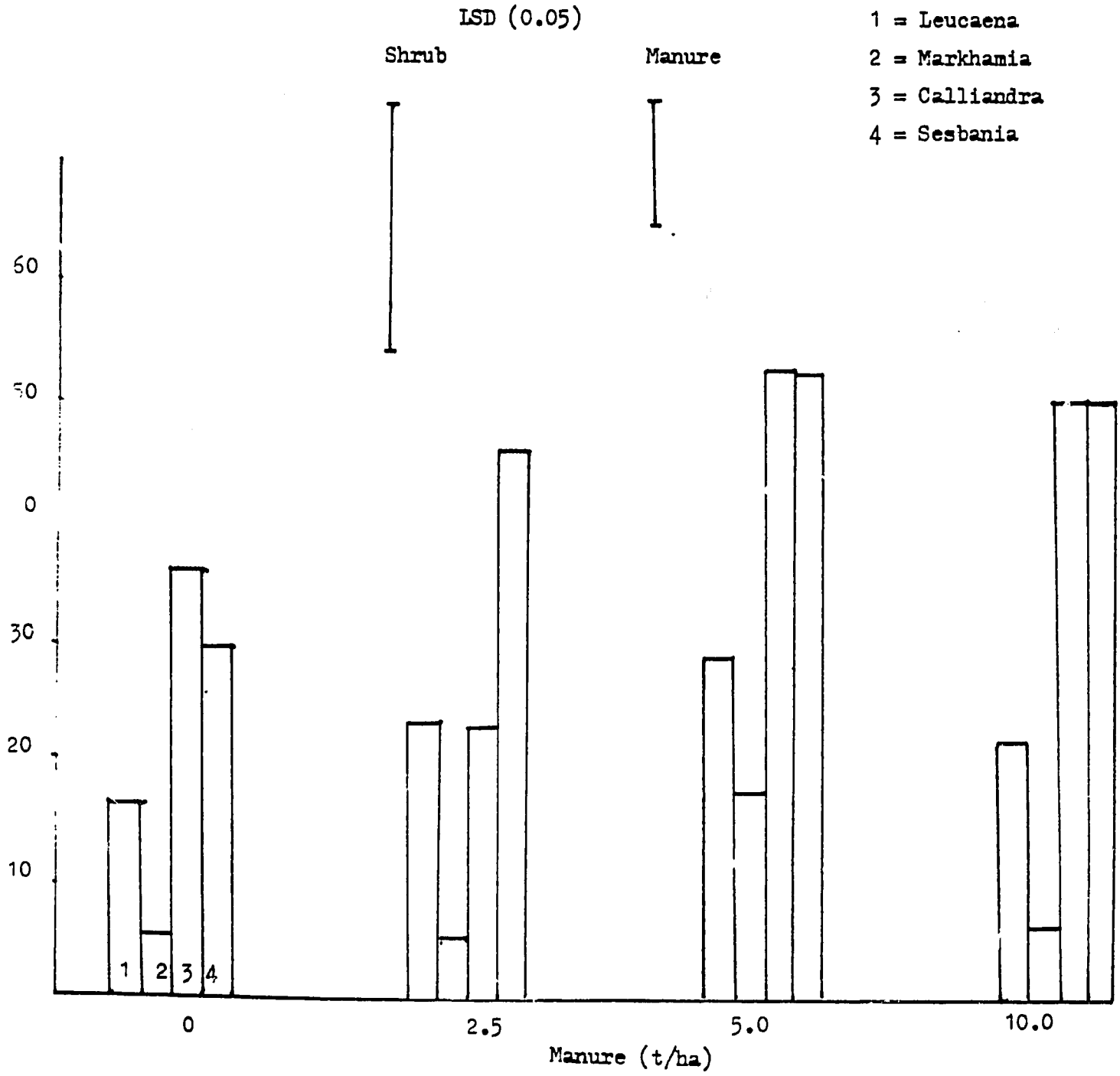

Fig. 3. Effect of manure on growth of leguminous shrubs.

