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Weed Control in Maize Using Mucuna and Canavalia as Intercrops in the Northern Guinea Savanna Zone of Ghana

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Abstract: Two field studies were conducted to investigate (i) the weed suppression and nitrogen fixing abilities of four cover crops, *Mucuna pruriens* var. *utilis*, *M. pruriens* var. *nagaland*, *M. pruriens* var. *cochinchinensis* and *Canavalia ensiformis* and (ii) weed control by *Mucuna pruriens* var. *cochinchinensis* and *Canavalia ensiformis* in an intercrop with maize at different planting distances. Results have shown that *M. pruriens* var. *cochinchinensis* and *M. pruriens* var. *utilis* gave higher ground cover than *M. pruriens* var. *nagaland* and *C. ensiformis*. The cover crops exhibited excellent weed suppression abilities in the range of 79-90% above the weedy check. The estimated fixed nitrogen were 495, 420, 479 and 333 mg N/plant for *M. pruriens* var. *cochinchinensis*, *M. pruriens* var. *utilis*, *M. pruriens* var. *nagaland* and *C. ensiformis*, respectively. *Canavalia ensiformis* gave the best weed suppression in maize at a spacing of (40×40 cm) and weeding once at 5 weeks after sowing (WAS). However, for *Mucuna pruriens* var. cochinchinensis effective weed suppression was observed at a wider spacing of 60×40 cm and weeding once at 5 WAS. The implication of the results is that the conventional manual weed control in maize twice before harvest could be reduced to one weeding by intercropping with *Canavalia ensiformis* and *Mucuna pruriens* var. *cochinchinensis* at planting distances of 40×40 cm and 60×40 cm, respectively. Weeding twice probably provided a more disturbed environment reducing the establishment of the cover crops and increased weed growth.

Key words: Agroecological zone, Conventional manual weed, *M. prupienes,* cover crops, intercropping, maize, weed suppression

INTRODUCTION

In the Savanna agroecological zone of West Africa, small-scale farmers cultivate maize (*Zea mays*) on an extensive scale. The cultivation of the crop, however, is hindered by numerous problems of which weed interference has been identified as the most problematic (Guy, 1984). To offset crop losses due to weeds, hand-weeding has been a major input into maize production (Akobundu, 1987). Akobundu (1987) observed that weed control is one of the major determinants of family sizes in developing countries as the practice benefits from free labour from large family sizes. In Ghana, yield losses due to weed competition alone can be as high as 55% for maize (Akobundu, 1980).

Non-conventional methods of weed control, for example inter-cropping could help in the suppression of weeds at secondary growth after the inter-crop has fully covered the ground (Akobundu, 1987). The use of Mucuna species is one of the most promising soil management and weed control strategies that has been introduced into some parts of West Africa. Buckles *et al.* (1998) reported that Mucuna intercropped between rows of maize improved soil fertility and controlled *Imperata cylindrica.* Aggressive cover crops such as *Mucuna pruriens* and *Canavalia ensiformis* form dense mat of vegetation to cut-off sunlight from weeds physically by smothering (Awiti *et al.*, 2000).

Awiti *et al.* (2000) however noted some limitations of cover crops due to their aggressive nature which may cause problems such as competition and entanglement of the main crop, if cover crop growth is not controlled. The climbing nature of Mucuna was reported to cause great damage to the other intercrop component (Awiti *et al.*, 2000). The damage caused by these cover crops could also be due to improper planting distances. It is in this vein that the present study of weed control in legume-maize intercrop using Mucuna and Canavalia was carried out at different planting distances with the aim of reducing weed infestation in maize field.

MATERIALS AND METHODS

Site description: The experiments were carried out at the Research Farm, Faculty of Agriculture, University for Development Studies at Nyankpala (about 18 km west of Tamale, Ghana). The area lies within the interior Guinea savanna, located between latitude 9°25ᴵ N and 0°58ᴵ S

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and is 183 m above sea level. The area experiences unimodal rainfall pattern with a mean annual rainfall of 1022 mm and the natural vegetation is characterized by grasses. The soil is brown, moderately drained, sandy loam, free from concretions, developed from Voltaian sandstone and classified as Nyankpala series (Plinthic Acrisol). Some of the physical and chemical characteristics of the soil used are shown in Table 1.

