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Comparative Effects of Nine Indigenous Multipurpose Tree Species on Maize Yield

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Abstract

Successful integration of useful trees and perennials into food crop production system is a key to developing sustainable agriculture in the tropics region. Alley cropping or inter-planting multipurpose tree legumes with annual food crops provides an ecologically sound basis for new farming system development. In this respect, nine indigenous multipurpose tree species; Croton megalocarpus, Pterygota mildbraedii, Podocarpus latifolius, Markhamia platycalyx, Polyscias fulva, Erythrina abyssinica, Ficus thonningii, Maesopsis eminii, Syzygium parvifolium were evaluated for their performance on crop yield, notably Maize planted in alley cropping system at Ruhashya sector, Huye district. These trees were planted in a randomized complete block design system with three replications. In the middle season these trees were pruned and thinned to assess their biomass nutritional concentrations. Maize was planted together with tree species in an alley cropping system. Data collected from the experiment included tree diameters at breast height (cm), total height of trees (m), nutritional concentrations of tree leaf biomass, number of leaves, leaves diameter, maize height, leaves diameter, total maize biomass and dry grain weight. It was found with the result that Sygygium parvifolium had the highest number of leaves (12.29) and highest leaves diameter (8.66cm) approximately two times more than Maesopsis eminii which had the lowest number of leaves (8.35) and lowest leaves diameter (4.50cm). The highest maize biomass and grain yield was found for Ptergotha mildbraedi (6.56 ton ha^{-1} and 2.89 ton ha^{-1} respectively) approximately 3 times and 4 times more than Maesopsis eminii which had the lowest maize biomass and grain yield. We concluded that to increase the crop production Ptergotha mildbraedi would be the best choice for intercropping. However, the choice should depend on the need of the farmers, for example if the purpose is to produce timber Maesopsis eminii and Croton megalocarps could be the best choice.

Keywords

Indigenous Multipurpose Trees, Biomass, Maize

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1. Introduction

Rwanda is a land locked country with restricted resources and most of the Rwandan population lives from agriculture which accounts for a third of Rwanda's GDP, it constitutes the main economic activity for the rural households and remains their main source of income [1]. Recently most of the Rwandan agriculture practice was dominated by monoculture which is the practice of growing the same crop each year on a given acreage but monoculture has not been generally successful in the past because non-legume crops usually exhaust the nitrogen in the soil with a resulting reduction in yields [2].

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Research from most of agriculture institutions found that planting agroforestry trees species together with crops can provide multiple functions and services not only for farmers but also for the environment in which they live [3]. Environmentally, trees provide shade for livestock living places for predators of pests such as birds and other insects which reduces the need for pesticides and recycles nutrients and organic matter for the soil that helps annual crops grow well and which not only reduces the need for fertilizers but also increases the soil's water-holding capacity [4]. Economically, trees provide sources of income other than those from annual crops and livestock and help make best use of land, labour and capital [5]. In a whole landscape, the trees and fields combined provide a range of functions that benefit entire communities: food and fuel; increasing infiltration of water into soil and generally improving the flow and quality of water; transferring nutrients across landscapes by livestock and preserving biodiversity that provides its own range of benefits such as medicines and control of pests and diseases ensuring watersheds function well and regulating micro- and meso-climates [6, 14].

Despite the many benefits provided by trees care must be taken when integrating trees with crops because of potential; competition for light, nutrients and water; hosting plant diseases and pests and low compatibility with mechanization of crop production [7, 8].

Agroforestry has attracted considerable attention in recent years because of its potential to reduce poverty, improve food security, reduce land degradation and mitigate climate change. However progress in promoting agroforestry is held back because decision-makers lack reliable tools to accurately predict yields from tree-crop mixtures [9, 10]. The aim of this study was to provide a description of the individual effects of the nine indigenous tree species on maize yield, regarding to some aspects such as: grain weight, total biomass, height, number of leaves and leaves diameters of maize.