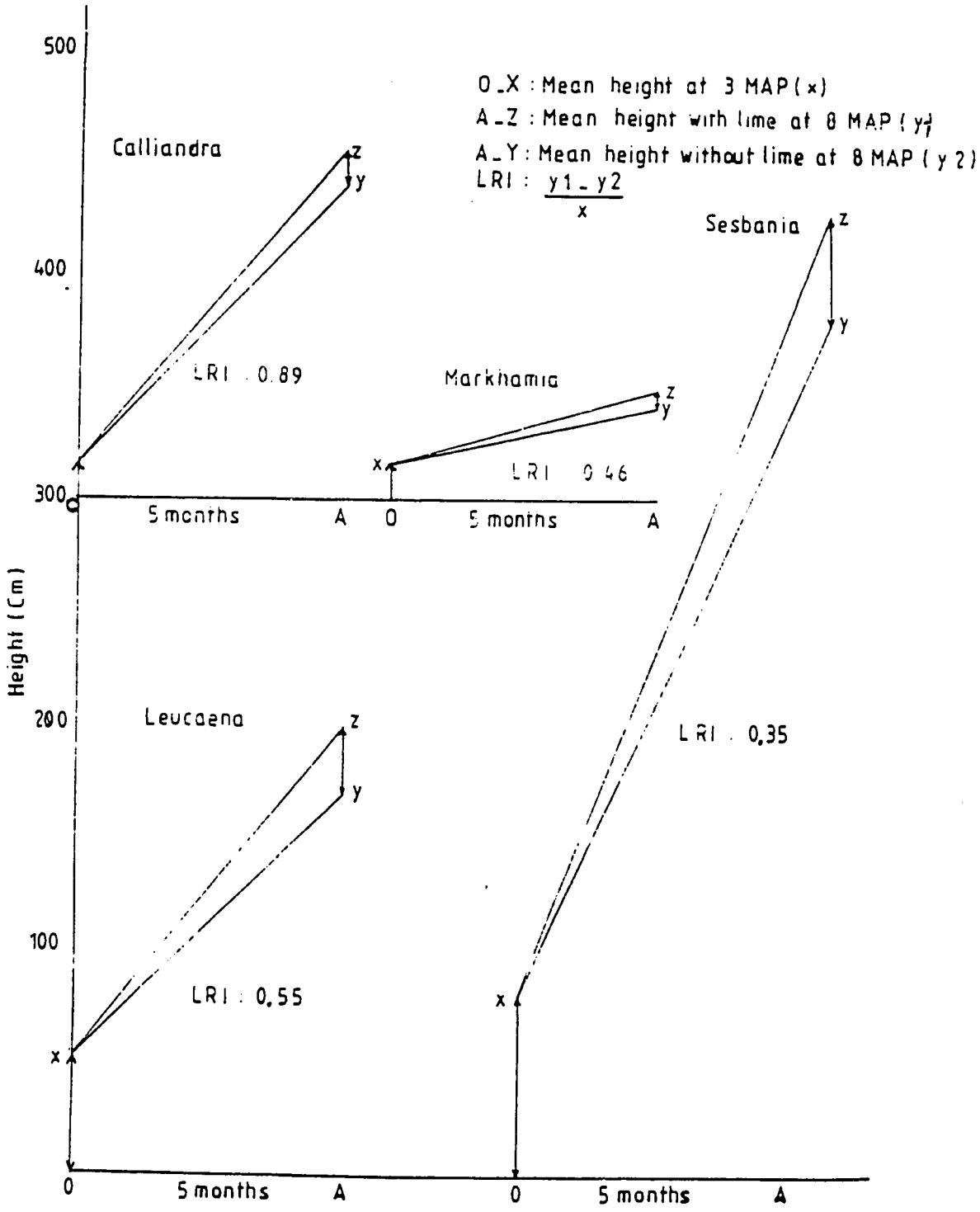

Fig. 4. Lime responses of alley cropping shrubs.