Experiment 1: The experiment was carried out to determine the weed suppression and nitrogen fixing abilities of *Mucuna pruriens* var. *utilis*, *Mucuna pruriens* var. *nagaland*, *Mucuna pruriens* var. *cochinchinensis* and *Canavalia ensiformis*. The cover crops were sown at a spacing of 60×15 cm and control plots were not sown to any crop. The treatments were arranged in a Randomized Complete Block Design (RCBD) with four replicates. Plant canopy cover, weed sum dominance and suppression potential of the cover crops were determined. N fixed was estimated before podding by the Nitrogen Difference Technique (the difference between N accumulated in the fixing legumes and N accumulated in a non-fixing control), using maize as a reference crop.

Experiment 2: A short-term (75-80 days) maturing maize variety, *Zea mays* var. *Dodzi*, was sown at a spacing of 80×40 cm. The maize was intercropped with *Mucuna pruriens* var. *cochinchenensis* and *Canavalia ensiformis* 1 Week After Sowing (WAS) the maize at three planting distances of 40×40, 50×40 and 60×40 cm. The treatments were arranged in a RCBD at a replicate of four. The plots were weeded 0 (T_0), 3 (T_1), 5 (T_2), 3 and 5 (T_3) WAS maize. Plant cover canopy, weed suppression of the cover crops and maize biomass were some of the parameters measured.

Table 1: Some physical and chemical properties of the soil used

Properties	Value
Chemical properties	
Total nitrogen (%)	0.04
Available phosphorus (mg kg^{-1})	8.50
Organic carbon (%)	0.56
pH ($CaCl_2$)	4.86
Exchangeable cation [mg kg^{-1} soil]	
Calcium	98.21
Magnesium	41.39
Potassium	38.50
Physical properties (%)	
Sand	54.40
Silt	40.40
Clay	5.20

RESULTS

Plant canopy cover: In experiment 1, the mean plant canopy cover for the four cover crops is shown in Fig. 1. The plant cover of *M. pruriens* var. *cochinchinensis* and *M. pruriens* var. *utilis* was significantly (p<5%) higher than that of *C. ensiformis* and *M. pruriens* var. *nagaland* between 4 and 9 WAS. However, between 10 and 13 WAS the plant cover for the four cover crops were similar.

In experiment 2, the mean plant canopy cover of Mucuna measured between 4 and 7 WAS is shown in Table 2. Rapid increase in plant cover occurred between 5 and 6 WAS at planting distances of 40×40 and 60×40 cm. However, increase in plant canopy cover at 50×40 cm occurred earlier between 4 and 5 WAS for T_2 and T_3, and later between 6 and 7 WAS for T_0 and

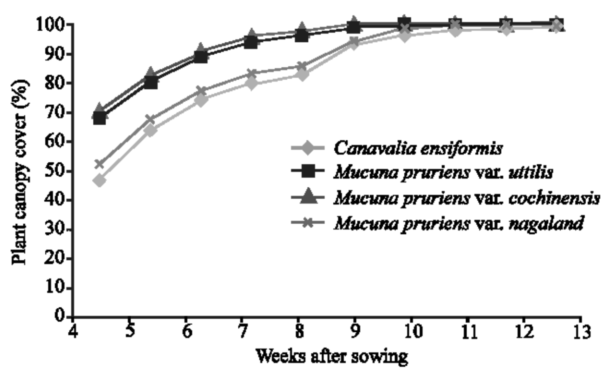

Fig. 1: Plant canopy cover of the cover crops measured for 10 weeks

Table 2: Effect of planting distance and time of weeding on plant cover of Mucuna and Canavalia

