CHAPTER 10

EFFECT OF LEGUMINOUS COVER CROPS ON THE GROWTH AND YIELD OF *ZEA MAYS L.* (MAIZE)

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ABSTRACT

The experiment was laid out in a randomized complete block design (RCBD) with four replicates. Treatments consist of: maize + *Mucuna* (T_1), maize + *Stylosanthes* (T_2), maize + *Centrosema* (T_3), maize + *Lablab* (T_4) and no legume intercrop (T_0) which served as a control. Significant increase in growth was seen in *Mucuna pruriens* (T_1) plots, as it increased most the growth characteristics of maize plant (plant height 220.0 cm, leaf number 12.0/plant, Root length 30.0 cm, collar diameter 9.0 mm and leaf area 87.0 cm^2) than other treatments. *Stylosanthes gracilis* (T_2) significantly improved the yield parameters of *Zea mays* at 11 weeks after planting as its recorded highest values of dry biomass weight (250.0g/plant), cob number (11.0/plot) and weight (1000.0g/plant) compared with values obtained from other treatments. A linear plot of the natural log of the growth data over time (5 to 11 weeks after planting) showed that all leguminous intercrops positively increased plant height, leaf area, collar diameter and root length. However, negative growth rate was observed on leaf number in all leguminous intercrop plots, except in *Stylosanthes* plots. Linear regression model was able to predict closely all growth parameters at 11 weeks after planting when compared with values obtained from experimental results at 11 weeks after planting. It was concluded that sustainable agriculture can be achieved in cereal-legume systems, and that application of *M. pruriens* (T_1) and *S. gracilis* (T_2) significantly improved the growth and yield parameters of maize, respectively.

Key words: Effect, Leguminous cover crops, Growth, Yield, *Zea mays.*

INTRODUCTION

In traditional agriculture, arable land is left fallow for some years to allow soil to acquire self-rejuvenation, but due to increased population pressure, fallow periods are shorter and are not sufficient to restore the soil nutrient ports sufficient to support economic crop yields (TASDS, 2001). The agricultural systems based on high external inputs are not sustainable and threatens food security particularly at the small holder levels (Brech and Freyer, 2007). Sustainable cropping systems as an integral part of a complete farming system of soil, water, air plant, animal and human resources have to be endorsed. (Arshad and Martin, 2002; Rahman, *et al.,* 2013). *Zea mays* L. is the most cereal crop produced by about 82% of all Nigerian farmers. In sub-Saharan Africa, *Zea mays* L. is a staple food for an estimated 50% of the population and provides 50% of the basic calories. The issue of low productivity in *Zea mays* L. is associated with high level of dependency of agriculture to exogenous factors such as drought, flooding, pests and high costs of agro-inputs, therefore the need for incorporation of legumes in *Zea mays* L. farms to improve soil fertility, weed control disease and insects, conserving soil moisture, reducing soil erosion and improving soil microbiology (Fageria and Baligar 2008; Delin *et al.,* 2008). Across Africa, the use of leguminous cover crop to increase *Zea mays* L. production has received substantial attention. Species like *Mucuna pruriens* have been used successfully to control weeds and improve farm productivity in West Africa (Carsky *et al.,* 2001). Similarly, scientists from East Africa acknowledged an increase in *Zea mays* L. grain yield of 0.4 to 1.0 $Mgha^{-1}$ over farmers' practice due to incorporation of 22 weeks old *Mucuna pruriens* (Kaizzi *et al.,* 2006). Therefore, this study was designed to evaluate the potential of four leguminous cover crops on the growth and yield of *Zea mays* L. plant.

Addressing the challenges facing production and sustainability of *Zea mays* L. is vital to the increasing population. Ayemi (2010) noted that the regular use of inorganic fertilizer like sulphate of ammonia, urea and ammonium nitrate contribute significantly to acidity of the soil and therefore the use of leguminous cover crops to increase the soil fertility and therefore enhance productivity is necessary. This study seeks therefore to look at the effect of leguminous cover crops and how it can enhance maize production other than just fertilizer subsidy which has come to be the major way of improving and thereby increasing maize production.

