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Effect of Maize –Legume Intercrop and Fertilizer on Weed Suppression and Maize Performance in South Eastern, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AOE and UEU designed the study. Authors AOE, UEU, OS and OJA supervised, managed and collected the data. Author UEU performed the statistical analysis, wrote the protocol and the first draft of the manuscript with author AOE. Authors UEU, AOE and OS managed the analyses of the study. Authors AOE, OS and OJA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Maize is one of the most commonly cultivated arable crops in the rain forest zone of South Eastern Nigeria. Globally soil fertility and weed pressure are the most important constraints limiting increase productivity of Maize especially in Sub Saharan Africa (SSA). Unavailability and cost of inorganic fertilizer as well as cost of labour for weeding have engendered low productivity of maize. Hence this trial was conducted to evaluate the efficacy of maize-legume systems on weed suppression and maize performance. The trial was carried out at the Teaching and Research Farm of Faculty of Agriculture, University of Port Harcourt, Nigeria located within latitude 04°54'N and longitude 6°55' E). The trial was conducted between April 4th and July 5th, 2017. The experiment was a 3 x 3 factorial arrangement fitted into a randomized complete block design (RCBD) consisting of 3 types of legume systems (*Mucuna pruriens*, *Lablab purpurens* and No legume) and three levels of NPK 15:15:15 fertilizer (0, 15, and 30 kg NPK/ha). The 9 treatment combinations were replicated thrice

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to give 27 plots. Data collected were on maize yield and yield components, weed and legume parameters at 4, 8 and 16 weeks after sowing (WAS). Result showed that legume significantly reduced weed biomass when compared to the natural fallow. The effect of weed biomass reduction was Mucuna 34.8% >Lablab 29.2%. The legume system significantly suppressed weed compared to natural fallow and the weed suppression ability average 56% and 30% respectively for Mucuna and Lablab whether or not they received NPK. Result of this trial also revealed that within 8 weeks after sowing legumes (8 WASL) 26% N and 22% N can be harvested by integrating this legume cover in cropping system and that NPK application has little or no effect in the performance of these legumes. *Mucuna* was not sensitive to fertilizer application while *Lablab* responded to fertilizer application. Maize was sensitive to Mucuna due to early integration; hence, it is recommended that these legumes be integrated at six weeks after sowing maize.

Keywords: Maize; mucuna; lablab; NPK-fertilizer; weed.

1. INTRODUCTION

Maize (*Zea mays* L.) is the World's third most important cereal crop after wheat and rice [1]. Maize is a member of Poaceae (grass family) which requires much nitrogen to achieve optimum yield. Maize has the potential to supply large amounts of energy-rich storage for animal diet and its fodder can safely be fed at all stages of growth [2]. Maize has been put to wide range of uses which include but not limited to feed and fodder for livestock and oil also used in food industry where they are used for margarine, maize syrup and sweeteners. Furthermore, maize is use in the manufacture of candy bar and industrial chemical [3]. The demand for maize is constantly increasing in global market in response to the multiple uses. The national demand for maize starch is increasing and is estimated at about 800,000 tonnes per annum while the current national supply is estimated at 350,000 tonnes per annum [4]. To meet the global demand for maize, intensive cultivation has led to decrease in soil fertility, build-up of weeds and other pests and fallow period have drastically been shortened. Due to this circumstances soil that was once fertile has become unproductive and also environmental degradation has occurred and crop yield has become low [5]. Maize requires a lot of nitrogen for maximum yield and this can be achieved by application of inorganic fertilizer. However, chemical nitrogenous fertilizer seems to be unaffordable to small scale farmers producing maize for their food security [6]. Therefore, maize/legume intercropping has become one of the solutions for food security among small scale maize producers [7]. Intercropping is defined as the system where two or more crops are grown on a piece of land within the same year to promote the interaction of component crops and maximize land productivity [8]. Intercropping of cereal/legume is being practiced in many areas of Southern Nigeria. Systems of intercropping maize with legumes are capable of reducing the amount of nutrient taken from the soil as compared to a sole maize production. However, when nitrogen fertilizer is added to the field, intercropped legume use the inorganic nitrogen instead of fixing nitrogen and this compete with maize for nitrogen, but when nitrogen fertilizer is not applied, intercropped legume will fix most of their nitrogen requirement from the atmosphere and not complete with maize for nitrogen resources [9]. Mucuna and lablab are among the legumes that can be intercropped with maize. However timing is of great importance because it has been observed that farmers intercrop legume with maize at their convenient time. According to [10] growing mucuna early could result in reduced maize yield while [11] reported that intercropping mucuna with maize at 6 weeks after sowing (WAS) gave higher maize grain yield that 8 and 10 (WAS) respectively. Therefore, it is important that in depth look at planting date of legume as component in a maize-legume intercrop should be taken into consideration.

Maize is one of the most commonly cultivated arable crops in the rainforest zone of Southern Nigeria [12]. It is a staple food for more than 300 million people in Sub Saharan Africa (SSA) [13]. Production is mainly in the hand of over 90% of the small holder farmers who face the constraints of low soil fertility and lack of and high cost of mineral fertilizers. Nigeria is one of the greatest maize producers in SSA [14]. Current yield of maize in farmers field is very low (≤1500 kg/ha). In SSA [15] intensive use of synthetic chemical herbicides and inorganic fertilizer for weeds control and soil fertility management has left the soil degraded with the buildup of resistant weed species. Weed problem and soil fertility decline are recognized by farmers as major constraints causing low maize productivity. This is partly due to the unavailability, accessibility and cost of inorganic nutrient for soil management and the cost and drudgery associated with weed management at this farmer's level. Legume cover crops are reported to suppress weed and improve soil fertility. Therefore intercropping maize with legumes has the capacity to sustain nitrogen requirement of maize in the small holder farming sector. The current study sought to evaluate the effects of two legume cover crops for weed suppression and soil fertility improvement. Velvet bean (*Mucuna pruriens* (L) DC. Var. Utilis) and Lablab (*Lablab purpureus* (L) Sweet) are two exotic legume species that may suppress weeds and enhance soil fertility. Although cover crops like melon are found in most maize intercrop, they can only provide short season cover and biomass that may not sustain weed suppression and nitrogen accumulation due to low biomass residues. Hence, Lablab and Mucuna were chosen for this research because of their ability to establish well in high forest zone and the production of large biomass that will continue to provide residual weed suppression and nitrogen accumulation for maize growth benefit. Therefore, the general objective of the present study was to identify maize legume system that will suppress weed by physical smothering through biomass canopy and enhance maize productivity through nitrogen accumulation.

