

Research Paper

Effect of root growth potential and spatial arrangement trials of *Gmelina Arborea* on the growth and yield of maize

Accepted 30th April, 2013

ABSTRACT

Maize was intercropped with 6-month-old *Gmelina* Root Growth Potential (RGP) trials in various spatial arrangements at Matalam, Cotabato Philippines, arranged in a strip-plot design with three replications. Analysis of data showed significant differences in all agronomic and morphological characteristics of maize as affected by tree spacing but not to RGP classes. Mono-maize crop were dominated significantly in all traits. Tree spacing is related significantly with maize yield, weight of 500 seeds and biomass while RGP class is negatively related with yield, weight of 500 seeds, biomass, leaf area, and leaf area index.

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Key words: RGP class, spatial arrangement, mono-maize crop.

INTRODUCTION

Planting of annual crops along woody perennials in certain parcel of land is one way of maximizing production, permitting suitable yield and growth of selected crops. There could sharing of nutrient and water between the crops planted along alleys of trees because trees were deep rooted than agricultural crops, and so trees could presumably take nutrient from different depths and from a larger combined volumes of the soil (Brewbaker 1976). The intelligent application of crop mixing requires an understanding of the various species interactions in the system. Vandermeer (1989) categorized the species interactions involved in agricultural intercropping as either "competitive or facilitative". This approach has been applied to species mixtures in agroforestry (Anderson and Sinclair, 1993) and silviculture (Kelty, 1992).

Intercropping of maize crops in *Gmelina* RGP trials planted at various spatial arrangements in this study attempted to investigate the effect of RGP class, planting distance of trees and their interactions on the growth and yield of maize.

METHODOLOGY

The study was conducted on May 8 – August 23, 2007 (1st

cropping) and September 16 – December 31, 2007 (2nd cropping) in a field trials of RGP of 0-10 (RGP class 1); 11-20 (RGP class 2); 21-30 or more lateral roots (RGP class 3) of *Gmelina* planted at different spacing such as: 2m x 2m; 2m x 3m; and 2m x 4m in Matalam, Cotabato Philippines. The climate is warm tropical with mean annual temperature ranging from 28 – 40°C and a mean annual rainfall of 2373.5 mm. The soil is silty clay with pH value ranging from 6.2 (1st crop sampling) to 7.2 (2nd crop sampling).

Six months after outplanting of the trees, maize (RR Corn2 seeds by Monsanto) were sown in the furrows prepared in between rows of the trees at 25 x 60 cm planting distance. Basal application of complete fertilizer (14-14-14) and side dressing of urea (46-0-0) at a rate of 120-28-28 (prevailing farmer's practice in the area) were employed.

RESULTS AND DISCUSSION

Maize height

The monthly mean height of the maize during the 1st and 2nd cropping showed a linear pattern of growth. This trend

is significant in both cropping periods in terms of the tree spacing and RGP classes. Maize planted as mono crop differed significantly with maize planted in the 2 x 2m tree spacing both in crop 1 and crop 2 with a mean height of 2.096 and 2.091 m, respectively. However, mono maize crop is insignificantly different with maize planted at 2 x 4m tree spacing in crop 1 and corn planted in 2 x 4 m and 2 x 3 m tree spacing in crop 2 (Figure 1). Tree spacing of 2 x 4 m has mean maize height of 2.078 and 2.05 m in the 1st and 2nd cropping respectively. The lowest mean height was found in the 2 x 2 m tree spacing.

The maize height in RGP class 1 was significantly lowered compared to the mono-maize crop and the other tree spacing (Figure 2). Comparison of the two cropping periods showed no significant differences in terms of maize height as affected by tree spacing and RGP classes. Significant interactions of S x R (Tree Spacing x RGP class) was evident in 30 DAP (Days after planting) – 90 DAP in crop 1. No significant interactions of D x R in crop 2.

Number of leaves

The number of maize leaf showed no significant differences in terms of tree spacing in crop 1. However, RGP class is significantly varied in 105 DAP. RGP Class 3 was significantly higher with the other root classes in both cropping periods (Figure 3). Significant results were observed both in tree spacing and RGP classes in crop 2. The maize mono crop and 2 x 4 m tree spacing were significantly more maize leaves compared with 2 x 3 m and 2 x 2 m tree spacing in 30 DAP, 90 DAP and 105 DAP. While mono-maize and 2 x 4m tree spacing is significantly different in 90 DAP and 105 DAP in crop 2 (Figure 4). Analysis of variance revealed significant interactions of tree spacing x RGP classes in crop 1 but not in crop 2.

Leaf area

The leaf area of the maize demonstrated significant differences in terms of tree spacing and RGP classes. The mono maize crop had bigger leaf compared with the other treatments in both cropping periods. The 2 x 4 m tree spacing was also significantly different with 2 x 2 m and 2 x 3 m tree spacing in the 1st cropping but not in the 2nd cropping (Figure 5).

Figures 5 and 6 shows the significant dominance of maize mono crop in both cropping periods in terms of leaf area compared with the maize planted in between trees. RGP class 3 had the lowest leaf area but was not significantly different with RGP class 2 and 1 in crop 1 but significant in crop 2. The relationship of RGP class with leaf area was negative (Table 3) thus, the increase in lateral roots of the trees may cause tremendous effect on the leaf area of the

maize in the cropping system but the reduction may not be that significant. Interaction of tree spacing and RGP class was found significant in both cropping periods.