Ugwumba *et al.,* (2010) opined that to increase *Zea mays* L. productivity, strategies which include intercropping of *Zea mays* L. and legumes which fix nitrogen and other nutrients in the soil aimed at maintaining improved yields without distorting or destabilizing the environment checking of pest infestation and diseases should be examined. This study enabled us to find out the effect of leguminous cover crops on the growth and yield of *Zea mays* L. The purpose of this work was to envisage long term production of *Zea mays* L. as well as provision of quality well-being for farmers and local communities going by the ever increasing population. The aim and specific objectives of study were (i) to determine the effect of selected leguminous intercrops on the growth characteristics of maize at 11 weeks after planting (ii) to determine the relative growth rate of maize growth indices between 5 and 11 weeks after planting using linear regression analysis (iii) to determine the yield parameters of maize due to applicator of some leguminous intercrop.

Materials and Methods

The study was conducted at the Department of Plant Science and Biotechnology Research Farm Imo State University, Owerri. It is situated between latitude 4^0 45′ N and 7^0 15′ N and longitude $6^0$5′ E and $7^0$25′E with an area of around 5100sqkm. The area has an annual rainfall of about 2500mm which span between early March and October. The temperature range from 27^0C to 30^0C with a relative humidity of 75%. Certified seeds of *Zea mays L*. were collected from Imo Agricultural Development Programme Centre (ADP); Ministry of Agriculture, Owerri. Seeds of *Mucuna prurines*, *Centrosema pubscens*, *Lablab* and *Stylosanthis gracilis* were obtained from National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria.

The experiment were carried out in a split plot using randomized complete block design with five treatments namely; maize + *Mucuna* (T_1), maize + *Stylosanthes gracilis* (T_2), maize + *Centrosena* (T_3) , maize + *Lablab* (T_4) while the other with no legume intercrop (T_0) serve as control. The field was cleared of weeds and plowed. Beds of 4m x 4m were made. Seeds of *Zea mays L.* were planted in a spacing distance of 1m apart. Treatments were applied 3 weeks after planting. Weeds were removed at weekly intervals and the experiment lasted for a period of three months (June to August 2017).

Three plants were randomly harvested at each sampling session from the experimental plots. The plants were carefully uprooted and the following growth parameters measured: Plant Height (cm), Number of Leaves per Plant, Leaf Area (cm^2), Root Length (cm), Collar Diameter (mm), Dry Matter Production (g), Relative Growth Rate, Number of Cobs and Weight of Cobs (g).

The soil physio-chemical properties were analyzed, prior to site experimentation and also at the end of the experiment in the Soil Science Laboratory of the Natural Root Crops Research Institute, Umudike, Abia State. Data obtained from the study was subjected to analysis using the Analysis of Variance (ANOVA) technique. The probabilities for the significance of the F-value were determined. Mean separation was done using least significant differences (Steel and Torne, 1980; Peterson, 1994) at 5% level or significance.

Results

Initial Physico-chemical properties of the study soil

A routine analysis on the initial soil physico-chemical properties of the soil was shown in Table 1. Results obtained showed that the soil was a loamy sand soil with a soil reaction (pH) that was strongly acidic (5.5). The pH value was suitable for maize (*Zea mays*) production according to Das (2011).

Exchangeable Ca in the study soil was low (2.0 Cmol/kg) with a very low exchangeable K (0.132 Cmol/kg). Magnesium content of the study soil showed a very high value (> 8 Cmol/kg), while exchangeable Na showed moderate value of 0.539 Cmol/kg. Effective Cation Exchange Capacity (ECEC) of the soil was low, falling between 5 and 15 Cmol/kg. However, the soil exchange site had 98% Base Saturation, while Exchangeable Acidity accounted for 2% of the exchange site. Soil Organic Carbon and total Nitrogen was moderate (1.38%) and moderately low (0.126%), respectively.

