

Residual Effects of Legume Cover Plants on Soil Weed Seed Bank and Weed Growth in a Subsequent Maize Crop.

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ABSTRACT

The residual effects of five legume cover plants on soil weed seed bank and weed infestation was measured during the succeeding three years following the establishment of the legume species, at Ilorin, in the southern Guinea savanna of Nigeria. In the original study, the efficacy of five legume cover plant treatments (No-legume, *Pueraria phaseoloides*, *Mucuna pruriens*, *Stylosanthes guianensis*, *Mucuna preturiensis* and *Mucuna jaspidea*) integrated with either chemical and/or cultural weed control practices, on weed control and crop production was evaluated. The present study evaluated the effect of the legume treatments on soil weed seed bank and weed growth in three succeeding crops. The volume of the soil weed seed bank was significantly affected by the legume cover crop treatments. Samples collected from *P. phaseoloides* and *S. guianensis* plots had similar number of weed seeds which were significantly lower than those from samples collected from plots planted to the *Mucuna* spp. Samples from the plots without legume cover ("No-legume cover") had the most numerous weed seeds. In the *in situ* field evaluations, none of legume cover crop treatments had an effect on weed growth on the portion of the field cultivated after 14 months of fallow growth/re-growth, during the first year of cultivation. However, weed density and weed biomass were significantly affected by the legume cover crop treatments during the second year of cultivation of this portion of the field, as well as in the portion cultivated after 26 months of fallow growth/re-growth. In all cases, plots previously planted to *P. phaseoloides* and *S. guianensis* supported lower weed growth than the other plots. The results show intercropping of perennating legume cover crops with arable crops can lead to reduction of weed infestation in succeeding crops, on the same field.

Key words: *Pueraria phaseoloides*, *Mucuna* sp. *Stylosanthes guianensis*

Introduction

Farmers in sub-humid tropical West Africa are faced with problems of intensification of land use and reduced fallow periods as a result of increased human population (Fadayomi *et. al.*, 2005) with consequences such as soil degradation, loss of soil nutrients (Kang *et. al.*, 1997) and high weed pressure (Roder *et. al.*, 1997). The traditional shifting cultivation where farmers slash-down and burn the fallow vegetation, cultivate the land for a few years and then abandon the site for 5 to 7 years to allow the

vegetation to regenerate and aid to keep pest population at low levels (De Rouw, 1995) is no longer sustainable (Ekeleme and Chikoye, 2003). Instead, continuous cropping with little or no fallowing period is gradually replacing the age long traditional mode of farming (Ajiboye *et.al.*, 2002). This has resulted in systematic degradation of arable land and the accompanying decline in the productive capacities of such land and low crop yields.

The use of leguminous fallow to replace natural fallow has been emphasized (Tie *et.al.*, 1999). The soil fertility and weed control

potential of herbaceous fallow have been reported (Akobundu *et al.*, 1999; Salako *et al.*, 2000; Ekeleme *et al.*, 2000, 2003 and 2004; Fadayomi *et al.*, 2005). Whereas there is a conclusive evidence of increase in soil fertility and reduction in weed infestation following medium to long-term planned fallow systems, the effects of short-term planned fallow on these indices are not always consistent.

The level of weed suppression and reduction in the weed seed bank varies among the planned fallow treatments (Ekeleme *et al.*, 2003) and is a function of the amount of biomass produced, the canopy structure, the quantity and quality of litter, and the duration of the fallow (Rao *et al.*, 1998). *Pueraria phaeoloides* has been reported to lower the annual weed population and the size of the seed bank over time (Chikoye *et al.*, 1997). In a study conducted at Ibadan, southwestern Nigeria, Ekeleme *et al.* (2004) reported that *Setaria staminea*, *Acerua auriculiformis* and *P. phaeoloides* fallows were superior to other planned fallow species in suppressing weeds and reducing the weed seed bank. This study was designed to evaluate the residual effects of five legume cover crops treatments in a previous maize/cassava intercrop, on soil weed seedbank and weed growth in three succeeding maize crops at Ilorin in the southern Guinea savanna zone of Nigeria.

Materials and Methods

Site Description

This study was conducted between January 2006 and October 2007 at the Teaching and Research Farm, University of Ilorin (9°29' N, 4°35' E). The study was conducted on a plot previously planted to a maize/cassava intercrop between 2004 and 2005. The plots were subjected to chemical and/or cultural weed management practices integrated with legume cover plants, as live mulch. The original study was laid out as randomized complete blocks with a cross-cross arrangement of the legume cover and weed management treatments. The six treatments in the previous study were: No-legume and five legume cover crop treatments namely, *Pueraria phaeoloides*, *Stylosanthes guineensis*,

Mucuna pruriens, *Mucuna preta* and *Mucuna jaspideata*.

