Nig. J. Biotech. Vol. 38 (1) : 61-67 (June 2021)
ISSN: 0189 1731
Available online at
http://www.ajol.info/index.php/njb/index
and www.biotechsocietynigeria.org
DOI: https://dx.doi.org/10.4314/njb.v38i1.7

NIGERIAN JOURNAL OF BIOTECHNOLOGY

Effects of cowpea (*Vigna unguiculata* L. Walp.) as a Live mulch on weed management in maize cropping

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Abstract

Weed interference is a major constraint in maize cultivation. Living mulch as an alternative weed control strategy has been established to be environmentally safe but has not been widely used in maize cultivation. The aim of this research was to evaluate the weed management attributes of *Vigna unguiculata* in maize cropping. A field study was carried out in the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. The treatments were maize interplanted with Cowpea at 20,000 (M1), 30,000 (M2), 40,000 (M3) plants/hectare, hoe weeding (M4), weedy check (M5) and Primextra-2.5 L/ha (M6). The treatments were arranged in randomized complete block design, each replicated four times. Weed Dry Weight (WDW) and Weed Control Efficiency–WCE (%) were calculated following standardized methods. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$. The treatment plots were dominated by weed species in the Asteraceae, Fabaceae and Poaceae families. The M5 accounted for the highest WDW (126.30 g). The WCE was highest in M3 (94.8%) and least in M5 (66.4%). Maize and cowpea interplant at 40,000 plants/hectare suppressed weed. Hence, cowpea is an ideal weed suppressant and can be inter-planted as a cover crop in maize cropping systems.

Keywords: Weed suppressant, Cover crop, Weed control efficiency, Cowpea.
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Introduction

Over the years, farmers have been faced with challenges of weed infestation that needs to be addressed because it negates optimum crop yield. The presence of weed seeds could be due to the presence of weeds in the soil seed bank or non-native seeds brought in with crops. Weed is an important pest of crops that has the potential of reducing crop yield if not adequately managed. In Nigeria, maize is currently an essential cereal crop for a good number of people; however, weed infestation limits its continuous production (IITA, 2012). Severe weed infestations have resulted in up to 89% loss in maize yield (Imoloame and Omolaiye, 2017).

Chemical herbicides do work, but croplands end up having weeds that are resistant to these herbicides, hence the need to adapt integrated weed management which includes cover crops. Over reliance on chemical herbicide brings about numerous ecological and crop management problems that have deleterious effects on the health of the ecosystem. Soil void of mulch is usually prone to problems such as wearing of top soil, fertilizer and pesticide runoff into underground and surface waters. The use of intensive fallow systems that are cost effective and environmentally friendly using promising leguminous cover crops could proffer solution to these problems (Awodoyin and Ogunyemi, 2005).

The reduction of weed incidence in maize through cover crop interplanting is dependent on a number of factors, including manipulation of plant arrangement, planting and interplant species, fertilizer doses and period of assessment. Sown fallow or planted fallow can act as weed-break by preventing the sprouting of seeds and establishment of weed seedlings. Cover crops of beneficial features should not only have the capacity to cover the soil expeditiously, it must also be able to smother weeds swiftly and bring about a reduction in the use of herbicides (Woghiren and Awodoyin, 2018). Weed control had remained the highest time consuming operation of all the cultural practices in crop production in Nigeria. The growing of live mulches in the midst of arable crops simultaneously has great possibility of reducing man-hour used on weed control and the amount spent on weed management in addition to maximizing return (Weber *et al*., 2017).

Cowpea (*Vigna unguiculata*) is an extensively cultivated, stress-resilient leguminous crop in Sub-Saharan Africa. Cowpea can generate a lot of biomass while also fixing a lot of nitrogen from the air. Cowpea has already been recognized as an excellent weed smothering cover crop (Woghiren and Awodoyin, 2018). It is essential to assess its preferred planting density to effectively suppress weeds in the maize cropping system. This study aimed at evaluating the various densities of cowpea that would enhance weed suppression in the maize field.