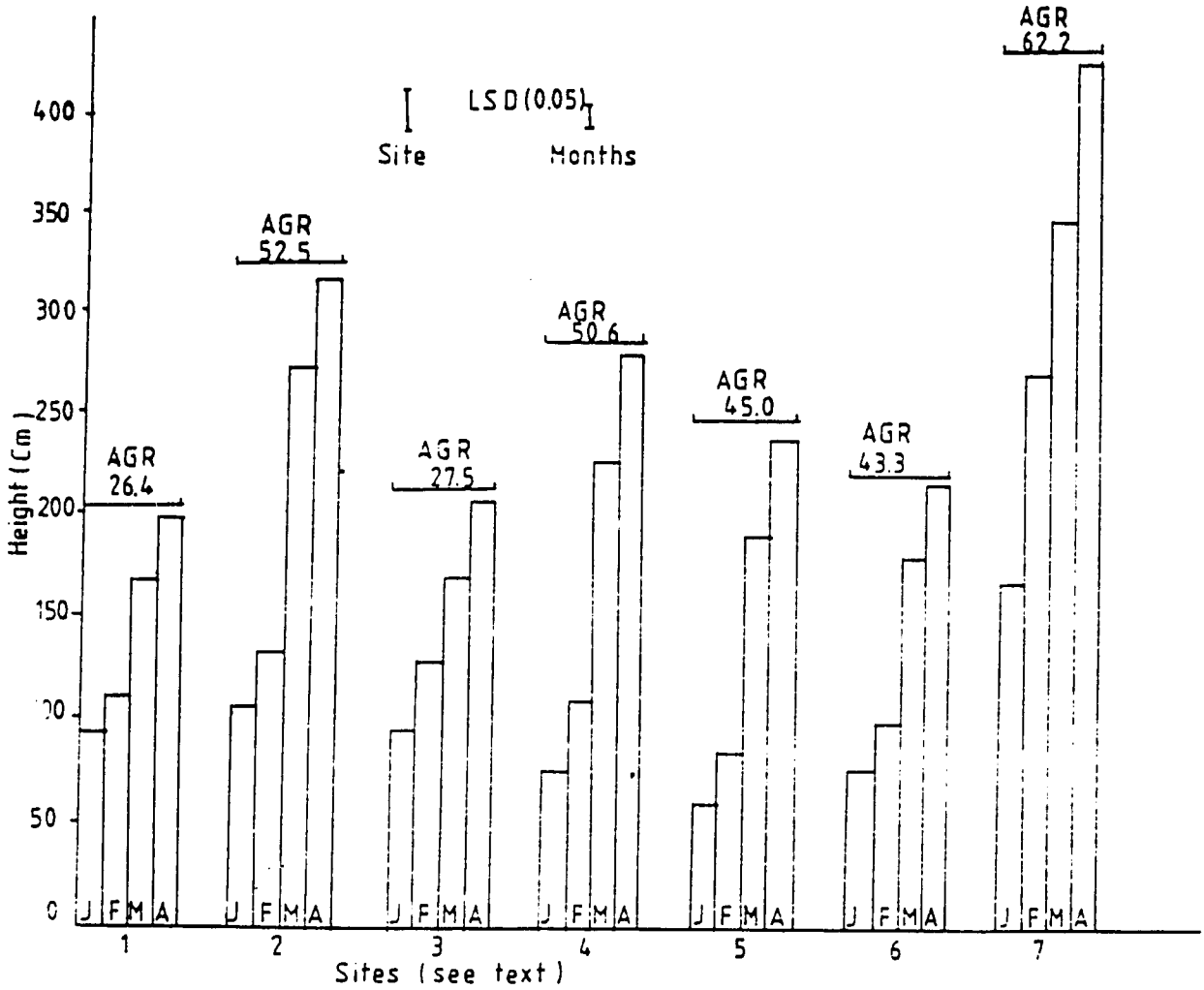

Fig. 5a. Growth of Sesbania sesban in selected microecozones in the highland region of Rwanda.