Estimation of soil weed seed bank under various plots

In January, 2006, seven months after the harvest of cassava from the original plog, soil samples were collected for seed bank analysis. Nine soil cores were randomly collected from each treatment plot with a pre-bore auger (7.4 cm in diameter) to a depth of 15 cm. The samples were mixed by hand in a bag, air dried for four weeks in the Laboratory and passed through a 2 mm sieve to remove large plant fragments and small pebbles. The sieved samples were used for the estimation of weed seed bank as follows:

Direct germination method

Three hundred grammes of the sieved soil samples from each plot were weighed out and placed in plastic bowls (13 cm in diameter and 6 cm depth) and arranged on screen house benches. Samples from each plot were replicated twice. Each bowl was perforated at the bottom and filter paper was placed at the base to facilitate drainage of excess water in the sieved samples. Germinating weed seedlings were counted every fortnight and then pulled out. The soil samples were watered on alternate days and stirred at two weeks intervals to stimulate germination by bringing to the surface other weed seeds that might have been deeply buried in them. The experiment was terminated after 3 months.

Potiation method

From the remaining portion of each of the sieved soil samples, 100 g were mixed with 10 ml of K₂CO₃ solution and dispersed with a mechanical stirrer for 2-3 minutes. The dispersed soil samples were transferred to 1 L cylinders and allowed to settle for 24 hours. Organic matter and seeds floated to the top of the supernatant while soil particles and other heavy materials settled at the bottom. The supernatant was filtered through a 15 cm diameter coarse mesh filter paper. The seeds and organic materials collected on the filter paper were blotted dry and sorted under a stereo-microscope.

Data analysis

The number of weed seeds in the seed bank (A) per unit land area (m²) was estimated by multiplying the number of seeds in an auger sample (G) by the inverse ratio of the volume of soil in the auger sample to the volume of soil in 1 m² area sampled to the depth of the auger (15 cm) (Madanah and Fadayomi, 2006), as outlined below:

The ratio was computed as follows:

$$\text{Volume of soil from the auger sample } (V_1) = \pi \times r^2 \times h;$$

where, $\pi = 22/7$;

r = radius of the auger and

h = depth of sampling; in this case,

$$V_1 = 22/7 \times (3.7 \text{ cm})^2 \times 15 \text{ cm}$$

$$= 645.2097 \text{ cm}^3; \text{ or } 6.45 \times 10^{-4} \text{ m}^3$$

Volume of soil from 1 m² area sampled

(V₂) was computed as:

$$V_2 = L \times B \times H, \text{ where } L = \text{length, } B =$$

breadth and H = depth of sampling.

$$V_2 = 100 \text{ cm} \times 100 \text{ cm} \times 15 \text{ cm} = 1.5 \times 10^3 \text{ m}^3.$$

The calculated inverse ratio of the volume of soil from an auger sample to the volume of soil in 1 m² land was 232.56. The ratio was then used to multiply the weed density per auger sample (G) to obtain the weed density per m²; thus: $A = V_2/V_1 \times G$, where A = estimated density of weed seeds per m² to the depth of 15 cm, G = number of weeds per the auger samples. Data so obtained were subjected to analysis of variance (ANOVA) using Genstat statistical package.

Residual effects of legumes on subsequent crop

In August, 2006, 14 months after the harvest of cassava in the previous study, the original plot was divided into two halves. The first half was cropped for two consecutive years while the second half was cultivated one year after, using maize as a test crop.

Experimental Design

The trials were designed as randomized complete blocks with a split-plot arrangement and replicated three times. The main plot

treatments consisted of the original legume cover crop plots while the sub-plots comprised of six different weed control treatments, viz. one hoe-weeding at 6 weeks after planting (WAP), two hoe-weedings at 3 & 6 WAP, pre emergence application of Primextra Gold, a formulated mixture of atrazine (370 g/L) and metolachlor (290 g/L), atrazine (2-chloro-4-ethylamino)-6-(isopropylamino)-s-triazine, or metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-ethoxyl-1-methylethyl)acetamide), each applied at 2.5 kg a/ha, and a weedy check.

Field Management

Prior to the establishment of trial plots, (planting of the maize) the legume cover crops were slashed to ground level and chopped into small pieces using a cutlass. Thereafter, the plots were ploughed and harrowed before ridging at 1.3 m apart. Each sub plot was made up of 4 ridges, 5 m long.

Planting of the maize crop was done at a spacing of 1.3 m x 0.25 m. Thinning was done at 2 WAP giving an approximate density of 61,538 plants/ha while fertilizer, NPK (20:10:10) was applied at rate of 200 kg NPK/ha at 3 WAP to all treatment plots. At 7 WAP, 100 kg NPK/ha⁻¹ was applied to half of the 'No-legume cover' plots only.