Materials and Methods

The experiment was carried out in the Crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, (Latitude 7°27`N; Longitude 3°53`E; Elevation 218 m ASL), Nigeria. The field site was cleared manually with cutlasses and hoes and soil samples were collected by hand auger to determine physicochemical parameters analysis. The soil was loamy sand (sand-796.0, silt-136.0 and clay-68.0 g/kg), slightly acidic (pH-6.5), low in organic carbon (1.6%) and low in total nitrogen content (0.2 g/kg) (Table 1). The study was a Randomized Complete Block Design (RCBD) with six treatments and four replicates. The experimental plot dimension was 19.4 m × 13.5 m which resulted in an area of 262 m^2. Each replicate had a dimension of 2.5 m × 1.6 m with an alley of 0.5 m between two blocks.

Three seeds of maize (DTMA - Y - STR) 60 days maturing variety, were sown on flat at a spacing of 0.80 m × 0.50 m. In the maize herbicide plots, primextra gold herbicide was applied (2.5 L/ha) to the experimental plots immediately after sowing. Maize plants were thinned to two (2) plants, two weeks after sowing (WAS), to give a plant population of 50,000 plants / ha. Two seeds of *Vigna unguiculata* were sown in between maize inter row (0.40 m) and later thinned at two weeks to one plant per stand. The M1 (20,000 cowpea plants per hectare) treatment were sown in between maize alleys at a spacing of 0.62 m. The M2 (30,000 cowpea plants per hectare) treatment was planted in the maize alley at 0.41 m. The M3 (40,000 cowpea plants per hectare) treatment was sown in the maize alley at a spacing of 0.31 m. The intra-row spacing for the cover crops are indicated in Table 2. While the sole maize (hoe-weeded, weedy all through and herbicide) control treatment, were sown at a distance of 0.80 m wide inter row and 0.50 m intra row spacing. The treatment plots had one weeding regime which was at 3 WAS, with the exception of the weedy and the herbicide control, which were weedy throughout the study.

Table 1: Soil Analysis of the Experimental Soil

Properties	Values
pH (H_2O)	6.5
Organic carbon (g/kg)	16.30
Total N (g/kg)	2.00
Available P (mg/kg)	15

Exchangeable base (cmol/kg)	
K (Potassium)	0.3
Physical properties (g/kg)	
Sand	796.0
Silt	136.0
Clay	68.0
Textural classification	Loamy Sand

Table 2: Treatments Combinations for Experimental Plots

Treatments	Cover Crop Density	Planting Spacing	
Crops Combinations	(Number of Plants / ha)	Maize	Cover Crops
Maize + Cowpea (M1)	20,000	0.5 m x 0.8 m	0.62 m x 0.8 m
Maize + Cowpea (M2)	30,000	0.5 m x 0.8 m	0.41 m x 0.8 m
Maize + Cowpea (M3)	40,000	0.5 m x 0.8 m	0.31 m x 0.8 m
Hoe weeding (M4)	-	0.5 m x 0.8 m	-
Weedy check (M5)	-	0.5 m x 0.8 m	-
Primextra- 2.5 L/ha (M6)	-	0.5 m × 0.8 m	-

Note: Maize population per hectare = 50,000 plants / ha

Data Collection

The weed species were enumerated at the physiological maturity of maize (60 DAS). Two 25 cm × 25 cm quadrats were randomly laid within each plot. The weeds rooting within the quadrat were identified to species level and counted using a flora handbook by Akobundu and Agyakwa (1987). The species that were not identified on the field were kept in a wooden press and taken to UI herbarium in the Department of Botany, University of Ibadan for identification. The weed samples were oven-dried at 80 ºC to a constant weight and weighed for dry matter content. The true extent of weed reduction caused by weed control treatment is denoted by weed control efficiency (WCE). It was calculated using the Mani *et al.* (1973) methodology and stated in percentage;

$$WCE (\%) = \frac{\text{Dry weight of weeds in un-weeded control} - \text{Dry weight of treatment plot}}{\text{Dry weight of weed in un weeded control}} \times 100$$

The compiled weed floristic information was evaluated using Paleontological Statistical Software (PAST, Version 2.01) of Hammer *et al.* (2001). The Relative Density (RD), Relative Frequency (RF) and Relative Importance Value (RIV) of floral species were calculated (Awodoyin and Olubode, 2009).