2. MATERIALS AND METHODS

2.1 Experimental Site and Description

The trial was carried out at the Teaching and Research Farm, of the Faculty of Agriculture, University of Port Harcourt, Nigeria located within latitude 04°54 538'N and longitude 006°55 329' E (with an latitude of 17 meters above sea level [16]. This trial was conducted between April 4th and July 5th 2017.

2.2 Sources of Planting Material

The maize cultivar used for this trial was OBA SUPER 2 (yellow) purchased from Premier Seeds Nigeria Limited (A member of seeds association of Nigeria).It is a hybrid line and also a single cross hybrid. It was chosen because it can adapt to rainforest zone and it is also resistant to lodging.

2.3 Sources of Legume Cover Crops

The two varieties of legume used for the trial were *Mucuna pruriens* and *Lablab purpurens* and they were purchased from National Animal Production Research Institute (NAPRI) Zaria, Nigeria. These two cover crops were chosen based on earlier screening that showed that they can grow well in the study environment with a good ground cover within a short period of time.

2.4 Source of NPK Fertilizer

The NPK 15:15:15 fertilizer was purchased from Agricultural Development Programme (ADP), Port Harcourt Rivers State, Nigeria.

2.5 Land Preparation and Experimental Design

The study area was tilled to loosen up the soil on 31st March, 2017. Prior to tillage, soil samples were collected diagonally across the plot with the aid of soil auger at a depth of 15 cm. The samples were air- dried and taken to the laboratory for physical and chemical analysis. Parameters analysed for were total nitrogen. Total N in which the soil samples passed through a 0.5mm sieve was determined by Micro-kjeldahl method [17]. The experiment was a 3 x 3 factorial arrangement in a randomized complete block design (RCBD) consisting of three legume systems (*Mucuna pruriens, Lablab purpureus* and No legume) and three levels of NPK 15:15:15 fertilizer (0, 15 and 30 kg NPK/ha) giving nine treatment combinations .The nine treatment combinations were replicated thrice to give a total of 27 plots. The maize was planted two seeds per hole on 4th April 2017 at a spacing of 100 cm x 25 cm on a plot size of 4 m x 4 m giving four (4) rows of maize plant per plot and a total population of approximately 40,000 per hectare. The alley way between each maize plot was 0.75 m and the alley way between replicates was 1.5m.

2.6 Treatments Plan and Application

The details of the 9 treatments are shown below.

- Maize + 0 kg NPK/ha
- Maize + 15 kg NPK/ha
- Maize + 30 kG NPK/ha
- Maize + lablab + 0 kg NPK/ha
- Maize + lablab +15 kg NPK /ha
- Maize + lablab + 30 kg NPK /ha

- Maize + mucuna + 0 kg NPK /ha
- Maize + mucuna +15 kg NPK /ha
- Maize + mucuna +30 kg NPK /ha

The NPK fertilizers were applied in two splits using NPK15:15:15, on 20th April 2017 (3 WAS). This application was done by banding the fertilizer after which it was covered with soil to avoid volatilization or being washed away. The second application was done on 22nd of May, 2017 (6WAS) The legume cover crops were planted four weeks after sowing maize (4WASM) which was on 5th May, 2017 meanwhile the first weeding was done before the planting of the legume cover crops which was on 3rd of May, 2017. Maize emergence count was done one week after sowing (1 WAS) and supply done to the ones that did not emerge. The maize was later thinned on 20th April, 2017 to one stand per plant (3 WASM) from two seed that was planted per hole. Second weeding was done on the plot and alley ways to keep off predators from invading the plant.

2.7 Data Collection

2.7.1 Maize

Maize emergence count was done (1 WAS). This was done by counting the number of maize stand that emerged on each row. Maize height was taken at 7 week after sowing maize (WASM) and 3 weeks after sowing legumes (WASL) using meter rule, three plants representing the shortest, medium and tallest plants were chosen from each row per four rows in a plot on 24th May, 2017.

2.7.1.1 Maize yield and yield components

Maize was harvested on 5th July which was 12 weeks after sowing maize and 8 weeks after sowing legumes.(12 WASM and 8 WASL), total biological yield of maize was determined for whole plot. The following yield data was assessed. Total stands at harvest: This was done generally by counting the number of standing maize plant at harvest and later the ones to be weighed was chosen from the net-plot area, this is where the unshelled cob weight, was gotten. Maize grain yield was also determined after drying the sample from cobs. This was done by taken the sample gotten from the unshelled cob to the green house for two weeks after it was shelled and the grain weight taken.

2.7.2 Weed

2.7.2.1 Weed density and weed biomass

Weed species density and biomass were determined using 50 cm x 50 cm quadrat thrown at a diagonal transect per treatment plot. In each quadrat the weed species were counted for density data and then clipped above ground for the biomass determination. The samples for biomass determination were oven dried at 80°C to a constant weight. Both density and biomass values were expressed in number and gram per meter square respectively.