Time of data collection (WAS)		40×40				50×40				60×40				
		T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	LSD (5%)
Mucuna	4	24.67	37.67	27.00	35.33	19.33	34.00	21.00	25.33	16.67	31.00	43.00	38.33	1.78
	5	25.00	36.00	36.33	36.67	24.67	41.67	30.50	35.00	22.23	37.67	37.17	43.33	1.06
	6	33.07	47.67	46.90	46.27	33.00	50.20	36.67	40.33	29.30	53.00	47.00	51.67	0.95
	7	42.00	57.67	55.67	57.33	49.33	61.00	49.33	51.33	42.00	59.33	56.67	60.67	1.18
Canavalia	4	34.33	30.00	39.33	37.67	33.67	47.67	43.67	34.33	26.33	51.00	43.00	35.67	4.35
	5	41.33	36.00	50.33	44.00	43.67	54.17	49.33	44.00	35.00	56.00	37.17	47.00	2.99
	6	51.33	45.67	57.33	50.33	53.67	62.77	60.00	52.73	42.20	64.33	47.00	55.67	2.19
	7	62.00	58.00	66.00	61.33	66.67	69.00	70.67	66.00	52.00	72.00	56.67	65.00	1.95

T_0 = No weeding, T_1 = Weeded once at 3 WAS, T_2 = Weeded once at 5 WAS, T3 = Weeded twice at 3 and 5 WAS

Table 3: Weed suppression potentials of the four cover crops

Cover crop	Weed suppression potential (%)
Canavalia ensiformis	80.25[b]
Mucuna pruriens var. *utilis*	80.02[b]
Mucuna pruriens var. *cochiuchinensis*	89.77[a]
Mucuna pruriens var. *nagaland*	79.32[b]

Means sharing same alphabets are not significant at p = 0.05

Table 4 : Weed suppression potentials of legume cover crops

Cover crop	Weed suppression potentials (%)		
	40×40 cm	50×40 cm	60 ×40 cm
Mucuna pruriens var. *cochinchenensis*	78.85	88.40	88.58
Canavalia ensiformis	80.76	73.87	5.66

LSD (5 %) = 0.29

Table 5 : Effect of legume cover crops on weed biomass production

Legume cover crop	Planting distance (cm)	Weeding regime		
		3 WAS	5 WAS	3 and 5 WAS
Mucuna pruriens	40×40	30.13	15.96	23.10
var. *cochinchinensis*	50×40	34.15	15.18	19.98
	60×40	26.34	9.71	17.41
Canavalia ensiformis	40×40	26.45	12.17	19.31
	50×40	52.67	38.84	45.76
	60×40	45.20	31.58	24.44

LSD (5%) = 24.94, WAS = Weeks After Sowing Maize

Table 6: Percent mean weed occurrence during the 2005 cropping season

Weed species	3 WAS	5 WAS	7 WAS	Mean (%)
a) Broadleaves	87.40%	90.30%	89.20%	88.9
Hyptis suaveolens	2.7	7.9	3.9	4.8
Leucas martinensis	5.4	9.9	7.7	7.7
Triumfetta cordifolia	2.7	1.0	0.0	1.2
Ageratium conyzoides	16.7	9.9	12.3	13.0
Schwenkia americana	17.3	8.9	0.6	8.9
Oldenlandia herbacea	5.4	5.0	5.2	5.2
Mitracarpns villosns	5.4	8.9	7.7	7.3
Ludwigia decurrens	10.8	4.0	15.5	10.1
Commelina benghalensis	2.2	5.0	3.9	3.7
Sida acuta	0.2	0.0	0.1	0.1
Phyllanthns amarns	2.7	5.9	0.3	3.0
Euphorbia hirta	0.5	2.0	1.9	1.5
Hibiscns spp.	0.1	0.0	0.5	0.2
Acanthospermum hispidum	0.1	1.0	0.5	0.5
Conyza sumatrensis	0.5	2.0	0.0	0.8
Physalis micrantha	2.2	5.0	1.0	2.7
Momordica charantia	0.2	0.0	0.0	0.1
Corchorns olitorius	5.4	8.9	23.9	12.7
Croton lobatus	5.4	1.0	0.6	2.3
Senna obtusifolia	0.2	2.0	0.5	0.9
Celosia leptostachya	1.1	1.0	0.0	0.7
Hewittia sublobata	0.2	0.0	0.0	0.1
Cassia spp.	0.0	1.0	0.2	0.4
Ipomoea cylindrica	0.0	0.0	0.1	0.0
Amaranthus spinosns	0.0	0.0	0.2	0.1
Tridax procumbens	0.0	0.0	2.6	0.9
b) Grasses	6.5%	9%	2.3%	5.8
Rottboellia cochinchinensis	0.0	0.0	0.2	0.1
Digitaria horizoutalis	1.1	2.0	1.3	1.4
Paspalum scrobiculatum	2.2	3.0	0.6	1.9
Brachiaria deflexa	1.1	2.0	0.2	1.1
Pennisetum polystachion	0.5	2.0	0.0	0.8
Brachiaria lata	1.6	0.0	0.0	0.5
c) Sedges	6.5%	1%	8.5%	5.3
Cyperns rotundns	5.4	0.0	8.4	4.6
Fuirena ciliaris	1.1	1.0	0.1	0.7