Results

Floristic Enumeration of the Different Cowpea population in maize Cropping

Maize + Cowpea (20,000 plants / ha) – M1

A total of nineteen plants from thirteen families was listed. *Sesbania pachycarpa* dominated with the highest Relative Importance Value (RIV) of 24.33% (Table 3). *Brachiaria deflexa and Indigofera hirsuta* followed with RIV of 13.84% and 13.79% respectively. Species with low RIV includes *Corchorus olitorius* and *Dactyloctenium aegyptium* which had

S/N	Species name	Family	M1	M2	M3	M4	M5	M6
1	*Ageratum conyzoides* Linn.	Asteraceae	7.45	33.82	34.21	35.38	5.52	36.78
2	*Amaranthus spinosus* Linn.	Amaranthaceae	0.74	–	–	1.60	–	–
3	*Boerhavia diffusa* Linn.	Nyctaginaceae	5.41	5.22	6.01	7.56	4.63	4.36
4	*Brachiaria deflexa* (Schumach) Robyns	Poaceae	13.84	20.18	18.10	19.22	17.30	33.46
5	*Celosia argentea* Linn.	Amaranthaceae	–	–	–	–	2.15	–
6	*Corchorus olitorius* Linn.	Malvaceae	0.68	–	1.74	0.77	3.79	1.31
7	*Cleome viscosa* Linn.	Capparidaceae	–	–	–	–	1.36	–
8	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	0.68	–	–	0.77	–	1.31
9	*Desmodium scorpiurus* (Swartz) Desvaux	Fabaceae	3.25	7.60	8.34	6.70	14.73	5.81
10	*Euphorbia heterophylla* Linn.	Euphorbiaceae	5.28	6.08	7.35	4.88	15.29	10.16
11	*Euphorbia hirta* Linn.	Euphorbiaceae	4.06	4.36	3.30	3.78	1.07	–
12	*Indigofera hirsuta* Linn.	Fabaceae	13.79	2.27	–	2.51	2.15	2.76
13	*Ipomoea repens* (L.) Poiret.	Convolvulaceae	0.74	1.51	0.97	–	–	–
14	*Ludwigia decurrens* (DC.) Walter	Onagraceae	1.22	2.34	–	2.51	1.07	1.31
15	*Mimosa diplotricha* C.Wright.	Fabaceae	–	–	–	–	1.64	–
16	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	6.02	3.46	2.71	4.12	–	1.45
17	*Momordica charantia* Linn.	Cucurbitaceae	–	–	0.87	–	–	–
18	*Panicum maximum* Jacq.	Poaceae	–	–	–	–	2.43	–
19	*Phyllanthus amarus* Schumach	Phyllanthaceae	4.46	2.27	1.84	–	1.64	1.31
20	*Portulaca oleracea* Linn.	Portulacaceae	1.62	2.99	2.13	2.94	2.43	–
21	*Sesbania pachycarpa* sensu auct./DC.	Fabaceae	24.33	–	0.97	–	4.07	–
22	*Talinum fructicosum* (L.) Juss.	Talinaceae	0.74	0.76	0.87	0.77	3.50	–
23	*Tithonia diversifolia* (Hemsl.) A. Gray.	Asteraceae	–	–	–	–	9.26	–
24	*Tridax procumbens* Linn.	Asteraceae	3.25	6.39	7.90	6.48	5.98	–
25	*Vigna unguiculata* (L.) Walp.	Fabaceae	2.43	0.76	2.71	–	–	–

Table 3: Relative Importance Value (%) for Weeds Sampled Within the Different Treatments in Maize Field in Ibadan, Nigeria (n = 8)

NOTE: M1 = Maize (50,000 plants/ha) + Cowpea (20,000 plant/ha) ; M2 = Maize (50,000 plants/ha) + Cowpea (30,000 plant/ha); M3 = Maize (50,000 plants/ha) + Cowpea (40,000 plants /ha); M4 = Hoe weeding (Maize (50,000 plants/ha); M5 = Weedy Check (50,000 plants/ha); M6 = Primextra – 2.5 L/ha (50,000 plants/ha)

Table 4: Diversity indices of herbaceous plants enumerated on maize plot in Ibadan, Nigeria