2.7.2.2 Weed suppression efficiency (WSE)

Weed suppression efficiency of the maize-legume was determined at 14WASL using treatment weed biomass with the following formula;

$$\text{WSE (\%)} = \frac{\text{weed biomass from natural fallow} - \text{weeed biomass from mucuna or lablab}}{\text{weed biomass from natural fallow}} \text{ X } \frac{100}{1}$$

$$\text{WSE (\%)} = \frac{WBMNF - WBM\ Mucuna}{WBMNF}\ x\ \frac{100}{1}$$

$$\text{WSE (\%)} = \frac{WBMMF - WBM\ Lablab}{WBMNF}\ x\ \frac{100}{1} \qquad [18]$$

2.7.2.3 Weed and legume cover assessment

The weed and legume cover were assessed monthly using point intercept method [19]. The above ground legume biomass was assessed using 50 cm x 50 cm quadrat thrown thrice at a diagonal transect 14 weeks after planting legumes.

2.7.3 Soil nitrogen determination

Soil samples were collected from each plot before and after planting. The samples were collected diagonal across each plot. These samples were air dried and taken to the laboratory and were analyzed using standard laboratory procedure. The test for the total N before planting was taken as the control (0) and the results were presented in Table 5.

2.8 Statistical Data Analysis

Analysis of variance (ANOVA) was computed for each of the data collected using statistical analysis system [20] model and significant means were separated using least significant difference (LSD) at 5% level of probability.

3. RESULTS

3.1 Effect of Legume System and NPK on Weed Growth

Results obtained from the study showed that there was no significant (P>0.05) difference in weed density among the treatments at 8 WASL but the highest weed number (523 no/m^2) was obtained in mucuna-maize while the lowest (373 no/m^2) was in sole maize (Table 1). The legume systems however significantly influenced the weed biomass at 8WASL. Mucuna significantly (P<0.05) reduced weed biomass when compared to the no legume system, but was not significantly superior to lablab in reducing weed biomass. The highest weed biomass was seen in sole maize followed by lablab-maize and mucuna-maize (353.2 g/m^2 > 249.9 g/m^2 > 229.6 g/m^2) respectively. Weed biomass of lablab-maize was not significantly different from weed biomass of sole maize although it was lower (249.9 g/m^2 < 353.2 g/m^2) (Table 1). At 14 WASL the legume system significantly influenced the weed density and biomass (P<0.05). The weed densities and biomass of Mucuna-maize and lablab-maize intercropping were both significantly lower than sole maize (146 no/m^2 and 159.3 g/m^2 < 408 no/m^2 and 379.9 g /m^2) and (205 no/m^2 and 230.5g /m^2 < 408 no/ m^2 and 379.9 g /m^2) respectively. The NPK rates and legume x NPK interaction did not influence the density and biomass significantly. The 0 kg NPK/ha and 15 kg NPK/ha rates had the same weed density at this period which was higher than the weed density of 30 kg NPK/ha while 30 kg NPK/ha had the highest weed biomass followed by 0 kg NPK and 15 kg NPK/ha although not significant at 5% level of probability.

3.2 Weed Suppression Efficiency (WSE) of the Legumes

At 14 WASL all legume systems were significantly better than the sole maize plots in terms of weed suppression efficiency. The mucuna-maize had significantly higher efficiency on weed suppression (55.6%) than the lablab-maize (39.4%) which was better than the sole maize plots (Table 2). Suppression efficiency of mucuna-maize was not significantly different from the suppression efficiency of lablab-maize (P>0.05) but both was significantly different from that of sole maize (P<0.05). Similarly the suppression efficiency of lablab-maize was significantly higher than that of sole maize (P<0.05). The NPK rates did not significantly influence weed suppression efficiency of the legumes. However, the 30 kg NPK/ha had higher suppression efficiency (42%) followed by 0 kg NPK/ha (33.9%) and 15 kg NPK/ha (19.1%). The legume x maize interaction did not significantly influence the weed suppression.

3.3 Effect of Legume System on Maize Yield Components and Grain Yield

The legume system, NPK rates did not influence the emergence significantly, however, their interaction significantly influence the emergence of the maize plant (Table 3). The final stand at harvest was not influenced by the legume system, NPK rates and their interaction (*P*>0.05). At 7 WASM and 3 WASL there was significant difference (*P*=0.05) in the height of the maize within the legume system only. The mean height of Mucuna-maize plots was higher with value of 141.4 cm followed by the sole-maize with value of 140.8 cm and lablab-maize with value 131.0 cm (Table 3). The height of the mucuna-maize intercropping was not significantly different from that of sole-maize. However, both mucuna-maize intercrop and sole maize were significantly different from that lablab-maize. Maize stand at harvest was not influenced by legume cover or NPK rates. The result also revealed no significant difference in the unshelled cob weight within the legume system, NPK rates and their interaction (P>0.05). However, the sole-maize had higher unshelled cob weight than the legume-maize plots (Table 4). The trend was different in the grain weight within the legume system. The sole-maize was significantly higher than the legume-maize (P<0.05). Grain yield advantage of sole maize to lablab-maize and mucuna-maize was seen to be 19.5% and 34.3% respectively. The NPK rates and legume x NPK interaction did not significantly influence the grain weight (Table 4). Similarly the biological yield of maize in sole-maize plots were significantly different from that in legume intercrop system (P<0.05). The sole-maize had biological yield advantage of 15.9% and 29.3% over lablab-maize and mucuna-maize respectively. Biological yield of lablab-maize was significantly higher than that of mucuna-maize system. The NPK rates and the legume x NPK interaction did not significantly (P>0.05) influence the biological yield of maize.