2. Materials and Methods

2.1. Study Area

This study was conducted at Rwanda Agriculture Board (RAB), Rubona Station. This station is located in southern province of Rwanda, Huye district precisely in Ruhashya sector. Its geographical coordinates is 2° 25' 25" South, 29° 46' 31" East, The altitude range from 1200 to 1700 m above sea level. The climate is of the type temperate tropical highland characterized by a long rainy season which lasts from about March to May, long dry season ranging from June to mid-September, short rain season which lasts from October to December and short dry season which lasts from January to March. The annual mean rainfall is estimated to 1,000 mm. The mean minimal and maximal temperature is estimated to 16°C and 30°C, respectively [11].

Figure 1. Location of Ruhashya sector, Kayonza District (File: http://197.243.22.137/Huye8/index.php?id=83

2.2. Experimental Design and Treatments

The experimental design consisted of nine treatments of nine indigenous multipurpose tree species planted in alley cropping with maize: treatment 1/ *Croton megalocarpus,* treatment 2/ *Pterygota mildbraedii,* treatment 3/ *Podocarpus latifolius,* treatment 4/ *Markhamia platycalyx,* treatment 5/ *Polyscias fulva,* treatment 6/ *Erythrina abyssinica,* treatment 7/ *Ficus thonningii,* treatment 8/ *Maesopsis eminii,* treatment 9/ *Sygygium parvifolium* and a control replicated three times in a randomized complete block design (RCBD). Each experimental plot size was 15x15 m. The spacing between trees in each experimental plot was 3×3 m and the spacing between experimental plots was 2m**.**

2.3. Sampling and Data Collection

Land preparation was done manually by farmers; nine indigenous multipurpose tree species used in this experiment were planted two years before the intercropping with maize. Every year these tree species were pruned to remove the damaged part and to control their size and shape. Pruning was done by cutting above the bud at an angle slowing away from it. In each experimental plot, a sample of five trees was selected and marked with red ribbon for repeated measurements for diameter at breast height and for the total height of the tree; these two parameters were measured using a calliper and graduated pole respectively.

Maize (Zea *Maize Saccharata* variety) was planted before the long rain season of February. The plant spacing used was 75 cm × 50 cm to give a plant population of approximately 27 000 per hectare. Two seeds were planted in each hole, no other fertilizer were applied. Weeding was done by farmers every two months. For each experimental plot 16 maize crops were selected randomly at 5 m away from the last selected trees for growth assessment. Maize crops were also marked with black ribbon for repeated measurements. The measured parameters included: number of leaves, leaves diameter, maize height (from the soil surface to the top of canopy), maize biomass and grain yield. The measurements were done at 6, 9 and 12 weeks after crop emergency. The maize yield in each plot was assessed at the end of the cropping season. The yield measurements included dry grain weight obtained after drying the maize cobs in oven (105°C) for four days and the dry weight of the maize grain was determined after shelling the cobs. The concentrations of Nitrogen and Phosphorus were determined in laboratory from dried leaves samples by using UV/visible spectrometry and flame photometry for Potassium [12, 13]. Data collected from this experiment was subjected to Analysis of variance (ANOVA) using Genstat discovery edition 13. Means was separated using Tukey test with an individual simultaneous confidence intervals at 5% of significance level.

3. Results and Discussions

3.1. Trees Diameters and Heights

Results obtained from the growth rate of the trees were summarized in figure 1. The highest average height and diameter were found for Croton megalocarpus (4.58m, 9.75cm respectively) followed by Maesopsis eminii (3.53m, 9.075cm) which were approximately four times more than Sygygium parvifolium (1.35m, 2.73cm) and Ptergotha (1.36m, 2.44cm) found to have the lowest diameter and height.