T_1. The highest plant canopy cover at 7 WAS was observed at planting distances of 50×40 and 60×40 cm for

Table 7: Estimated nitrogen fixed and nitrogen accumulation

Cover crops	N (%)	N fixed (mg/plant)
Canavalia ensiformis	2.51	333
M. pruriens var. *utilis*	2.63	420
M. pruriens var. *nagaland*	2.54	479
M. pruriens var. *cochiuchinensis*	2.31	495
LSD (0.05)	0.05	20

T_1 and T_3, respectively. The lowest plant canopy cover (42%) was observed at 40×40 and 60×40 cm when no weeding (T_0) was done.

Results have shown that rapid increase in plant canopy cover of Canavalia occurred between 4 and 7 WAS (Table 2). The highest plant canopy cover (72%) at 7 WAS was observed at planting distance of 60×40 cm for T_1 followed by 50 × 40 cm for T_2. The lowest plant canopy cover (52%) was observed at 40×40 and 60×40 cm when no weeding (T_0) was done. Comparing the two cover crops at 7 WAS, Canavalia gave greater plant canopy cover than Mucuna at the three planting distances in the intercrop system. In exception of T_0, T_2 and T_3 at 60×40 cm, the plant canopy cover of Canavalia was significantly ($p<0.05$) higher than that of Mucuna.

Weed suppression and biomass: In experiment 1, the cover crops showed substantial weed suppression potentials, ranging from 79 to 90% at 12 WAS (Table 3). *M. pruriens* var. *cochinchinensis* gave higher weed suppression than the three other test covers crops, which were similar in weed suppression.

In experiment 2, the mean weed suppression potential of Mucuna and Canavalia under the intercrop system at 7 WAS showed a significant ($p<0.05$) difference (Table 4). Generally, the cover crops showed substantial weed suppression potentials ranging from 74 to 89%. C. *ensiformis* reduced the growth of weeds at closer spacing (40×40 cm) than *M. pruriens* var. *cochinchenensis*. However, at wider spacings M. *pruriens* var. *cochinchenensis* suppressed growth of weeds more than *C. ensiformis*.

Results have shown that *C. ensiformis* reduced more weed biomass at closer spacing than at wider spacing (Table 5). Weed biomass production was least for *Mucuna pruriens* var. *cochinchenensis* and *Canavalia ensiformis* when the field was weeded once at 5 WAS.