Leaf area index

Both cropping period shows significant differences of leaf area index (LAI) as affected by tree spacing and RGP classes. Maize-mono crop is significantly different with the other treatment in both cropping periods (Figure 7 and 8). Maize planted under 2 x 4 m tree spacing was also significantly different with the other two tree spacing arrangement in crop 1 but not in crop 2.

Mono-maize crop and RGP class 1 were significantly higher in leaf area index in both cropping periods as compared to the other RGP classes. The significant effect of RGP class in leaf area index in crop 1 became insignificant in crop 2. Comparison of the two crops also showed significant differences. Mono- maize crop had significantly higher LAI than the maize planted under 2 x 2 m tree spacing but not to 2 x 4 m and 2 x 3 m tree spacing.

The interactions of tree spacing x RGP class on leaf area index were found significant in both cropping periods.

RGP classes were negatively related with LAI of the maize. Per analysis, the LAI of mono-maize crop is comparable with LAI in RGP class 1 for both cropping periods. It says that when two factors have negative relationship, it means, increase of one factor will cause the decrease of the other. In the case of the RGP class and LAI relationship, when lateral roots increases in trees, LAI of maize will probably decreases.

Weight of 500 maize seeds

The weight of 500 maize seeds shows significant variation in terms of tree spacing and RGP classes in both cropping periods (Table 1). Maize seeds in mono crop were significantly heavier with mean 500 seed weight of 126.67 and 128.65 g in crop1 and crop 2 respectively. The lowest mean value was found in 2 x 2 m tree spacing (120.83 and 120.68 g).

The RGP class on the other hand reported mono-maize crop as significantly heavier in weight of 500 maize seeds as compared to the maize planted with the trees (Figure 9). Interactions of tree spacing and RGP class revealed insignificant differences in the weight of 500 maize seeds.

Maize biomass

Significant differences were observed in maize biomass as affected by tree spacing and RGP classes. The calculated maize biomass in mono-maize crop as affected by tree

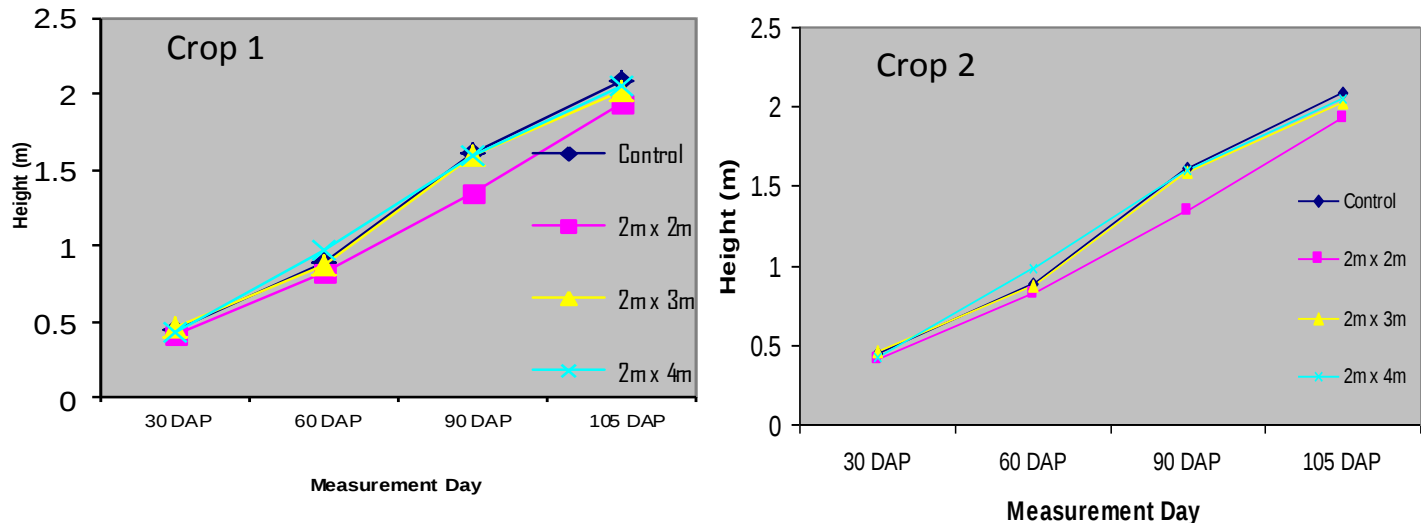


Figure 1. Maize height in both cropping periods as affected by tree spacing and RGP classes.