Table 1. Effect of legume system and NPK on weed growth

Legume system	8 WASL						14 WASL					
	Weed density(No/m^2)			Weed biomass(g/m^2)			Weed density(No/m^2)			Weed biomass (g/m^2)		
	0 kg	**15 kg**	**30 kg**	**0 kg**	**15 kg**	**30 kg**	**0 kg**	**15 kg**	**30 kg**	**0 kg**	**15 kg**	**30 kg**
M. pruriens	578	636	354	240.5	188.8	259.4	156	170	112	135.0	193.8	149.2
L. purpureus	549	352	650	197.2	309.5	243.1	310	233	73	201.4	281.9	208.1
No legume	502	316	301	373.9	335.4	350.1	378	439	407	343.0	289.8	506.8
Means for legumes												
M. pruriens	523^a			229.6^b			146^b			159.3^b		
L. purpureus	517^a			249.9^{ab}			205^b			230.5^b		
No legume	373^a			353.2a			408^a			379.9^a		
LSD (5%)	274.86 ^{ns}			107.81*			147.88**			147.75**		
Means for NPK												
0 kg NPK/ha	543^a			270.5^a			281^a			226.5^a		
15 kg NPK /ha	435^a			277.9^a			281^a			255.2^a		
30 kg NPK/ha	435^a			284.1^a			197^a			288.0^a		
LSD (5%)	274.86 ^{ns}			107.81 ^{ns}			147.88 ^{ns}			147.75^{ns}		
LSD (Legume x NPK)	476.09 ^{ns}			186.74^{ns}			256.14 ^{ns}			255.93^{ns}		

WASL: Weeks after Sowing Legume

Means within the same column followed by the same alphabet are not significantly different at 5% level probability by LSD test

**, **Significant at 0.05, 0.01 level of probability*

Table 2. Weed suppression efficiency (WSE) of the legumes

Legume system	WSE at 14 WASL		
	0 kg	**15 kg**	**30 kg**
M. pruriens	60.9	31.8	74.1
L. purpureus	40.7	25.5	52.0
No legume	0.0	0.0	0.0
Means for legumes			
M. pruriens		55.6^{a}	
L. purpureus		39.4^{a}	
No legume		0.0^{b}	
LSD (5%)		32.42**	
Means for NPK			
0 kg NPK/ha		33.9^{a}	
15 kg NPK /ha		19.1^{a}	
30 kg NPK/ha		42.0^{a}	
LSD (5%)		32.42^{ns}	
LSD (Legume x NPK)		56.16^{ns}	

*WASL: Weeks after Sowing Legume; Means within the same column followed by the same alphabet are not significantly different at 5% level probability by LSD test; **Significant at 0.01 level of probability*

3.4 Effect of Legume System on Soil Nitrogen Level

At 0 WAPL, the soil Nitrogen level of the plots differ significantly (P>0.05) (Table 5), however the NPK rates applied significantly influenced the soil (P=0.04). There was no significant difference in the soil nitrogen level at 14 WASL within the legume system, NPK rates and their interaction. However the legume system plots had some advantages irrespective of NPK level applied when compared to the natural fallow without legumes. The N-level gains by the cover crops as against the system without cover crop intercrop at 14 WASL without NPK application were as follows 22% N(0 kg/ha) and 26.5% N (0 kg/ha) for Lablab and Mucuna respectively (Table 5). At 15 kg NPK/ha and 30 kg NPK/ha, both legumes slightly gained Nitrogen as follows 16.6% N and 11.1% N respectively for Lablab and 24.2% N and 10.3% N respectively for Mucuna (Table 5).

3.5 Response of Weed to Legume Cover Crop

At 4WASL, there was no significant (p>0.05) different between weed cover and the legume cover in both *Mucuna and Lablab* system .However, the natural fallow system without legumes had a significantly (p<0.05) higher weed cover compared to the legume system (Fig. 1) At 8WASL, the trend was similar to that of 4WAPL, but *Lablab* had a slightly higher ground cover and lower weed cover compared to Mucuna. *Mucuna* 12 WASL had a significantly (P<0.05) higher ground cover and lower weed cover compared to Lablab .Both *Mucuna* and *Lablab* systems at this period had a significantly(p<0.05) lower weed cover compared to the natural fallow system (Fig. 1).

4. DISCUSSION

4.1 Effect of Legume Cover and NPK on Weed Growth

Traditional intercropping system is often believed to be better than monocrops in weed, pest and disease control. Weed growth in intercropping largely depends on the competitive abilities of the component crops and their respective plant populations [21]. Significant reduction in *Striga* infestation was observed in cereal/cowpea intercropping [22]. This was attributed to cover placed on the soil by the intercropped cowpea [23,24]. The result of this study did not show significant reduction in the weed density at 8 WASL but showed significant reduction in weed density at 14 WASL. This could be because the legumes have not developed enough canopies to suppress weeds [25] and [26] in their studies attributed differential rate of weed suppression to how early the canopy of the cover crop develops to cover the soil and also to the duration of the cover crops' shading. [27] reported a reduction in the density of weed and dry matter with maize-legume intercrop compared to sole maize, which they attributed to decrease in light available to the weeds in the maize-legume intercrops. The superiority of mucuna in weed density and weed biomass reduction at 14 WASL over lablab is in agreement with the findings of Mureithi et al. [28] in Kenya where farmers ranked mucuna as the best green manure cover crop, which they based on its high biomass accumulation and quick crop establishment.

4.2 Weed Suppression Efficiency (WSE) of the Legumes

All legume systems were better than the sole maize plots on weed suppression efficiency at 14 WASL probable because the legume systems had developed enough canopies to suppress weed growth by acting as a physical barrier such as preventing direct sun light penetration that could had stimulated weed growth. Although, *M. pruriens* and *L. purpureus* had similar weed suppression efficiency, weed suppression efficiency was higher in *M. pruriens* than *L. purpureus* probable due to better weed control. Many researchers [29,30,31] noted that herbaceous cover crops smother weeds. Akobundu et al. [25] also noted that legumes suppressed weed growth by secreting chemical substances (Allelopathy compounds). The different rates of NPK fertilizer had identical weed suppression efficiency probable due to lack of treatment effect. Although the different rates of NPK fertilizer had identical weed suppression efficiency, weed suppression efficiency was higher in 30 NPK kg/ha than others NPK fertilizer rates probable due to better weed control.