Weed summed dominance: Thirty four weed species were identified at the experimental site and were classified into Broadleaves, grasses and sedges (Table 6). Generally, the final weed populations of Broadleaves and sedges were similar to the initial populations, whilst the final grass weed occurrence decreased from the initial population. The highest mean weed occurrence was observed for Broadleaves (89%) followed by grasses (6%) and sedges (5%). The most persistent Broadleaves were *Hyptis*

Table 8: Effect of planting distance and time of weeding on maize biomass (t ha^{-1})

	Spacing 1															
	40×40				50 × 40				60 × 40				80 × 40			
Cropping Pattern	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
Canavalia maize intercrop	1.75	3.40	3.80	3.67	2.69	2.81	3.50	3.80	2.50	3.00	2.57	3.50	-	-	-	-
Mucuna maize intercrop	1.44	1.64	2.10	2.69	1.80	1.94	2.95	3.30	3.00	3.00	3.54	3.13	-	-	-	-
Sole maize	-	-	-	-	-	-	-	-	-	-	-	-	0.92	1.13	2.10	3.10

LSD (5%) = 0.14, 1 Where T_0 = Weeding at time of sowing, T_1 = Weeding at 3 Weeks After Sowing (WAS), T_2 = Weeding at 5 WAS and T_3 = Weeding twice at 3 and 5 WAS

suaveolens, *Leucas martinensis*, *Mitracarpus villosus*, *hudwigia decurrens*, *Commelina benghalensis* and *Corchorus olitorius* whilst that of sedges was *Cyperus rotunduns*.

The four legumes generally suppressed grasses with the exception of *Rottboellia cochinchinensis* and *Digitaria horizontalis*. Broadleaves on the other hand proved more resilient to control by the legume covers. The most persistent broadleaves were *Hyptis suaveolens*, *Leucas martinensis*, *Mitracarpus villosus*, *Hudwigia decurrens*, *Commelina benghalensis* and *Corchorus olitorius* whilst that of sedges was *Cyperus rotunluns*.

Nitrogen fixed and accumulated: The amount of N fixed and accumulated in the cover crops is shown in Table 7. The N accumulated was in the range of 2.3-2.6 %. The lowest value was observed for *M. pruriens* var. *cochinchinensis,* however, it fixed the highest nitrogen because of large biomass production (data not shown). Results also showed that *C. ensiformis* fixed the least nitrogen. The nitrogen fixed by the mucuna species was between 420 and 495 mg/plant. There was no significant ($p>5$ %) difference in N fixed by Mucuna species.

Maize biomass: The legume-maize intercrop produced more maize biomass than the sole maize under the three weeding regimes (Table 8). At closer spacings (40×40 and 50×40 cm), the canavalia-maize intercrop produced more maize biomass than the mucuna-maize intercrop. The highest maize biomass (3.80t ha^{-1}) was observed under canavalia-maize intercrop at 40×40 and 50×40 cm when the field was weeded once 3 WAS (T 2) and twice 3 and 5 WAS (T 3), respectively.

DISCUSSION

The mean plant canopy cover of the cover crops increased with growth. This agrees with the findings of Carsky *et al*. (2000) who reported that canopy development measured as percentage ground cover increased with time of assessment. The mean plant canopy cover of the Mucuna species was higher than that of *C. ensiformis*. This finding agrees with Buckles *et al.* (1998) who observed that Mucuna species reached 100% ground cover 60-90 days after planting, whereas *C. ensiformis* rarely reached 100% ground cover.

However, intercropping *C. ensiformis* with maize in the present study gave higher plant canopy cover than Mucuna. This could be attributed to difference in growth habit because Buckles (1993) reported that intercropping Mucuna with tall crops such as millet and maize resulted in Mucuna growing upwards as it climbed on the companion crop. Awiti *et al.* (2000) also reported the growth habit of *C. ensiformis* as upright whilst Mucuna as a climber.

The cover crops showed substantial weed suppression abilities, especially *M. cochinchinensis* and *C. ensiformis*, probably due to their high rate of growth and biomass production relative to the competing weeds. The present study confirms the findings of Awiti *et al.* (2000) who observed that aggressive cover crops such as Mucuna species and *C. ensiformis* formed dense mat of vegetation that controlled weeds physically by a smothering effect. Besides, Carsky *et al*. (2000) reported that *C. ensiformis* is a good cover crop in perennial crops such as plantain or crops which could not be combined with Mucuna. Comparatively, *C. ensiformis* suppressed weeds better than *M. pruriens var cochinchenensis* when planted at closer spacing (40×40 cm) under intercropping system. This suggests that closer spacing favoured better and rapid canopy formation of *C. ensiformis.*