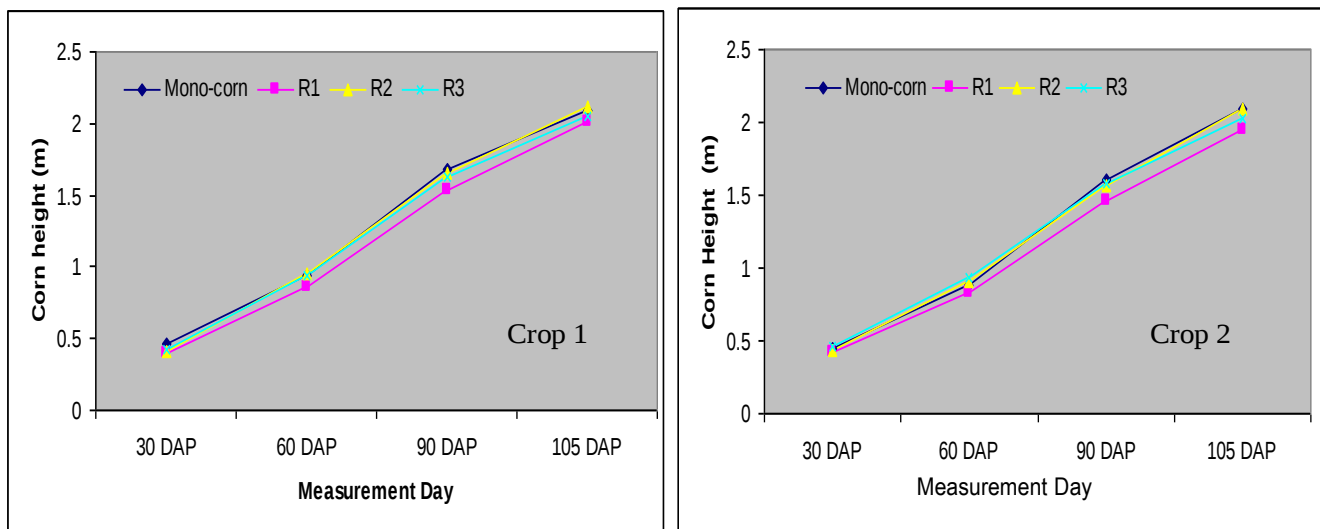


Figure 2. Height of maize in both cropping period as affected by tree spacing and RGP classes.

spacing (Table 2) and RGP classes (Figure 10) was significantly higher with the other treatments in both cropping periods. The 2 x 4 m tree spacing however is not significantly different with 2 x 3 m but significantly higher with 2 x 2 m spacing in the 1st cropping but not in the 2nd cropping period. There is no significant interaction of the tree spacing and RGP classes on maize biomass as revealed in the analysis of variance.

Guevarra (1976) mentioned that in Hawaii, yield of annual dry matter decreased with wider plant spacing. In wider alleys, the percentage forage production of dry matter was higher and the stems thicker. At IITA, Ibadan, Nigeria, a higher quantity of biomass per unit area was

observed from a 2-meter alley width than from a 4-meter alley width because of higher plant population.

Grain yield

The mean yield trend of the maize as affected by tree spacing and RGP classes of *Gmelina* is shown in Figure 12 and 13. The yield of maize was significantly affected by tree spacing. Maize mono-crop has significantly higher yield compared with the maize planted along the trees both in the 1st and 2nd cropping. In the 1st cropping, mono-maize crop did not significantly varied with 2 x 4 m tree spacing.

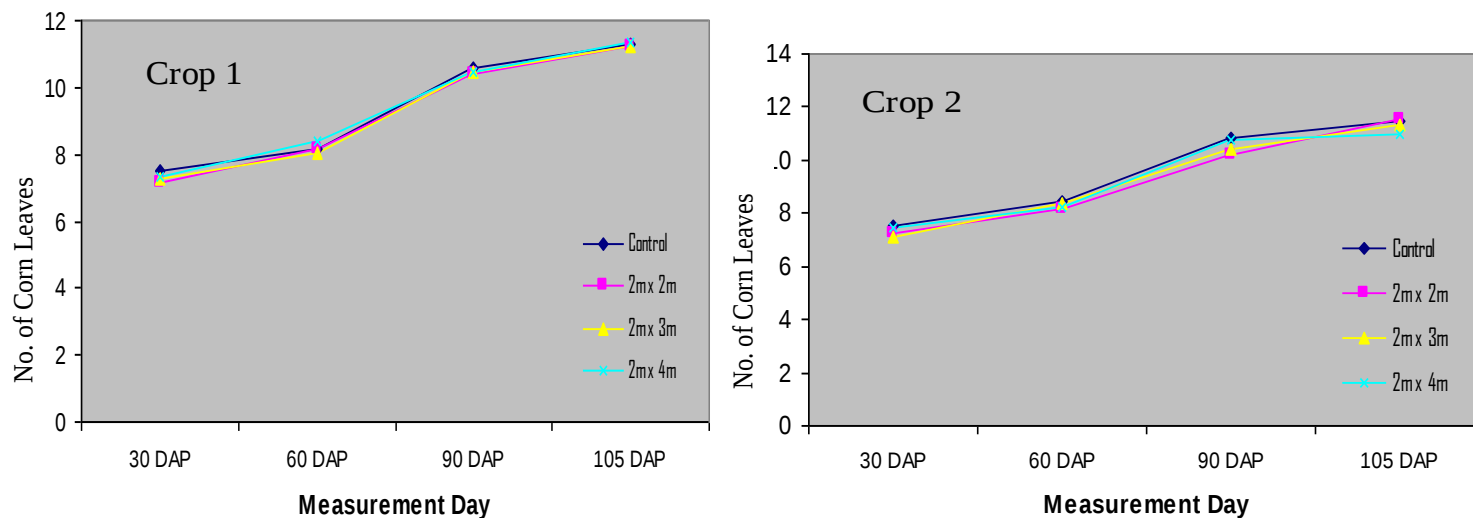


Figure 3. Maize number of leaves in both cropping period as affected by tree spacing.