4.3 Effect of Legume System on Maize Yield

The height of the sole maize was not significantly different from that of mucuna-maize. The result suggested that plant height was associated with population and competition per unit area where less populated plot with minimum competition showed high plant height. The present findings was in agreement with the findings by [32] who observed taller plant height in sole cropped maize while the minimum in maize intercropped with faba bean. Flores-Sanchez et al. [33] stated that plant density may affect both intra- and interspecific competition and has particularly a direct effect on grain yield of maize. The result of this study showed that maize grain yield was reduced with increasing competition of the component crops as seen in reduced grain yield with mucuna-maize intercrop. This result disagrees with the findings documented by Kassahun et al. [34] who reported that grain yield of 6496.0 kg ha^{-1} was obtained when common bean intercropped with maize. Furthermore, intercropping effect on grain yield of maize was reported by Tolera [35] and Kimani et al. [36] when haricot bean was intercropped with maize. Alemayehu et al. [37] also reported that maize grain yield was 16% more on maize-narrow leaf lupine intercropping relative to sole crop maize studied on Maize-common bean/lupine intercrop productivity and profitability in maize-based cropping system of North–western Ethiopia. Low grain yield under simultaneous cropping of legume cover crops with food crops has earlier been attributed to competition and the aggressive nature of cover crops by many researchers [38,39,40] and [41]. Mucuna *(Mucuna utilis)* when intercropped with maize was found lowering down the maize yields, while cowpeas *(Vigna sinensis)* and greengram *(Phaseolus aureus)* had much less effect on maize and where themselves tolerant to maize shade. Pathak and Singh [42] observed that the grain yield of maize was not significantly influenced by the different intercropping treatments at Pantnagar. The lablab-maize yield was significantly lower than the sole maize yield, this result is consistent with the findings of Maluleke et al. [43] who found that the dry matter of maize was reduced with increasing Lablab population.

4.4 Response of Weed to Legume Cover Crop

The result of this study revealed that a progressive increase in legume cover led to a significant decrease in the weed cover in mucuna-maize and lablab-maize plots. Flores-Sanchez et al. [33] reported that residues of legumes creates mulching layer that increases the physical barrier of early germination and that such effect required sufficient organic material residue on the soil surface. This explains the reason for reduction in weed cover with increase in legume cover. Furthermore, Creamer and Baldwin [44] reported that lablab bean suppressed weeds by up to 40% with its vine morphology when intercropped with sorghum-sudangrass as compared to weedy sole sorghum-sudangrass.