The relative growth rate of maize growth indices between 5 and 11 weeks after planting

In order to determine the rate at which the test plant (maize) increased in plant height, leaf number, root length, collar diameter, and leaf area due to leguminous intercrops, a linear regression plot of the natural log of measured growth parameter was plotted against time (wks). The slope of the straight line was the relative growth rate (RGR) while the intercept (a) was the natural log of the measurement taken from the point the equation becomes true. All the leguminous intercrops tested, positively improved plant height with time, except on *Lablab* plots which showed a sharp reduction in plant height after 5 weeks of planting. *Mucuna* recorded the highest relative growth rate in plant height (0.029 cm/wk) with a coefficient of determination (R^2) value of 0.63 (Fig. 1b). However, *Stylosanthes* showed highest fitness in predicting plant height and was able to account for 68% of the variation in plant height of maize. The RGR of plant height due to *Lablab* treatment showed a negative slope effect which may be attributed to the observed presence of caterpillar insect (though data was not collected on their incidence) which caused lodging of the maize plant and reduction in plant height. Other leguminous intercrops positively improved plant height as rate of growth ranged from 0.013cm/wk for *Centrosema* plots to 0.029 cm/wk for *Mucuna* plots (R^2 0.63).

Table 1: Initial soil physico-chemical properties of the experimental soil.

Soil properties	Values
Sand (%)	86.40
Silt (%)	8.80
Clay (%)	4.80
Texture	LS
pH	5.5
N (%)	0.126
P (mg/kg)	20.3
O C (%)	1.38
O M (%)	2.37
Ca (cmol/kg)	2.00
Mg (cmol/kg)	12.00
K (cmol/kg)	0.132
Na (cmol/kg)	0.539
EA (cmol/kg)	0.24
ECEC (cmol/kg)	14.91

LS = Loamy sand

The relative growth rate of leaf area due to the application of the various leguminous intercrops showed a positive improvement in the plant leaf area from 0.001cm^2/wk for *Centrosema* plots (R^2 0.80) to 0.004 cm^2/wk for *Mucuna*, *Lablab*, and control treatment plots (R^2 of 0.036, 0.80, and 0.60 respectively). *Lablab* recorded the highest RGR in leaf area (0.0048 cm^2/wk) with an R^2 value of 0.80.

Relative growth rate (RGR) of collar diameter of maize due to leguminous intercrops on *Centrosema* treatment showed a negative slope effect and a very weak R^2 of 0.113. The over 80% variability unaccounted for by the regression model in *Centrosema* plots may be attributed to insect attack by caterpillar which caused weakening of the stem and therefore reduction in diameter of the collar. Other leguminous intercrops and the control variously and positively improved collar diameter as rate of growth ranged from 0.021 – 0.090 mm/wk. *Lablab* treatment plots recorded highest rate of collar diameter (0.090 mm/wk) (R^2 = 0.81).

The relative growth rate of root length in all the treatments positively increased root length as rate of growth ranges from 0.005 cm/wk for *Lablab* treatment plots (R^2 = 0.60) to 0.043 cm/wk for *Mucuna* treatment plots (R^2 = 0.90).

The effect of leguminous intercrops on rate of increase of leaf number of maize in all the treatments, except *Stylosanthes* plots, which showed negative slope effect ranging from −0.012 (R^2 = 0.60) for *Mucuna* to 0.060 (R^2 = 0.90) for *Centrosema.* Positive RGR (0.014 No/wk) of leaf number of maize recorded on *Stylosanthes* plots was discarded because of very weak R^2 (0.080). The observed decline in leaf number may be attributed to the observed presence of caterpillar insects (though data was not collected on their incidence) which caused a reduction in leaf number of the affected plots after the 5th week of planting (Table 3).

Analysis of variance of the growth parameters of maize as influenced by leguminous intercrops were shown in Table 2. Significantly ($P < 0.01$) highest values of plant height (220 cm), leaf area (87 cm^2), collar diameter (9 mm) and root length (30 cm) were recorded on *Mucuna* treated plots. There was no significant ($P > 0.05$) treatment effect on leaf area of maize.