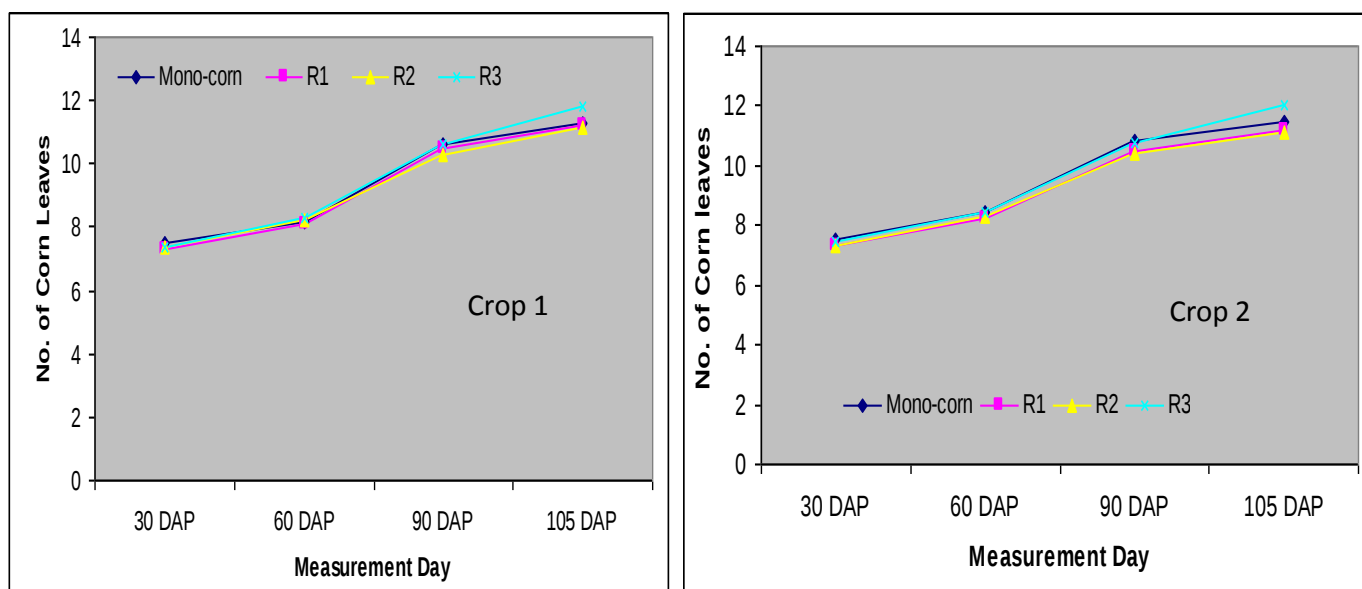


Figure 4. Maize number of leaves in both cropping period as affected by RGP classes.

This implies that planting of maize in between rows of wider spaced *Gmelina* plantation at early stage yields similar result with mono-maize crop. Maize-mono crop has a mean yield of 5.44 and 6.39 tha^{-1} in the 1st and 2nd cropping respectively. The next higher yield was found in maize planted between the 2 x 4m tree spacing with a mean of 4.79 tha^{-1} in the 1st cropping and 4.55 tha^{-1} in the 2nd cropping.

RGP class also significantly affected the yield of the maize in both cropping periods. The maize planted along RGP

class 3 (21–30 and up) has significantly lower yield compared to root class 1 (0–10) and 2 (11–20) which were not significantly different to each other (Figure 13). The interactions of tree spacing and RGP class did not show significant variations as revealed in the analysis of variance.

The two cropping periods showed insignificant differences in terms of tree spacing, such as: 2 x 2 m, 2 x 3 m, and 2 x 4 m. However, the mono maize crop varied significantly among the tree spacing with a mean yield of 5.92 tha^{-1} followed by 2 x 4 m with 4.67 tha^{-1} . The least

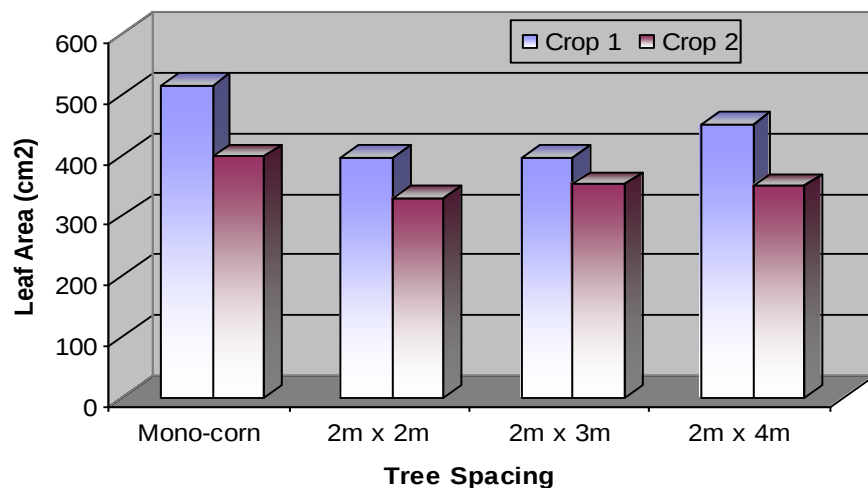


Figure 5. Leaf area of maize as affected by tree spacing.