Data Collection

Weed cover rating was assessed at 6, 9, and 12 WAP using the beaded string method (Sarrainio, 1991). A string, with knots at 10 cm intervals, was laid across both diagonals of each plot. The number of knots touching weed vegetation were counted and summed for the two diagonals and then divided by the total number of knots across the two diagonals in a plot. This ratio was thereafter multiplied by 100 to obtain percentage weed cover. Weed density was estimated from two fixed 0.5 m² quadrats, established after sowing, at 8 WAP, while weed biomass was determined at 10 WAP, by harvesting the weeds from each of the quadrats. Crop parameters assessed included stand count at 3 WAP, plant height, and leaf number at 7 WAP and grain yield at harvest. The latter parameters are however, not reported here.

Data were subjected to analysis of variance (ANOVA) using the Genstat statistical analysis package. Means were compared using the least significant difference (LSD) test.

Results and Discussion

Weed seed bank

The size of the soil weed seed bank was significantly affected by legume cover crop and weed control treatments of the previous trial (Table 1). Samples collected from *P. phaseoloides* and *S. guianensis* plots had similar number of weed seeds which were significantly lower than those from samples collected from plots planted to the *Mucuna* species. Samples from the "No-legume cover" plots had the most numerous weed seeds. These results are in agreement with other studies which reported that *P. phaseoloides* was more effective for weed control than natural fallow and large seeded legumes (in this study, *Mucuna* species) (Akoibundu et al., 1999; Ekeleme et al., 2000). Because *P. phaseoloides* and *S. guianensis* produce high amount of biomass (Kang et al., 1997), their residue may have altered the quantity and quality of light required for germination in addition to physically obstructing the emergence of weed seedlings; thus reducing the seed returns in each cropping season. Kamara et al. (2000) reported that the leaf litter under *P. phaseoloides* and *S. guianensis* persisted on the ground much longer than under the *Mucuna* species and natural fallow canopies and thus may have contributed significantly to controlling weeds and reducing the weed seed bank. In contrast, *Mucuna* species did not provide long lasting mulch for weed suppression. Ekeleme et al. (2004) reported that, its poor mulch structure for weed control may be due to their fast rate of decomposition.

Samples collected from the herbicide treated plots and in plots where herbicide applications were supplemented with one or two hand weeding(s) had similar number of weed seeds which were significantly lower than those from the weedy control plots and plots that received three hoe-weedings. The same pattern

of results was obtained with both the direct germination and flotation methods of seed bank estimation (Table 1). However, a higher number of seeds were estimated by the flotation method than by the direct germination method. Previous workers including Tsuyuzaki (1994), Wilson and Lawson (1992) have reported that the flotation method gives a high percentage recovery for all species and enables the rapid evaluation of seed from soil. Tsuyuzaki (1994) reported that this method (flotation) provides a means of efficiently and accurately determining seed densities and diversity in soils.

Table 1: Effect of previous legume cover crop and weed control treatments on weed seed bank (no/m²).

Treatments	Number of seeds/m ²
Legumes	Direct germination
<i>Pueraria phaseoloides</i>	1332.36a
<i>Mucuna pruriens</i> var	2504.63b
<i>utilis</i>	3140.21b
<i>Sesbania guianensis</i>	1546.38a
<i>Mucuna pruriens</i>	1962.86a
<i>Mucuna pruriens</i>	2406.33b
<i>Mucuna pruriens</i>	3345.04b
<i>Mucuna pruriens</i>	2674.75b
<i>Mucuna pruriens</i>	3566.34b
<i>Mucuna pruriens</i>	3391.29c
No legume	4330.57c
Weed control	
Primextra	2023.11a
Galex + 1 Hand weeding	2570.60ab
Galex + 1 Hand weeding	2083.31ab
Primextra + 2 Hand weeding	2656.50ab
Primextra + 2 Hand weeding	2045.80ab
Galex + 2 Hand weeding	2663.31b
Galex + 2 Hand weeding	1925.06ab
3 hand weeding	2299.51b
3 hand weeding	2688.04b
Weedy control	1688.26a
Weedy control	2417.49ab
Interaction	3101.27c
Legume X Weed control	3620.22c
	4034.66d
	5275.77d
	NS

Numbers carry the same letters in the column are not significantly different @ $P = 0.5$ using DMRT

Weed Infestation in Succeeding Crops

Weed ground cover (%) in the plots was not significantly affected by the previous legume cover crop treatments (Table 2). Percentage

Table 2: Effect of previous legume cover crop and current weed control treatments on weed ground cover (% cover)