Values of measured growth parameters at 11 weeks after planting were compared with predicted values obtained from linear regression models (Table 3). All regression models due to leguminous intercrops and control predicted, though weakly (R^2 0.58 – 0.68) plant height of maize plant. The regression models of *Centrosema* and *Lablab* treatments predicted most (R^2 0.80) leaf area of maize plant, while the model obtained from *Mucuna* could not predict (R^2 0.36) measured values. The regression models obtained from control, *Mucuna*, *Stylosanthes* and *Lablab* treatments were able to predict well the measured collar diameter of maize at 11 weeks after planting (R^2 0.81 – 0.95). Regression model obtained from *Centrosema* plots did not predict (R^2 0.11) the collar diameter of maize plant. Regression models obtained from all the treatments were able to predict measured root length of maize plant at 11 weeks after planting with R^2 that ranged from 0.60 to 0.90

Table 2: Effect of leguminous intercrops on growth parameters of maize plant (11 weeks after planting) in 2017 cropping season at Imo State University, Owerri.

Leguminous intercrops	Plant height (cm)	Leaf number/plant	Root length (cm)	Collar diameter (mm)	Leaf area (cm^2)
Control	193.0	11.0	17.0	7.5	66.0
Mucuna	220.0	12.0	30.0	9.0	87.0
Centrosema	188.0	10.0	20.0	6.5	54.3
Stylosanthes	182.0	11.0	24.0	6.8	64.0
Lablab	120.0	11.0	28.7	7.0	42.0
LSD(0.05)	4.8**	NS	4.6**	0.7**	5.6**

**=significant at 1% probability level: NS = Not significant at 5% probability level

Table 3: Linear regression model, growth rate constants, measured and predicted growth values at 11 weeks after planting of maize plant grown under different leguminous intercrops at Imo State University, Owerri.

Leguminous intercrop	Regression model	Experimental value	Predicted value	RGR (wk^{-1}) (b = slope)	R^2
Plant height (cm)					
Control	Y= 0.018x+5.083	193.0	197.0	0.018	0.60
Mucuna	Y= 0.029x+5.110	220.0	228.0	0.029	0.63
Centrosema	Y= 0.013x+5.107	188.0	191.0	0.013	0.60
Stylosanthes	Y= 0.016x+5.037	182.0	184.0	0.016	0.68
Lablab	Y= -0.053x+5.304	120.0	112.0	-0.053	0.58
LSD (0.05)		4.8**			
Leaf area (cm^2)					
Control	Y= 0.004x+4.145	66.0	65.9	0.004	0.60
Mucuna	Y= 0.004x+4.422	87.0	87.0	0.004	0.36

Centrosema	Y= 0.001x+3.982	54.3	54.2	0.001	0.80
Stylosanthes	Y= 0.002x+4.136	64.0	63.9	0.002	0.60
Lablab	Y= 0.004x+3.687	42.0	41.7	0.004	0.80
LSD (0.05)		5.6**			
Colar diameter (mm)					
Control	Y= 0.050x+1.482	7.5	7.6	0.050	0.95
Mucuna	Y= 0.045x+1.683	9.0	8.8	0.045	0.90
Centrosema	Y= -0.027x+2.030	6.5	5.7	-0.027	0.11
Stylosanthes	Y= 0.021x+1.665	6.8	6.7	0.021	0.86
Lablab	Y= 0.090x+1.038	7.0	7.6	0.090	0.81
LSD (0.05)		0.7**			
Root length (cm)					
Control	Y= 0.032x+2.512	17.0	17.5	0.032	0.82
Mucuna	Y= 0.043x+2.952	30.0	30.7	0.043	0.90
Centrosema	Y= 0.015+2.790	20.0	19.2	0.015	0.60
Stylosanthes	Y= 0.008x+3.088	24.0	23.9	0.008	0.80
Lablab	Y= 0.005x+3.298	29.0	28.6	0.005	0.60
LSD (0.05)		4.6**			
Leaf number/plant					
Control	Y= -0.025x+2.683	11.0	11.1	-0.025	0.90
Mucuna	Y= -0.012x+2.601	12.0	11.8	-0.012	0.60
Centrosema	Y= -0.060x+2.981	10.0	10.1	-0.060	0.90
Stylosanthes	Y= 0.014x+2.343	11.0	12.1	0.014	0.08
Lablab	Y= -0.025x+2.723	11.0	11.6	-0.025	0.60
LSD (0.05)		NS			