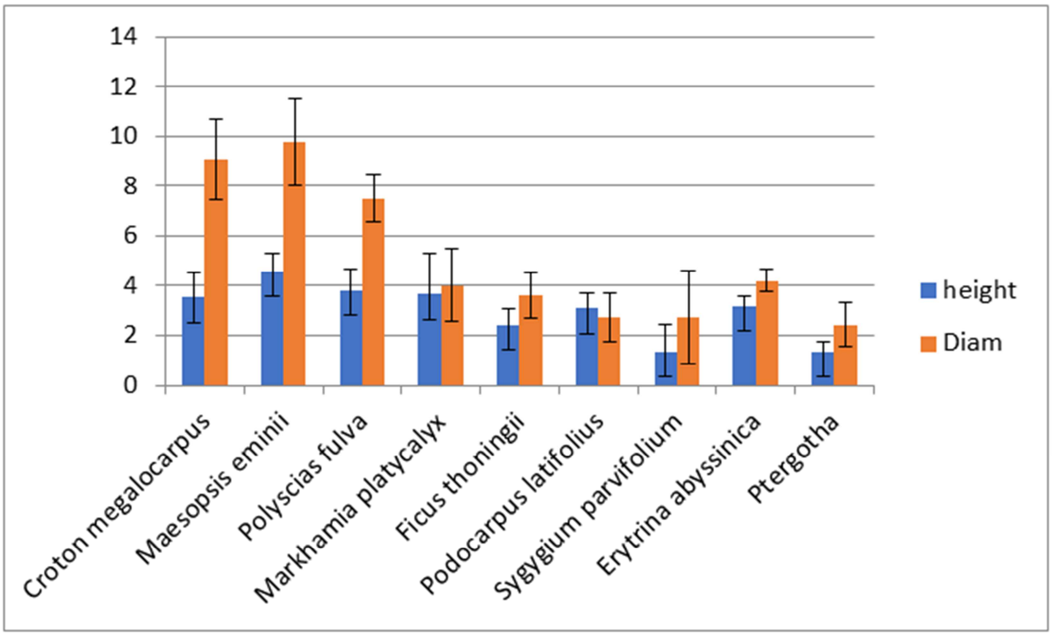

Figure 2. Average Heights and Diameters of the tree species.

3.2. Agronomic Parameters at Harvest

It was found that some tree species influenced significantly maize for some measured parameters (Table 1). Even though the maize heights were not statistical significant different among tree species, the maize intercropped with Markhamia platycalyx was found to have the highest height. Sygygium parvifolium was found to have the highest number of leaves (12.29) and highest leaves diameter (8.66cm) approximately two times more than Maesopsis eminii which had the lowest number of leaves (8.35) and leaves diameter (4.50cm). The highest maize biomass and grain yield was found for Ptergotha mildbraedi (6.56 ton ha^{-1} and 2.89 ton ha^{-1} respectively) approximately 3 times and 4 times more than Maesopsis eminii which had the lowest value. However maize yields showed a slightly negative response when intercropped with Croton megalocarpus and Maesopsis eminii relative to the control.

This can be explained by the fact that due to high canopy of

Croton megalocarpus and Maesopsis eminii, the Shading effect was reducing the light to reach the crop leaves, the fastest growing rate of this two tree species also increased the competition for nutrients and water between then and maize, even if this two species could have an appreciable amount of litter production which after decomposition could produce organic matter, this effect was dominated by low light and nutrients competition. The highest yield observed to other species could be resulted to the low competition of the light and nutrients, and the high litter production, which after decomposition provided nutrients to the crop.

These results are in agreements with those found by [9, 14, 15] through their research on Influence of selected tree species on soil characteristics, growth and yield of maize in Western Kenya and reported a no significant difference in the height of maize under different tree species and a significant increase in maize yield under intercropping with different tree species.

Table 1. Agronomic parameters after harvest.