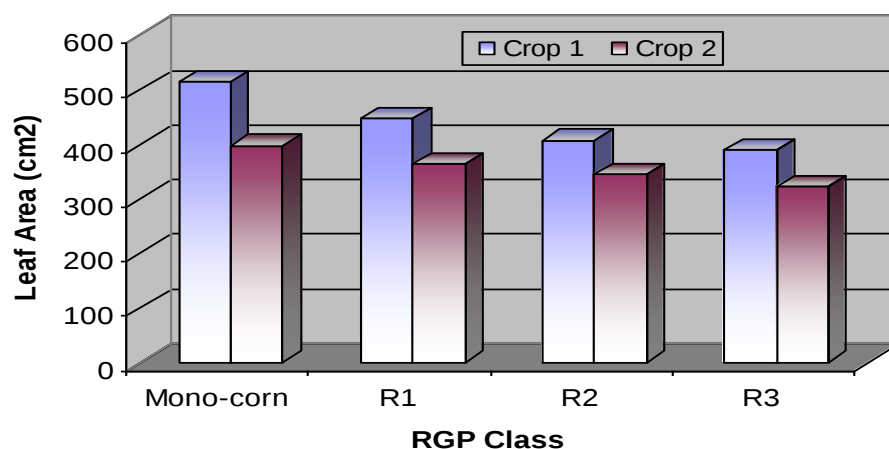


Figure 6. Leaf area of maize as affected by RGP classes.

Table 1. Mean of weight of 500 maize seeds in both cropping season as affected by tree spacing.

Tree spacing	Weight of 500 corn seeds	
	Crop 1	Crop 2
Mono-maize crop	126.67a	128.65a
2m x 2m	120.83b	120.68b
2m x 3m	123.50ab	124.57ab
2m x 4m	122.50b	124.50b

Means followed by the same letter are not significantly different at 5% level.

Table 2. Maize biomass (tons/ha) in both cropping season as affected by tree spacing.

Tree spacing	Corn biomass	
	Crop 1	Crop 2
Mono-maize crop	7.3000a	7.5867a
2m x 2m	4.0233b	4.0367b
2m x 3m	4.7800bc	3.8500b
2m x 4m	5.3133c	4.5500b

Means followed by the same letter are not significantly different at 5% level.

yield was obtained in the 2 x 2 m tree spacing with 3.24 tha⁻¹.

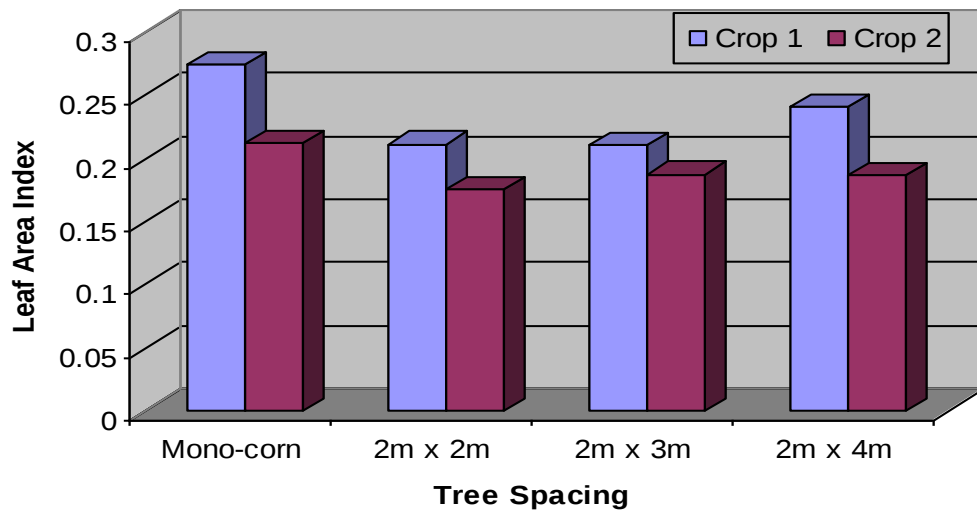
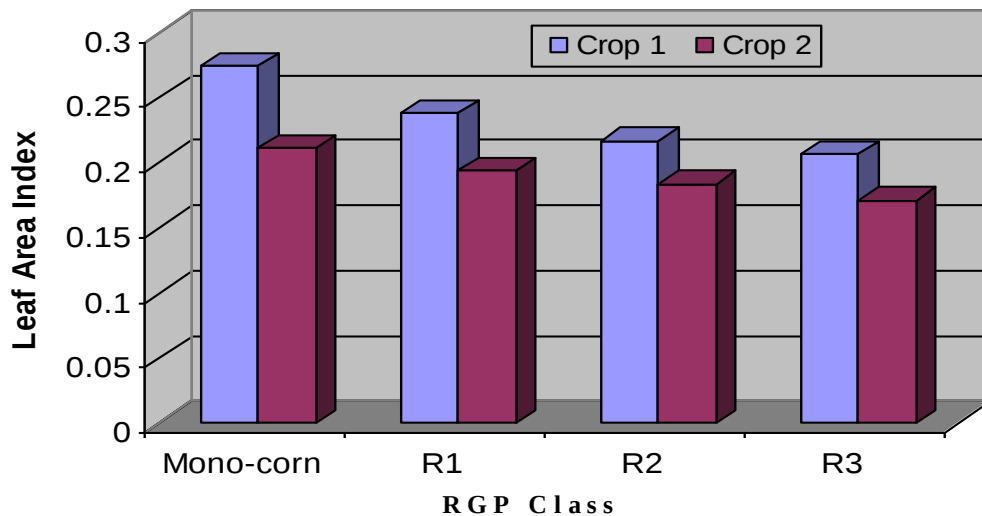
Young (1988) stated that *G. arborea* is a valuable source of poles and timber but has a depressive effect on yields of

adjacent crops, which may be caused by dense shade. Yields of crops are usually affected by the spacing of tree component of the system. Seekabembe (1985) mentioned that population of annual crops should be higher in the

Table 3. Multiple correlation analysis of the growth and yield of corn as affected by tree spacing and RGP classes.