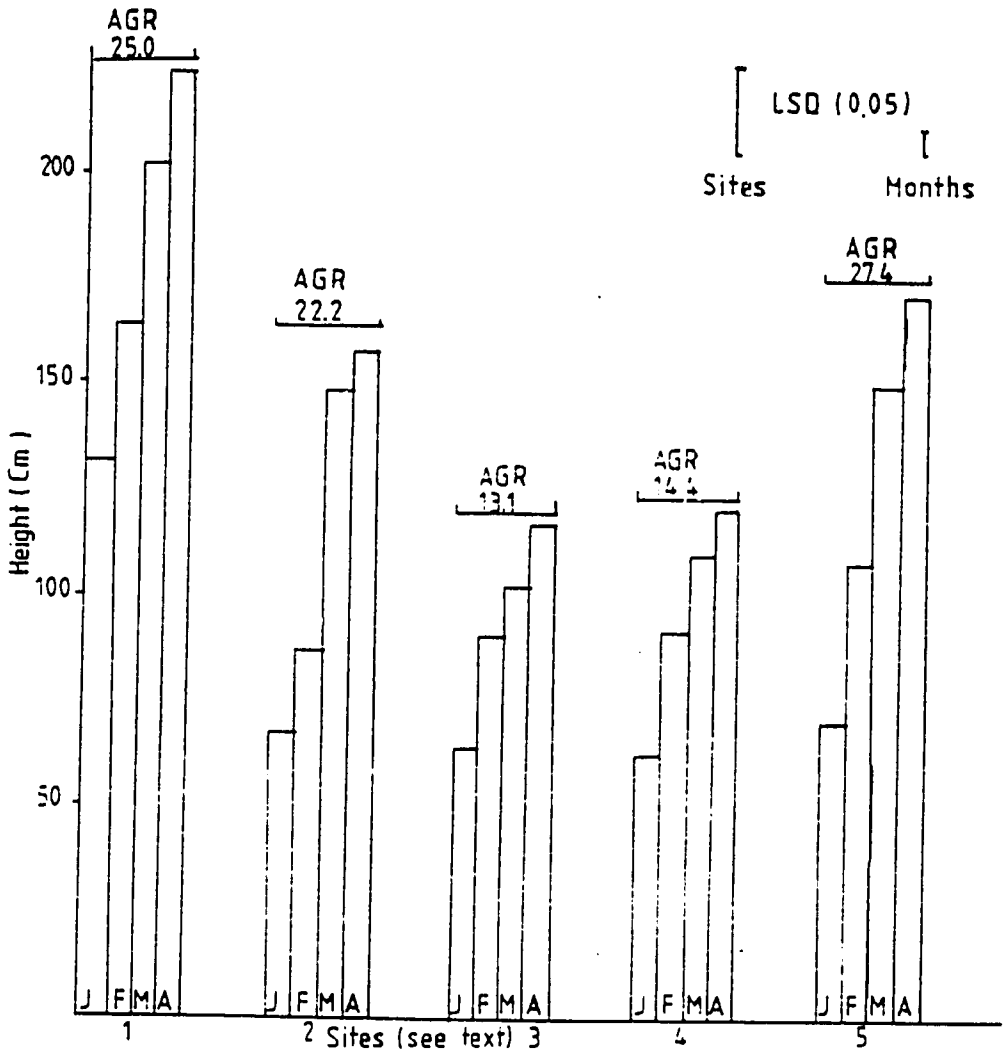

Fig. 5b. Growth of Leucaena leucocephala in selected microecozones in the highland region of Rwanda 3-6 months after planting.