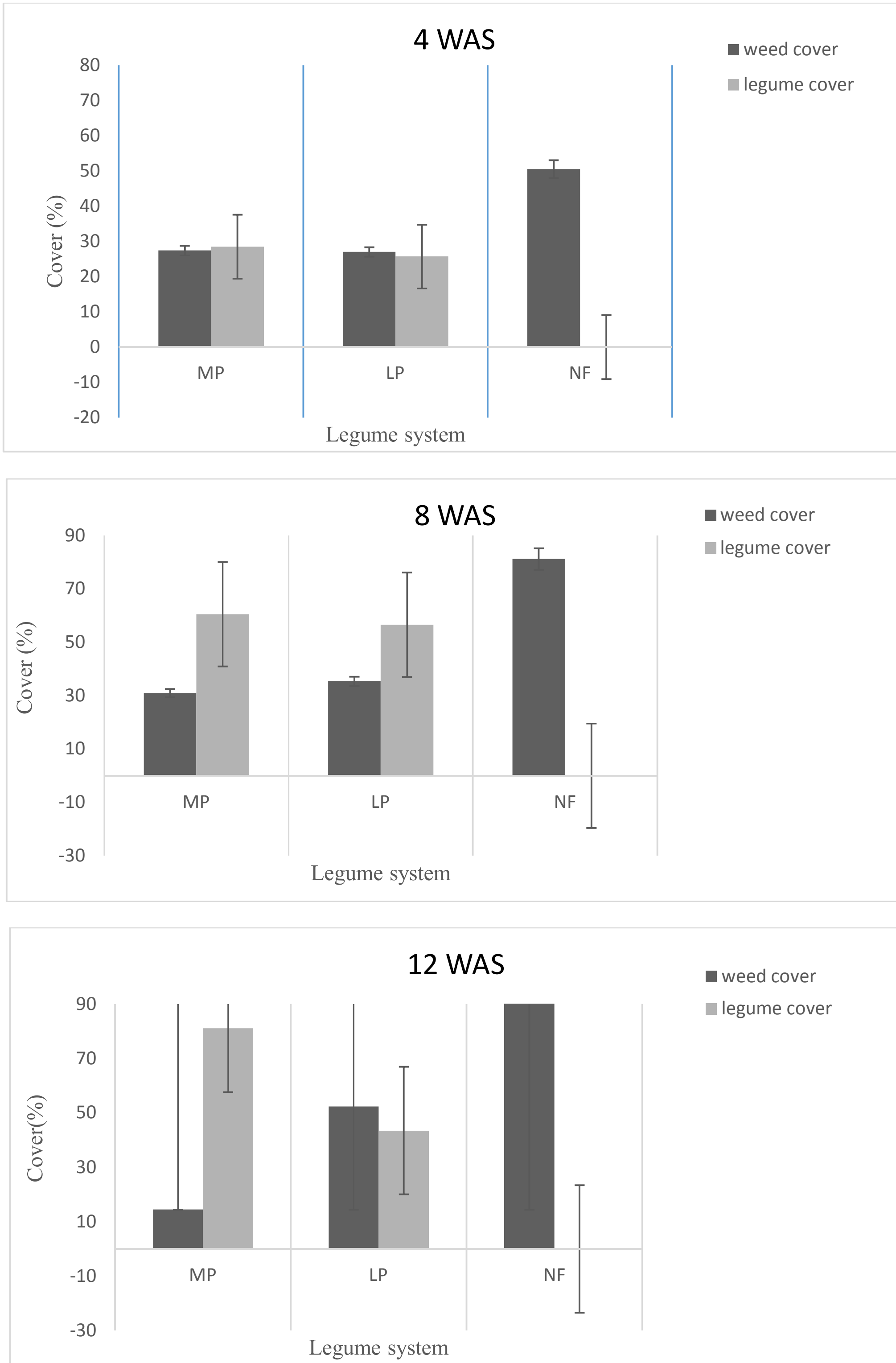

Fig. 1. Response of weed to legume cover crop

MP = Mucuna pruriens, LP = Lablab purpureus, NF = Natural fallow. Vertical bar are the standard error of mean

Table 3. Effect of legume system on maize yield components

Legume system	Emergence count (No ha^{-1})			Stand at harvest (No ha^{-1})			Maize height at 7 WASM (cm plant^{-1})		
	0 kg	**15 kg**	**30 kg**	**0 kg**	**15 kg**	**30 kg**	**0 kg**	**15 kg**	**30 kg**
M. pruriens	33958	28958	35208	33750	33958	31250	140.4	145.6	138.1
L. purpureus	36667	31042	36667	31875	32708	33750	130.5	137.6	125.0
No legume	28125	34167	29792	28958	33958	31458	147.4	134.6	140.4
Means for legumes									
M. pruriens	32708a			32986^{a}			141.4^{a}		
L. purpureus	34792a			32778^{a}			131.0^{b}		
No legume	30694a			31458^{a}			140.8^{a}		
LSD (5%)	4119.80^{ns}			3993.60^{ns}			8.38*		
Means for NPK									
0 kg NPK/ha	32917^{a}			31528^{a}			139.4^{a}		
15 kg NPK /ha	31389^{a}			33542^{a}			139.3$_{a}$		
30 kg NPK/ha	33889^{a}			32153^{a}			134.5^{a}		
LSD (5%)	4119.80^{ns}			3993.60^{ns}			8.38^{ns}		
LSD (Legume x NPK)	7136.10*			3161.71^{ns}			14.52^{ns}		

Means within the same column followed by the same alphabet are not significantly different at 5% level probability by LSD test
NS: not significant at 5% level of probability
**Significant at 0.05level of probability*

Table 4. Effect of legume system on maize yield

Legume system	Unshelled cob weight (Kg ha^{-1})			Grain weight (Kg ha^{-1})			Total plant yield (Kg ha^{-1})		
	0 kg	15 kg	30 kg	0 kg	15 kg	30 kg	0 kg	15 kg	30 kg
M. pruriens	3507.6	3495.6	3519.5	2636.4	2631.0	2669.1	15888.9	13444.4	14722.2
L. purpureus	3654.3	4592.2	4572.7	2954.3	3457.3	3311.6	16666.7	17333.3	18388.9
No legume	5311.7	5351.6	5079.5	4120.7	4132.1	3832.5	21388.9	21388.9	19500.0
Means for legumes									
M. pruriens	36852[a]			2645.5[b]			14685[c]		
L. purpureus	40000[a]			3241.1[b]			17463[b]		
No legume	41111[a]			4028.4[a]			20759[a]		
LSD (5%)	6392.70 [ns]			696.46**			2693.90***		
Means for NPK									
0 kg NPK/ha	39815[a]			3406.8[a]			17981.0[a]		
15 kg NPK /ha	40185[a]			3271.1[a]			17389.0[a]		
30 kg NPK/ha	37963[a]			3237.1[a]			17537.0[a]		
LSD (5%)	6392.70[ns]			696.46[ns]			2693.90[ns]		
LSD (Legume x NPK)	11072.92 [ns]			1206.35[ns]			4666.20[ns]		

WASL: Weeks After Sowing Legume; Means within the same column followed by the same alphabet are not significantly different at 5% level probability by LSD test
*NS: Not significant at 5% level of probability. **,*** Significant at 0.01, 0.001 level of probability respectively*

Table 5. Effect of legume system on soil nitrogen level

Legume system	Total soil nitrogen					
	0 WASL			14 WASL		
	0 kg	15 kg	30 kg	0 kg	15 kg	30 kg
M. pruriens	42.0	47.6	56.0	68.5	71.8	61.3
L. purpureus	50.8	52.0	59.7	72.8	68.6	77.1
No legume	68.0	38.1	73.6	57.8	63.9	63.6
Means for legumes						
M. pruriens	48.5^{a}			67.2^{ab}		
L. purpureus	54.1^{a}			72.8^{a}		
No legume	59.9^{a}			61.8^{b}		
LSD (5%)	13.10^{ns}			9.96^{ns}		
Means for NPK						
0 kg NPK/ha	53.6^{ab}			66.4^{a}		
15 kg NPK /ha	45.9^{b}			68.1^{a}		
30 kg NPK/ha	63.1^{a}			67.3^{a}		
LSD (5%)	13.10*			9.96^{ns}		
LSD (5%) (Legume x NPK)	22.69^{ns}			17.25^{ns}		

*Means within the same column followed by the same alphabet are not significantly different at 5% level probability by LSD test; NS: Not significant at 5% level of probability. *Significant at 0.05level of probability*

5. CONCLUSION

The result of this study has shown that the maize-legume system has the ability to suppress weed and improve or enhance soil fertility, with or without additional fertilizer in the form of NPK. The result also showed that the system may have the ability to improve upon maize crop performance, but this might be influenced by the timing of the legume introduction or integration into the system. In this study, the legumes were introduced at 4 weeks after planting maize. However, this appeared to be too early for the maize, following the aggressive growth habit of the legume. Hence, the effect on the performance of the maize.