	RGP	TS	H	NL	YD	WT5	BIOM	LA	LAI
RGP	1.000								
TS	0.000	1.000							
H	0.144	0.127	1.000						
NL	0.159	0.133	0.354	1.000					
YD	-0.344	0.821**	0.106	0.138	1.000				
WT5	-0.074	0.668**	0.173	0.171	0.677**	1.000			
BIOM	-0.454	0.862**	0.138	0.204	0.904**	0.605**	1.000		
LA	-0.124	0.187	0.072	-0.134	0.249	0.166	0.211	1.000	
LAI	-0.123	0.181	0.069	-0.129	0.241	0.162	0.205	0.999**	1.000

** Highly significant; LAI - Leaf Area Index; RGP - Root Growth Potential; YD- Maize Yield; TS - Tree Spacing
 WT5 - Weight of 500 Seeds; H - Maize Height; BIOM- Maize Dry Biomass; NL - Number of Leave; LA - Leaf Area.

**Figure 7.** Leaf area index of maize as affected by tree spacing.**Figure 8.** Leaf area index of maize as affected by RGP classes.

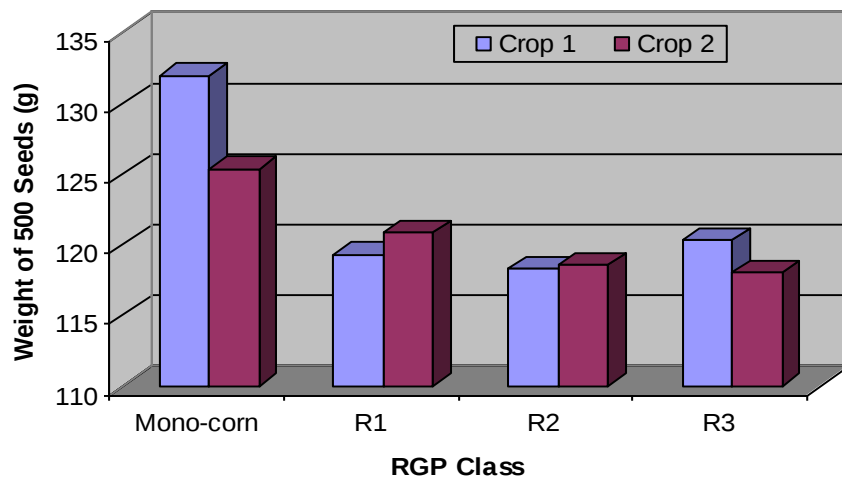


Figure 9. Weight of 500 maize seeds in both cropping period as affected by RGP classes.

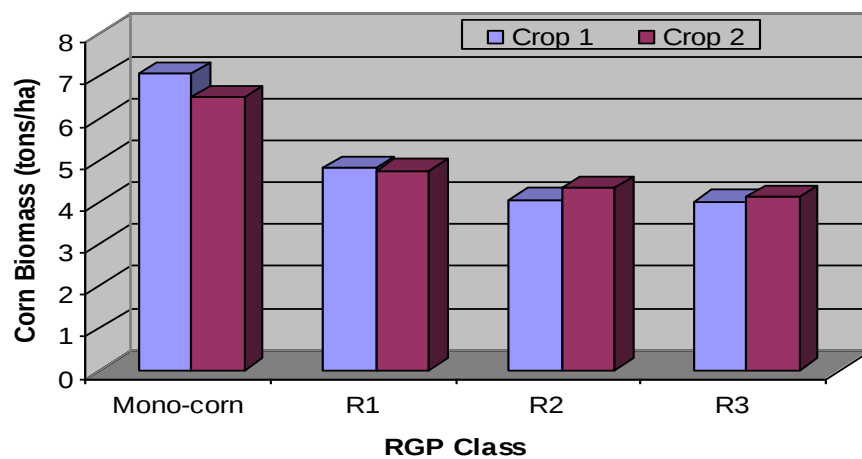


Figure 10. Maize biomass in both cropping periods as affected by RGP classes.