Treatment	Taxa _ S	Shannon _ H	Evenness e^H/S	Dominance _ D
M1	19	1.65	0.29	0.30
M2	15	1.51	0.30	0.34
M3	16	1.58	0.30	0.32
M4	15	1.44	0.28	0.38
M5	19	2.42	0.59	0.12
M6	11	1.19	0.30	0.39

NOTE: M1 = Maize (50,000 plants/ha) + Cowpea (20,000 plant/ha) ; M2 = Maize (50,000 plants/ha) + Cowpea (30,000 plant/ha); M3 = Maize (50,000 plants/ha) + Cowpea (40,000 plants /ha); M4 = Hoe weeding (Maize (50,000 plants/ha); M5 = Weedy Check (50,000 plants/ha); M6 = Primextra – 2.5 L/ha (50,000 plants/ha)

RIV values of 0.68% each. The Shannon-Wiener index was 1.70, evenness index of 0.29 and dominance index of 0.30 was recorded (Table 4).

Maize + Cowpea (30,000 plants / ha) – M2

The sum of fifteen plants from twelve families were listed. *Ageratum conyzoides* dominated with the highest RIV of 33.82% (Table 3). *Brachiaria deflexa* followed with a RIV of 20.18%. Species with low RIV were *Talinum fruticosum* , and *Vigna unguiculata* with RIV of 0.76% each. The Shannon-Wiener index was 1.90; evenness index of 0.30 and dominance index of 0.34 were recorded (Table 4).

Maize + Cowpea (40,000 plants / ha) –M3

A total of sixteen plants from twelve families were listed. *Ageratum conyzoides* dominated with the highest RIV of 34.21% (Table 3). *Brachiaria deflexa* followed with a RIV of 18.10%. Species with low RIV were *Momordica charantia* and *Talinum fructicosum* with RIV of 0.87% each. The Shannon-Wiener index was 1.58, evenness index of 0.30 and dominance index of 0.32 for the first trial (Table 4).

Maize hoe – weeded control (M4)

A total of fifteen plants from eleven families were listed. *Ageratum conyzoides* had the highest RIV of 35.38%. *Brachiaria deflexa* followed with RIV 19.22%. Species with low RIV were *Corchorus olitorius, Dactyloctenium aegyptium* and *Talinum fructicosum* with RIV of 0.77% each. The Shannon-Wiener index was 1.44, evenness index of 0.28 and dominance index of 0.38 (Table 4).

Maize (50,000) herbicide control (M5)

A total of eleven plants from nine families were listed. *Ageratum conyzoides* had the highest RIV of 36.78%. *Brachiaria deflexa* followed with RIV of 33.46%. Species with the lowest RIV were *Corchorus olitorius, Dactyloctenium aegyptium* and *Phyllanthus amarus* with RIV of 1.31% each (Table 3). The Shannon-Wiener index was 1.19, evenness index of 0.30 and dominance index of 0.39 (Table 4).

Maize (50,000) weedy control (M6)

A total of nineteen plants from eleven families were listed. *Brachiaria deflexa* had the highest RIV of 17.30%. *Euphorbia deflexa* followed with RIV of 15.29%. Species with the lowest RIV were *Indigofera hirsuta* and *Ludwigia decurrens* with an RIV of 1.07% each (Table 3). The Shannon wiener index was 2.42, evenness index of 0.59 and dominance index of 0.12 (Table 4).

Weed Dry Weight and Percentage Weed Reduction

The M6 (Weedy Control) treatment accounted for the highest weed dry biomass weight, which had 126.30 g. This was higher than all other weed biomass weight that ranged between 6.6 g in maize (50,000 plants per hectare) + cowpea (40,000 plants per hectare) and 7.7 g in maize (50,000 plants per hectare) + cowpea (40,000 plants per hectare). The reduction in weed dry weight were as follows; M1 (20,000 plants per hectare) treatment reduced weed by 92.32%; M2 (30,000 plants per hectare) treatment reduced weeds by 93.11%; 94.75% reduction was observed in M3 (40,000 plants per hectare); M4 (Maize Hoe Weeded) treatment reduced weed by 90.72%; M5 (Maize Herbicide Control) treatment had weed reduction of 71.61% (Table 5).