The integration of legumes into maize cropping system may be a cheaper alternative for weed suppression and soil fertility improvement. This system will be more sustainable to the agro ecosystem compared to the use of herbicides and more inorganic amendment which in the long run will leave the soil with a buildup of resistant weed species. That the integration of legumes into the maize should not be too earlier than 5WASM and not later than 7WASM to achieve good ground cover for weed suppression and biomass accumulation for soil improvement. In this system additional fertilizer use to boost and enhance both maize and legume performance should not be more than 30 kg NPK/ha.

Since this legumes are forage legumes and are aggressive in their growth, it is recommended that *Mucuna and Lablab* be integrated into maize system at about 6 weeks after planting maize. This method will reduce the aggressive effect on the maize and also enable enough time for the legumes to form enough canopy for weed suppression and biomass accumulation for nitrogen accumulation in the system subsequently.

Based on other strategies available in the literature, it can also be recommended that the legume be established earlier in the season between 8 and 10 WAS and terminated as short fallow in the later season followed by maize.

The research is of benefit to farmers by increasing productivity without bearing unnecessary cost of fertilizer, beside its unavailability.

The cost of cropping and subsequent cost of weeding will be reduced.

The legume-maize system is environmentally friendly and will lead to sustainable soil productivity and weed management.

Fallow length for soil fertility regeneration will be reduced, as the legume will contribute to soil fertility enhancement.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAOSTAT. FAO Statistical database. Italy, Rome; 2005.
   (Assessed 30 January 2019)
   Available:http:// www.faostat.fao.org
2. Dahmardeh M, Ghanbari A, Syasar BA, Ramrodi M. Effects of intercropping maize with cowpea on green forage yield and quantity evaluation. Asian J. Plant Sci. 2009;8:235-239.
3. Wilkes G. Corn. Strange and marvelous, but is a definitive origin known? In: Smith, CW, Bethran J, Runge ECA (eds) corn: Origin, history, technology and production. Willey Hoboken. 2004;3-64.
4. SBC. How to make corn {maize} starch – the opportunities.
   (Accessed 20 February 2019)
   Available:http://smallbusinessclub.ng/2016/04/20/
5. Dogbe W. Green-Manure crop for sustainable agriculture in inland valley of Northern Ghana. In cover crops in West Africa contributing to sustainable agriculture (DRC), IITA and Sasakawa Global (2000). Eds. Bukles D, Eteka A, Osiname O, Galiba M, Galiano G. Ottawa.Canada. 1998;213-215.
6. Javanmard AD, Mohammadi-Nasab A, Javanshir A, Moghaddam M, Janmohammadi H. Forage yield and quality in intercropping of maize with different legume and double cropped. J. Food Agric. Environ. 2009;7:163-166.
7. Thobatsi TJ. Growth and yield respond of Maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* L.) in intercropping system. Masters Dissertation. University of Pretoria, South Africa. 2009;58-69.
8. Sullivan P. Intercropping principles and production practices. In Williams P, (ed). Appropriate Technology Transfer for Rural Areas (ATTRA) Fayelteville Arkansas; 2003.
9. Adu-Gyamfi JJ, Myaka FA, Sakala WD, Odgaaro R, Vesterager JM, Hoghjenjen H. Biological nitrogen fixation and nitrogen and phosphorus budgets in farmer-managed intercrops of maize-pigeon pea in semi-arid southern and eastern Africa. Plant and soil. 2007;295:127-136.
10. Osei-Bonsu. (On-farm trials of Mucuna spp in Ghana (Abstract). UIn cover crop in West Africa contributing to sustainable agriculture. IDRC, IITA and Sasakawa Global 2000 Eds Buckles D, Eteka A, Osinname O, Galiba M, Galano, G Ottawa, Canada. 1991;20-202.
11. Kambock JM, Clottey VA. Maize yield and soil n as affected by date of planting mucuna in maize-mucuna intercropping in Ghana. Tropical Agriculture (Trinidad). 2005;80:77-82.
12. Akinyemiju AO. Chemical weed control in maize (*Zea Mays* L) and cowpea (*Vigna unguiculata* L) walp in the rain forest zone of southwestern Nigeria. Niger J. Weed Sci. 1998;1:29-41.
13. Siamachira J. Harnessing maize biodiversity for food security. Improved Livelihoods in Africa; 2016.
    Available:https://www.cimmyt.org › Featur
14. FAO. Food and Agriculture Organization of the United Nations statistical database; 2008.
    Available:http://faostat.fao.org
15. Ajeigbe HA, Oseni TO, Singh BB. Effects of planting pattern crop Variety and Insecticide on the productivity of cowpea-cereal system in Northern Guinea Savanna of Nigeria. J. Food Agric. Environ. 2006; 4(1):145-150.
16. Nwankwo CA, Ehirim CA. Evaluation of aquifer characteristic and ground water using geo-electric method in choba port harcourt. J. Scholar Res. Lib. 2010;2:396-403.
17. Bremmer JM, Mcleaney CS. Nitrogen-total in methods of soils Analysis part II 2nd edn. Page AL, Miller RH, Keeney DR. Am. Soc. Agron. Madison, USA; 1982.
18. Subramanian S, Alli AM, Kumar R. All about weed control. Kalyani Publisher New Delhi 11002, India; 1991.
19. Martin K, Paddy C. Vegetative description and analysis. A practical Approach. John Wileys and sons. Baffins, lane. chichesta, cost Susex po141 UD, England; 1994; (Chapter 2):49-52.
20. SAS. SAS User's Guide: Statistics Released 6.12. SAS Inc., Cary NC., USA; 2002.
21. Willey RW. Evaluation of intercropping advantages. Expl. Agric. 1983;21:119-133.
22. Khan ZR, Hassanali A, Overholt W, Khamis TM, Hooper AM, Pickett JA, Wadhams LJ, Woodcock CM. Control of witchweed striga hermonthica by

intercropping with *Desmodium* spp., and the mechanism defined as allelopathic J. Chem. Ecol. 2002;28(9): 1871-1885.