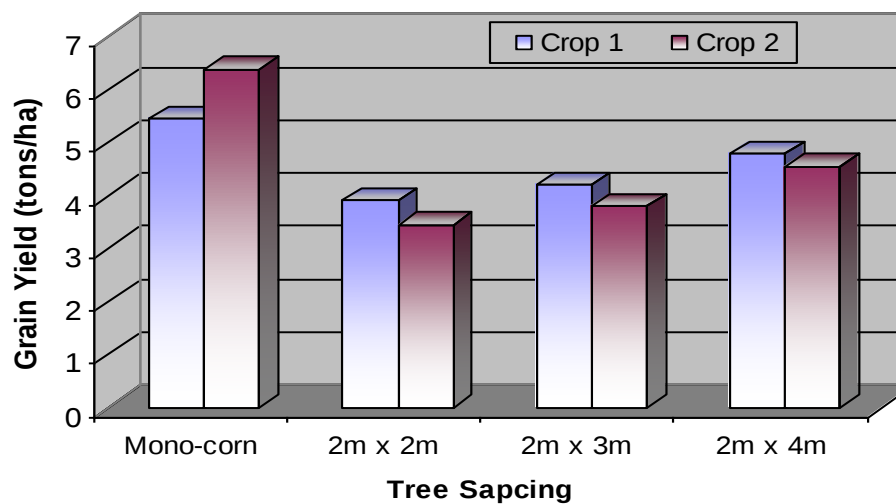


Figure 11. Grain yield of maize in both cropping season as affected by tree spacing.

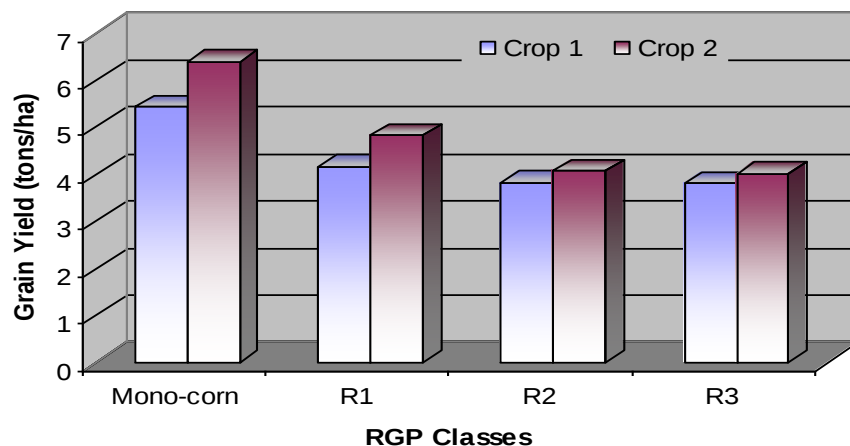


Figure 12. Grain yield of maize in both cropping season as affected by RGP class.

wider alleys (crops in between rows of tree component). He stressed that wider spacing of alleys could prevent excessive shading of the agricultural crops especially when pruning height is high. Likewise, wider alleys could also minimize competition between the hedgerows and the crops especially in dry areas. Escalada (1980) reported that in the Philippines, pruned ipil-ipil plants developed thin and lanky stems with reduced herbage yield per plant in a narrow alley. However, higher number of plants per unit area compensated for reduced vegetation growth. Trees competed to a significant extent with adjacent crop in terms of absorbing nutrients and light. Competition was most severe in the 2-3 rice rows closest to the hedgerows where yields are reduced by 50-75% compared to those at the center of the alleys (Basri et al., 1990). In Colombia, Rachie (1983) reported a higher corn yield of 6 tha^{-1} at lower population of ipil-ipil (3,000 trees/ha⁻¹). Higher population of 4,000 trees/ha⁻¹ gave a total corn yield of 4.5 tha^{-1} only.

Abas (2006) in his study on Bagras (*Eucalyptus deglupta* Blume) and Maize (*Zea mays* L.) aboveground interactions in alley cropping system at Claveria, Misamis Oriental and Mindanao Philippines found that maize grain yield across cropping season was consistently lower under hedgerow system than in the sole maize treatment. Yin and He (1997) reported a 60 – 100% reduction of crop yields from higher tree density and or later stage of rotation in a paulownia intercropping system.

Kang et al. (1981) reported low yield of maize from rows adjacent to the hedgerows to shade from the *Leucaena leucocephala* hedges cut at 1–1.5 m high. Bertomeu (2003) in his study reported reduced maize yield from 4.9 tons/ha to 2.7 tha^{-1} in the hedgerow (1 x 10 m), 4.9 tha^{-1} to 3.0 tha^{-1} along trees spaced at 2 x 2.5 m. He further stated that even if trees of *Gmelina* are as far as 10 m, yield in alley crops are reduced below economic levels two cropping seasons after tree establishment. He suggested however that *Gmelina*

would be preferably planted on farm boundaries, home gardens or other farm niches away from crop areas.

Comparison of the two cropping period as affected by tree spacing showed significant variations. The yields from plots with trees were reduced by as much as 22 - 29%. For the maize mono-crop, the yield increased by 15%. The RGP class reported a reversed result with the tree spacing. The yield of the maize increased in crop 2 as shown in Figure 2. However, RGP is negatively related with maize yield (Table 1). This negative relationship implies that the increase of RGP in tree would mean a decrease in yield of the maize crops. Increasing roots of trees would increase its competitive ability in absorbing water and nutrients from the soil that may suppress water and nutrient uptake of maize roots resulting to yield reduction.

Bertomeu (2003) stated a reducing maize yield of the second crop to an estimated 1.5 to 2 tha^{-1} . He further stressed that after planting *Gmelina* trees in block arrangement, farmers could expect to grow only 1 crop with average yields and second crop with reduced yields close to the break-even.