Treatments	Weed Cover Rating @ 9 WAP			Weed Cover Rating @ 12 WAP		
	Plots subjected to 14-months fallow	Plots subjected to 26-months fallow	Plots subjected to 14-months fallow	Plots subjected to 26-months fallow	Plots subjected to 14-months fallow	Plots subjected to 26-months fallow
Legumes	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
<i>P. phaseoloides</i>	43.7	44.5	33.3	66.8	47.1	34.7
<i>M. pruriens</i>	48.8	42.2	42.1	72.1	53.4	43.5
<i>S. guianensis</i>	45.3	41.2	30.7	71.8	46.9	35.3
<i>M. pruriens</i>	47.9	42.4	34.5	74.8	48.1	42.9
<i>M. pruriens</i>	40.1	43.8	40.7	75.6	44.1	43.0
<i>M. pruriens</i>	53.3	47.7	48.8	75.9	52.4	62.7
No legume	NS	NS	NS	NS	NS	NS
LSD (0.01)						
Weed control	7.5	7.9	6.1	47.1	17.1	19.3
1 HW @ 6WAP	10.3	10.3	6.8	47.3	18.8	25.3
2 HWS @ 3 & 6WAP	6.2	41.9	36.2	82.1	46.2	44.8
Primextra	53.3	52.1	41.9	79.2	64.2	42.0
Atrazine	54.9	47.7	40.7	95.5	71.7	54.1
Metolchlor	80.6	81.9	74.4	95.8	89.0	77.5
Weedy control	8.41	9.40	12.70	10.10	9.37	9.30
LSD (0.01)						
Interaction						
Legume x weed control	NS	NS	NS	NS	NS	NS

Table 3: Effect of legume cover crop and weed control treatments on weed biomass (g/m²) and weed density (no/m²)

Treatments	Weed Density @ 8 WAP				Weed Biomass @ 10 WAP			
	Plots subjected to		Plots subjected to		Plots subjected to		Plots subjected to	
	14-months fallow		26-months fallow		14-months fallow		26-months fallow	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
Legumes								
<i>P. phaseoloides</i>	32.7	37.2	21.4		173.2	129.5		56.2
<i>M. pruriens</i>	42.3	53.0	26.8		205.5	163.1		77.5
<i>S. guianensis</i>	31.8	37.6	18.4		145.4	110.6		50.5
<i>M. pruri</i>	40.0	50.5	26.2		195.2	159.4		79.8
<i>M. jaspidea</i>	43.0	58.4	29.3		199.5	145.2		73.3
No legume	50.3	67.0	34.4		209.4	161.8		91.4
LSD (0.01)	NS	8.54	3.48		NS	NS		15.06
Weed control								
1 HW @ 6WAP	40.1	50.8	8.4		75.0	19.0	15.1	
2 HWS @ 3 & 6WAP	31.6	45.2	22.1		64.3	24.4	16.1	
PrimeAtra	31.7	46.5	22.7		200.0	190.6	84.2	
Atrazine	36.1	46.1	23.2		188.8	139.6	79.5	
Metolachlor	36.7	51.1	24.4		237.7	199.9	91.7	
Weedy control	64.0	64.1	35.7		362.4	296.2	141.9	
LSD (0.01)	6.67	6.07	2.59		30.40	28.46	35.16	
Interaction								
Legume x weed control	NS	NS	NS		NS	NS	NS	

weed cover was, however, influenced ($P<0.05$) by the current weed control treatments. The effect of legume cover crops on weed density and biomass followed the same trend as for the weed cover rating (Table 3). This agrees with the findings of Faduyomi *et al.*, (2005), who reported that weed cover and biomass in a succeeding crops were not significantly affected by the preceding legume cover crops. However, weed density and weed biomass were significantly affected by the legume cover crop treatments during the second year of cultivation in the 14 months fallow sub plots as well as in the portion cultivated after 26 months of fallow growth/re-growth (Table 3). In all cases, lower weed growth was recorded in *P. phaseoloides* and *S. guianensis* than the other previous legume cover treatment plots. The extent of weed growth during fallow is a function of the duration of the fallow as well as the longevity and ability of the fallow species to suppress weed growth. Thus, those plots that had 26 months of fallow growth/re-growth recorded lower weed ground cover than those that had 14 months of fallow re-growth before re-cultivation. Kang *et al.* (1997) reported a significant weed suppression by *P. phaseoloides* plots compared to other fallow species plots.

From the results this study, intercropping of perennating legume cover crops with arable crops can lead to reduction of weed infestation in succeeding crops on the same field. Of the legumes evaluated, *Pueraria phaseoloides* and *S. guianensis* were the most promising species in this regard.

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