23. Mbawaga AM, Massawe CR, Kaswende AM, Hella JP. On-farm verification of maize/cowpea intercropping on the control of Striga under subsistence farming. Seventh Eastern Africa Regional Maize Conference. 2001;165-167.
24. Musambasi D, Chivinge OA, Mariga IK. Intercropping maize with grain legumes for striga control in Zimbabwe. African Crop Sci. J. 2002;10(2):163-171.
25. Akobundu IO, Udensi EU, Chikoye D. Velvetbean (*Mucuna* spp.) suppresses spear grass (*Imperata cylindrica* (L) Raeuschel) and increases maize yield. Int. J. Pest Management. 2000;46:103–108.
26. Ekeleme F, Akobundu IO, Fadayomi RO, Chikoye D, Abayomi YA. Characterization of legume cover crops for weed suppression in the moist savanna of Nigeria. Weed Technol. 2003;17:1–13.
27. Bilalis D, Papastylianou P, Konstantas A, Patsiali S, Karkanis A, Efthimiadou A. Weed-suppressive effects of maize-legume intercropping in organic farming. Int J. Pest Manag. 2010;56:173-181.
28. Mureithi JG, Mwauraand P, Kamade T. Introduction of green manure legumes to small holders in Gatanga Division, Thika District, Legume Research Network Project Newsletter. 2000;3.
29. Tarawali SA. Evaluating selected forage legumes for livestock and crop production in the sub-humid zone of Nigeria. J. Agric. Sci. (Cambridge). 1994;123:55–60.
30. Akobundu IO, Ekeleme F, Chikoye D. The influence of the fallow management system and frequency of cropping on weed growth and crop yield. Weed Res. 1999; 39:241–256.
31. Udensi EU, Akobundu IO, Ayeni AO, Chikoye D. Management of cogon grass (*Imperata cylindrica)* using velvet bean (*Mucuna prunens* var. *utilis*) and herbicides. Weed Technol. 1999;13:201-208.
32. Farzaneh J, Safar N, Mohammad R, Adel AB. Effect of different intercropping patterns on yield and yield components of maize (*Zea mays* L.) and Faba Bean (*Vicia faba* L.). Biol. Forum Int. J. 2015;7:854-858.
33. 33. Flores-Sanchez D, Pastor A, Janssen BH, Lantinga EA, Rossing WAH, Kropff MJ. Exploring maize-legume intercropping systems in south west Mexico Agroecology and Sustainable Food Systems; 2013.
34. Kassahun A, Tamado T, Nigussie D. Influence of Maize-Bean intercropping pattern and nitrogen fertilizer application on the productivity of the crops at Wolaita Sodo, Southern Ethiopia.Msc Thesis Harmoya University, Haromaya; 2003.
35. Tolera, A. Effects of nitrogen, phosphorus, farmyard manure and population of climbing bean on the performance of maize (*Zea mays* L.) climbing bean (*Phaseolus vulgaris* L.) intercropping system in Alfisols of Bako. M.Sc. Thesis, Haromaya University, Kewet Wereda; 2003.
36. Kimani KK, Gathua R, Delu D. JT, Cadish G. Effects of maize bean intercropping, phosphorus and manure additions on maize production in the central Kenya Highlands. Proceedings of the 6th Eastern and South Africa Regional maize Conference, Addis Ababa. 1998:293-29.
37. Alemayehu A, Tamado T, Nigusie D, Yigzaw D, Kinde T, Wortmann, CS. Maize-Common Bean/Lupine Intercrop Productivity and Profitability in Maize-Based Cropping System of Northwestern Ethiopia. Ethiopian J. Sci and Tech. 2016; 9:69-85.
38. Tian G, Kolawole GO, Salako FK, Kang BT. An improved cover crop-fallow system for sustainable management of low activity clay soil of the tropics. Soil Sci. 1999;164: 671-682.
39. Chikoye D, Manyoung VM, Carsky RJ, Gbehounoi G, Ahancheoye B. Response of spear grass (*Impereta cylindrica*) to cover crops integrated with hand weeding and chemical control in maize and cassava. Crop Protect. 2002;19:481-487.
40. Chikoye D, Schulz S, Ekeleme F. Evaluation of integrated weed management practices for maize in the Northern Guinea Savanna of Nigeria. Crop Protect. 2004;23:895-900.
41. Fadayomi O, Abayomi YA, Ajayi AS, Tain G. Intercropping and residual effects of six legume cover crops on weed suppression and crop yield in the southern Guinea savanna of Nigeria. J. Trop. Biosci. 2005; 5(1):51-56.

42. Pathak K, Singh NP. Genotypic compatibility and planting pattern in urdbean and maize intercropping system. Ind. J. Pulses Res. 2006;19(1):116-118.
43. Maluleke HM, Addo-Bediako A, Ayisi KK. Influence of Maize-Lablab intercropping on lapidopterous stem borer infestation in Maize. J Econ Entomol. 2005;98:348-388.
44. Creamer NU, Baldwin KR. An evaluation of summer cover crop for use in vegetable production System. North Carolina. Hort. Sc. 2000;35:600-603.

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