Table 5: Biomass accumulation of herbaceous floras on the enumerated maize plot in Ibadan, Nigeria

Treatment	Weed dry weight (g) per 0.25 m^2	Weed Control Efficiency (%)
M1	9.7 ± 0.7	92.32
M2	8.7 ± 1.0	93.11
Maize + Cowpea (20,000)	6.6 ± 0.7	94.75
Maize Hoe Weeded	11.7 ± 0.8	90.72
Maize Herbicide Control	35.9 ± 1.7	71.61
Maize Weed Control	126.3 ± 2.0	-
LSD (0.05)	3.23	

NOTE: M1 = Maize (50,000 plants/ha) + Cowpea (20,000 plant/ha) ; M2 = Maize (50,000 plants/ha) + Cowpea (30,000 plant/ha); M3 = Maize (50,000 plants/ha) + Cowpea (40,000 plants /ha); M4 = Maize Herbicide Control (Maize (50,000 plants/ha); M5 = Maize Weedy Control (50,000 plants/ha); M6 = Maize Hoe–Weeded (50,000 plants/ha)

Discussion

The maize + Cowpea (40,000 plants / ha) plot did better in˝smothering˝ weeds, as the weed dry weight was less than what was obtained from other treatments. There was better land coverage in maize plots inter-planted with *V. unguiculata* which resulted in cutting off weeds from solar radiation. The shading led to a marked reduction in the ability of the weeds to photosynthesize, and hence low biomass accumulation. The lowest value of weed biomass consistently recorded in the plots of maize and *V. unguiculata* interplant, suggests smothering of weeds by cowpea. The highest weed biomass was recorded at weedy control (MWC). Weed dry weight is a vital tool to authenticate the impact of weed management on crops and their associated weeds. This agrees with the findings of Mashingaidze (2004) on maize – beans intercropping, who observed a reduction in weed dry weight by 55 – 66% when planted at a population of 222,000 plants/ha for beans corresponding to 33% of maize population (37,000 plant/ha). In a report by Bilalis *et al.* (2010), intercropping maize with leguminous vegetables significantly decreased weed density relative to maize monocrops. This is attributed to the reduced illumination available in maize legume intercrop for weeds. This brings about a decrease in weed density and weed dry weight when compared to mono crop. Rao (2000) claimed that a kilogram of weeds usually correlates to one kilogram of crop yield loss in the field.

In this study, the ability of *V. unguiculata* to effectively suppress weeds may have been either through interception of light from reaching the soil surface or by inhibiting weed growth by the release of allelochemicals. The laboratory analysis revealed that *V. unguiculata* has high secondary metabolite in the shoot and root (Woghiren *et al.*, 2020). Previous studies revealed that cover crops could smother weeds either by decreasing resource accessibility (Ngouajio and Mennan, 2005) or by impairing the growth of weeds through the secretion of allelochemicals (Reberg-Horton *et al.*, 2005). Cover crop can help to alter prevalence of weed interference by denying weeds the opportunity to use water, light, nutrients as well as soil (Ngouajio and Mennan, 2005) and the structure of weed vegetation (Wright *et al.*, 2003). The ecosystem of soil microbes can be changed by the leftover parts of cover crops or increase microbial diversity, ensuring better soil micro-organisms predation of weeds and decreased weed seed potency (Ngouajio and McGiffen, 2002). This could also influence weed population flux (Jordan *et al.*, 2000).

The treatment plots were dominated by species in the Asteraceae, Fabaceae and Poaceae families. The abundance of the Asteraceae and Poaceae families may be due to the fact that they are the largest families of the dicotyledons and the monocotyledons. The major weeds encountered in the treatment plot comprised all categories of weeds which are grasses, broad leaves and sedges. This findings agrees with the result of Taah *et al.* (2017) in which they observed the Asteraceae, Fabaceae and Poaceae families to be the most prominent families in a cassava and legume intercropping system.

Conclusion

The results of this study justify the use of *Vigna unguiculata* as a cover crop in maize cropping. The maize + Cowpea (40,000 plants / ha) plot did better in˝smothering˝ of weeds, as the weed dry weight was less than what was obtained from other treatments. The superior performance of *V. unguiculata* at the various planting densities is an indication that the plant could be an ideal cover crop in arable agriculture.

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