Regression and correlation analyses

Only biomass has significant regression with RGP class. The maize yield and weight of 500 seeds is significantly regressed with tree spacing. Figure 13 presents the correlation pathways of tree spacing versus the different morphological and agronomic characters of maize. Regression between yield and other character provides significant results in biomass and weight of 500 seeds. Maize yield is strongly correlated positively and significantly with biomass, and weight of 500 seeds. On the other hand, the production of biomass is dependent on leaf area and leaf area index as shown in the analysis. Biomass is positively and significantly correlated with LA and LAI. As

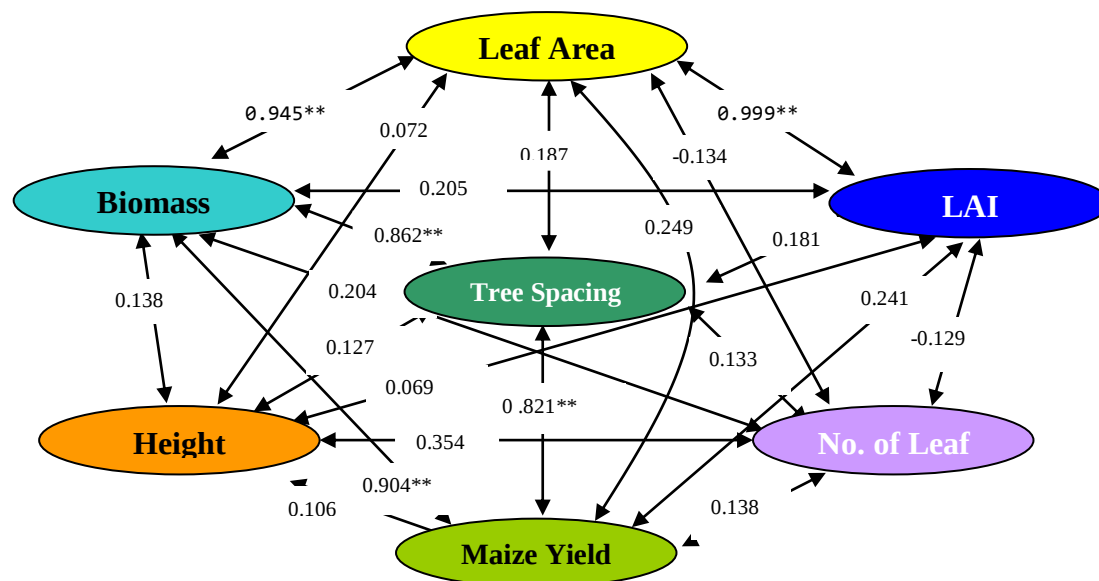


Figure 13. Pearson's path correlation analysis across tree spacing, maize yield, biomass, height at harvest, number of leaves, leaf area and leaf area index.

proof, LAI is 99.99% related positively with leaf area index. In physiology, LAI determines the amount of photosynthetic activity in plant. Higher LAI indicates the presence of shading in plants leading to lower production. In the case of the present study, however, maize yield was poorly related with leaf area index (Figure 13) thus, production of the mono-maize crop (open field) was high with higher LAI.

On one side, regression between maize yield and biomass was found to be highly significant with $R^2 = 0.904$. Yield vs. leaf area and leaf area index has regression coefficient value of $R^2 = 0.249$ and 0.241 , respectively. Yield vs height has the lowest value of $R^2 = 0.106$. The significant R^2 value obtained from regression and correlation analysis implied positive relationship of the two characters. The yield of maize was affected by tree spacing. This is true as the two parameters were highly related to each other. In the case of yield and biomass, the two have higher correlation value which means that increase in yield would mean an increase in biomass.

Conclusion

The intercropped maize showed significant difference in all agronomic and morphological characters as affected by tree spacing and RGP classes. Mono-maize crop was dominated significantly in all traits compared to the maize planted with the rows of trees. Tree spacing was significantly related to maize yield, weight of 500 seeds, and biomass, while RGP class was insignificantly and negatively

correlated with maize yield, weight of 500 seeds, biomass, leaf area and leaf area index. The significant relationship of tree spacing with maize yield, weight of 500 seeds and biomass implies that wider tree spacing will mean higher yield in maize and the reversed is true with the negative relationship.

Recommendation

The results of the analysis were significant. Yield of the mono crop maize is significantly higher in both cropping periods. The 2 x 4 m tree spacing reported an insignificant yield with the mono-maize crop in the 1st crop period. It is therefore recommended to intercrop maize with *Gmelina* at the early stage (not more than a year) of the tree component with wider tree spacing. A reducing maize yield would be expected when trying to intercrop maize in an older *Gmelina* plantation because of above ground competition of sunlight and below ground competition of absorbing water and nutrients by plant roots. The result of this study showed a negative relationship of RGP class with maize yields that implies a reversed relationship between the two parameters.

Acknowledgement

I would like to express my warmest gratitude and thanks to the Management of the Cotabato Foundation College of Science and Technology and the Commission on Higher

Education for financial assistance given in the conduct of this study (Part 2 of the original paper titled "Root growth potential and early field performance of *Gmelina arborea* Roxb. intercropped with zea maize").

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Cite this article as:

Corpuz OS (2013). Effect of root growth potential and spatial arrangement trials of *Gmelina Arborea* on the growth and yield of maize. Acad. J. Environ. Sci. 1(5): 078-087.

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