The dominance of broadleaves was initially more than that of the other weed groups and remained greater throughout the season. This season-long dominance could probably be due to favourable edaphic conditions, particularly soil fertility that encouraged persistence of broadleaves since leguminous crops fix nitrogen and promote the availability of some other soil nutrients (e.g., phosphorus). There was however, a sharp decrease in the prevalence of grasses and the sedge-*Fureina ciliaris* probably due to the smothering by the cover crops, leaving about only 20% of grasses at the end of the experiment. This conforms to the work of Akobundu (1987) in which live mulch

(*Centrosema pubescens*) suppressed the growth of grasses but encouraged the growth of broadleaves. The four legumes generally suppressed grasses whilst broadleaves population proved more resilient to control by the cover crops as a likely result of their differences in photosynthetic efficiencies. Grasses being generally C4 plants are less shade tolerant than the broadleaved which are C3 plants (Akobundu *et al*., 1987).

The cover crops fixed substantial amount of nitrogen. The Mucuna species fixed more nitrogen than *C. ensiformis*. Carsky *et al*. (2000) reported that growing maize after Mucuna was better than that of *C. ensiformis* and they attributed it to difference in nitrogen fixing abilities of these cover crops. The *C. ensiformis* accumulated higher percentage of nitrogen than *M. pruriens* var. *cochinchinensis* but recorded the least nitrogen fixed. This could be attributed to difference in biomass production because *M. pruriens* var. *cochinchinensis* produced higher biomass than *C. ensiformis* (data not shown).

Generally, legume-maize intercrop increased maize biomass at the three planting distances and weeding regimes. Sarpong (2001) also observed increase in maize biomass when cowpea was intercropped with maize. Aggarwal *et al.* (1992) observed significant increase in maize biomass production in a maize-legume intercrop and attributed the increase to transfer of nitrogen from the legumes to maize. The increase in maize biomass in the present study could be attributed to nitrogen transfer because the cover crops showed good nitrogen fixing abilities. The increase in maize biomass could also be attributed to the massive weed suppression by the cover crops. According to NRI-MoFA (2000), aggressive cover crops such as Mucuna and *Canavalia ensiformis* formed dense mat of vegetation that controlled weeds by smothering effect. In Ghana, yield loss due to weed competition can be as high as 55% for maize (Akobundu, 1980).

The highest maize biomass (3.54 t ha^{-1}) in Mucuna-maize intercrop was observed at wider spacing (60×40 cm) when the field was weeded once (5 WAS). Mucuna gave high yield at wider spacing because there was more space for spreading to increase smothering effect on weeds. In the case of Canavalia-maize intercrop, the highest biomass (3.80 t ha^{-1}) was observed at closer spacing (40×40 cm) when the field was weeded once (5 WAS). Closer spacing therefore favoured better canopy formation by the *C. ensiformis* which smothered the weeds.

CONCLUSIONS

The study revealed that the test cover crops, *M. pruriens* var. *utilis*, *M. pruriens* var. *nagaland*, *M. pruriens* var. *cochinchinensis* and *C. ensiformis*, have high grass weed suppression potentials which formed the most competitive flora in the ecology. The cover crops also fixed between 333 to 495 mg N/plant. The study further revealed that weed infestation in maize was reduced when it was intercropped with the cover crops. At closer spacing (i.e., 40×40 cm) and weeding once at 5 WAS, *Canavalia ensiformis* gave the best weed suppression in maize. However, for *Mucuna pruriens* var. *cochinchinensis* effective weed suppression was observed at a wider spacing of 60×40 cm and weeding once at 5 WAS. This implies that the conventional manual weed control in maize twice before harvest could be reduced to one weeding by intercropping with *Canavalia ensiformis* and *Mucuna pruriens* var. *cochinchinensis* at planting distances of 40×40 cm and 60×40 cm, respectively.

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