** = Significant at 1% probability level; NS = Not significant at 5% probability level.

Effect of leguminous cover crops on yield parameters of maize at 11 weeks after planting

To determine the effect of leguminous cover crops on yield parameters of Maize (Dry weight, Number of cobs, weigh of cobs) at 11 weeks, the data collected were subjected to analysis of variance (ANOVA) test. Significant treatment means were separated using Fischer's least significant difference (F-LSD) at 5% probability level. Results of the ANOVA were presented in Table 4. Leguminous intercrops significantly (P < 0.01) influenced dry biomass of maize plant. *Centrosema* and *Stylosanthes* yielded equally highest dry biomass (250 g) which differed significantly with those obtained with control and *Mucuna* (150 g). Treatments significantly (P > 0.05) influenced number of cobs per plant. *Stylosanthes* recorded the highest number of cob (11) which did not differ significantly with cob numbers per plot obtained from *Centrosema* (10) and *Mucuna* (9) plots. Least number of cob/plot was recorded from control and *Lablab* plots. Highest cobs weight (1000 g) of maize was obtained from *Stylosanthes* plots which differed significantly (P < 0.01) from cobs weight recorded by other treatments. Lowest cobs weights (300 g) were produced by the control and Lablab treatments.

Table 4: Effects of leguminous intercrops on yield parameters of maize plant (11 weeks) in 2017 cropping season at Imo State University, Owerri.

Leguminous intercrops	Dry weight of biomass/plant (g)	Number of cobs/plot	Weight of cobs/plant (g)
Control	150.0	3.0	300.0
Mucuna	150.0	9.0	400.0
Centrosema	250.0	10.0	500.0
Stylosanthes	250.0	11.0	1000.0
Lablab	200.0	4.0	300.0
LSD (0.05)	61.0**	4.3**	50.3**

** = Significant at 1% probability level; NS = Not significant at 5% probability level

Discussion and conclusion

The significantly ($p < 0.01$) highest values of growth parameters observed in *Mucuna* treatment indicated the importance of *Mucuna* intercrop in legume–cereal cropping system. The improvement in growth parameters of maize plant could be as a result of increase in soil nitrogen as a result of nitrogen fixed by the legumes (Gary *et al*., 2003). This increase in growth parameters by *Mucuna* treatment plots than other leguminous cover treatments may be attributed to the earlier nodulation of *M. pruriens* over other treatments. This is in agreement with an earlier finding that increase in growth characteristics of maize can be achieved using leguminous cover crops (Kaizz *et al*., 2006). The effect of leguminous cover crops in maize yield shows that *Stylosantes gracilis* treatment plots showed an increase in maize yield (Cob weight, number of cobs and dry weight of biomass). The lower yield observed in the other leguminous cover crops is an indication of some degree of competition by *M. pruriens, C. pubescens* and lablab as all the cover crops climbed or spread more aggressively to smother the maize crop before their senescence. Chikoye *et al*., (2001) also observed the same trend of result when maize was intercropped with *M. coclinchinenensis*.

The cover crops showed varying potentials for growth and yield of maize plants. Significant increase in growth and yield parameters were obtained under *M. pruriens* and *S. gracilis* respectively. The results were likely due to superior nodulation of the two leguminous cover crops compared to others. Therefore, this study suggests that sustainable agriculture can be achieved through cereal-legume systems in order to satisfy changing human needs while maintaining or enhancing the environment quality. Intercropping using legumes in maize farms helps reduce labour peaks, minimizes crop-failure risks, enhance soil fertility and protect the soil against erosion. Therefore, in order to feed the growing population and achieve greater agricultural sustainability, effective use and management of internal resources that focuses on cereal-legume cropping systems should be given due consideration.

Recommendation

Considering that *Mucuna pruriens* and *Stylosanthes gracilis* increased the growth and yield parameters of maize plant, I recommend that farmers use the best legumes while planting or cultivating maize and other crops that trials well in Nitrogenous environment.

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