Treatments	Number of leaves	Plant height (m)	Leaves diameter (cm)	Total biomass (ton ha^{-1})	Grain yield (ton ha^{-1})
Control	9.55±1.19 bc	1.76±10.4	5.65±1.11 bc	3.75±0.15 d	1.86±0.41 ab
Croton megalocarpus	10.03±1.13 abc	1.85±1.05	5.05±0.55 bc	3.35±0.15 d	1.20±0.67 b
Maesopsis eminii	8.35±0.60 c	1.78±0.71	4.50±0.14 c	2.20±0.28 e	0.70±0.1 c
Polyscias fulva	10.37±1.21 abc	2.27±0.22	6.43±0.63 abc	6.14±0.66 ab	2.34±1.00 ab
Markhamia platycalyx	11.62±0.98ab	2.62±1.04	6.62±0.12abc	2.62±10.41d	2.21±1.13 ab
Ficus thonningii	11.41±1.70 ab	2.41±0.40	7.41±0.41 ab	4.11±1.66 cd	2.58±0.58 ab
Podocarpus latifolius	12.00±0.76 ab	2.42±0.45	6.00±1.00 abc	4.40±1.10bcd	2.04±0.10 ab
Sygygium parvifolium	12.29±0.53 a	2.26±0.51	8.66±0.55 a	5.84±0.81 abc	2.12±1.03 ab
Erytrina abyssinica	10.23±1.52 abc	2.16±0.50	7.56±2.2 ab	6.19±0.55 ab	2.62±0.23 ab
Ptergotha mildbraedii	10.56±1.06 abc	2.46±1.1	7.56±1.00 ab	6.56±0.45 a	2.89±0.81 a

Mean value ± standard deviation (SD); treatments with same letters are not significantly different (Tukey test, $p<0.05$). Number of leaves ($p<0.001$), Plant height ($p=0.771$), leaves diameter ($p=0.001$), total biomass ($p<0.001$) and total grain yield ($p=0.013$).

3.3. Nutritional Evaluation of Tree's Leaf Biomass

As summarized in table 2, they have been a slightly significant difference among tree species for Phosphorus, contrarily to Nitrogen and Potassium where treatments were highly significant different. Polyscias fulva was found to have the highest nitrogen (1.125%) and phosphorus concentrations (0.699%), Ficus thonningii was found to have the highest Potassium concentration (0.898%). However the lowest Nitrogen and Potassium concentrations was found for Croton megalocarpus (0.236 and 0.152% respectively) and the lowest Phosphorus concentration was found for Sygygium parvifolium (0.142%).

Table 2. Nutritional contents of tree's leaves.

Treatments	N (%)	P (%)	K (%)
Croton megalocarps	0.236+0.001 e	0.432±0.438 ab	0.152±0.004 e
Maesopsis eminii	0.625+0.004 d	0.425±0.004 ab	0.366±0.002 cd
Polyscias fulva	1.125±0.002 a	0.699±0.002 a	0.522±0.003 bc
Markhamia platycalyx	0.871±0.001 bc	0.676±0.001 a	0.208±0.002 de
Ficus thonningii	0.616±0.001 d	0.494±0.003 a	0.898±0.003 a
Podocalpus latifolius	0.322±0.002 e	0.578±0.001 a	0.154±0.002 e
Erytrina abuscinica	0.864±0.004 c	0.495±0.004 a	0.313±0.004 de
Sygygium parvifolium	0.991±0.001 abc	0.142±0.004 b	0.522±0.004 bc
Pterygotta mildibradei	1.0182±0.001 ab	0.613±0.004 a	0.639±0.002 b

Mean value ± standard deviation (SD); treatments with same letters are not significantly different (Tukey test. $p<0.05$). Nitrogen ($p<0.001$), Phosphorus ($p<0.001$), Potassium ($p<0.001$).

4. Conclusions

From this study it was concluded that except Maesopsis eminii and Croton megalocarps other experimented tree species revealed to have a positive influence on maize yield. Pterygotta mildibradei was the best recommended tree species due to its high nutrients content in leaves in term of Nitrogen, Phosphorus and Potassium which after accumulation and decomposition produced organic material used by the crop to increase the yield, in addition, there was a low completion between Pterygotta mildibradei and maize for light and water due to its rapid growth in height compare to diameter and its deep rooting system. Then, it was concluded that while selecting the tree species for intercropping, the choice should depend on the need of the farmers and the purpose of growing them. For example if the purpose is to produce trees for timber, fodder, fire wood or wind protection Maesopsis eminii and Croton megalocarps could be the best choice. Moreover, if the purpose is to increase the maize production, Pterygotta mildibradei and other tree species would be the recommended ones.

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