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Effect of weed removal on insect populations and yield of Cowpea [*Vigna unguiculata* (L) Walp]

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Abstract

Field studies were conducted during the cropping seasons of 2008 and 2009 at Ilorin, Nigeria to evaluate the influence of weed removal on insect population and yield of cowpea [*Vigna unguiculata* (L) Walp]. The trial was designed as a randomized complete block in a split-plot arrangement and three replications. The main plots were two cowpea varieties while the sub plots were three weeding regimes (no-weeding, 1 hand weeding at 3 weeks after sowing and 2 hand weeding at 3 and 6 weeks after sowing). The cowpea varieties were similar in most of the parameters assessed. Reduced cowpea biomass, pods and grain yield were associated with weedy cowpea plots. Grain yield reduction due to uncontrolled weed growth was estimated to be 50-60 % and 70-80 % compared to one-hand weeding and two-hand weeding, respectively, while a yield reduction of 30-60 % in one-hand weeding compared to two-hand weeding. Weedy situation in the cowpea ecosystem supported higher insect population whereas *Aphis craccivora* Koch and *Empoasca spp.* population increased when the crops experienced weed-free situation because of the influence of groundcover on the optomotor landing response of the aphids and probably due to reduction in natural enemies of *Empoasca spp.* It is concluded that a search for alternative methods of Pests Management, which entails a quantitative understanding of the dynamics of weed and insect population outflow in cowpea agro-ecosystem in the humid tropics is needed for a profitable cowpea production.

Keywords: cowpea; yield; *Aphis craccivora* Koch; *Empoasca spp.*

Introduction

In West Africa and many parts of the world cowpea [*Vigna unguiculata* (L) Walp] is an important grain legume. Total worldwide production of cowpea is estimated at 3.3 million tons (FAO, 2001) of dry grain of which 64% is produced in Africa. Conservative estimates suggest that 12.5 million ha are planted annually to cowpea around the world. Of this area, about 9.8 million ha are planted in West Africa, making it the region with the largest production and consumption of cowpea in the world (CGIAR, 2001). Cowpea production is regarded as an integral part of traditional cropping system throughout Africa (Isubikalu et al., 2000). The crop is very popular and unique in that it produces food for man and fodder for livestock. It has high potential to increase income of both farmers and traders (Owolade et al., 2004). However, the crop is attacked by spectrum of pest species (Isubikalu et al., 2000). It is considered too risky an investment by many growers, because of the numerous pest problems associated with it (Remison, 1997). Farmers obtained low average yield due to these field pests. For instance, average world yield of cowpea grain is quite low at less than 0.3 ton/ha. Within Africa, average cowpea yields vary dramatically from 0.05 to 0.55 ton/ha (Cisse et al., 1995). Alghali (1992) reported 200-300 kg ha^{-1} in Nigeria, 150-300 Kg ha^{-1} in Uganda and more than 2000 Kg ha^{-1} under research environment (Rusoke & Rubaihayo,1994). These major pests of cowpea in the humid tropics are weeds (Ayeni, 1992) and insects (Jackai & Adalla, 1997). These pests, especially insect pests, damage cowpea from seedling emergence to storage (Karungi et al., 2000). Weeds constitute a major limiting factor to cowpea production in Nigeria (Okafor & Adegbite, 1991). Tijani-Eniola (2001) reported that weed could cause yield losses ranging from 50 to 80 %. Crop losses by weeds could be aggravated by delay in weeding or inability to weed throughout the entire crop growth period. However, studies of threshold levels of weeds have shown that complete weed elimination is not essential for high yields (Sangakkara, 1999), probably because the crop also competed strongly with weeds. In addition, to their repressive effects owing to competition, weeds also act as reservoirs or alternate hosts for insects, diseases and nematodes (Jackai & Adalla, 1997). Weeds and insects often coexist and reduce yields in agricultural systems. Weeds reduce yields by an estimated 12% annually, whereas insects account for a 13% annual reduction in yields in United States agricultural systems (Pimentel 1991). In addition to the individual effects that insects and weeds have on crops, these two types of pests and their management practices can interact and impact crop production. Weeds reduce crop yields and quality by competing for nutrients and water. They also may decrease the value and productivity of land, reduce harvesting and processing efficiency, increase cost and labor for control measures, and restrict flow of water to reservoirs, canals, and ditches (Smith and Hill 1990). Losses from insects include defoliation of root or leaf tissue, removal of fluid from phloem and xylem systems, mining of parenchyma tissue, formation of galls, or blemishing the

harvested fruit or vegetable (Schoonhoven et al., 1998). Additional problems associated with insects are transmission of plant diseases, costs involved with insect management, and development of resistance to control measures (Paoletti and Pimentel 2000).

In addition to their individual effects, studies have shown that insects and weed interactions occur in the field (Gurr and Wratten 1999; Mensah, 1999). Presence or absence of certain weeds may contribute to or reduce insect infestations in crops (Hambäck et al., 2000; White and Whitham 2000). Additionally, management practices for weeds can affect insects and vice versa. Akinyemiju & Olaifa (1991) reported that reduced cowpea biomass, flowers, pods and grain yields were associated with cowpea plots where weeds and insect pests were not controlled. Weed control without insect pests control led to more than 90 % reduction in cowpea yield and yield components. On the other hand, insect pests control without weed control resulted in about 70 % loss in yields of cowpea. Ezueh & Amusa (1988), Okafor & Adegbite (1991) recorded 17 weed species predominantly found in most cowpea agro ecologies in Nigeria while Ezueh (1991), Jackai & Adalla (1997), Karungi et al., (2000) and Malgwi & Onu (2004) reported that flower thrips (*Megaluthrips sjostedt* Trybon), pod borer (*Maruca testulalis* Geyer), *Cydia* species and the Hemipteran complex (*Pentatomid spp*), *Coreids* and *Aphids* are the major pests attacking cowpea. It is important to know if any of the weeding regimes will lead to a substantial reduction in insect pests of cowpea. This study was designed to examine the influence of removal of weeds on insect pests population and grain yield of cowpea in the southern Guinea savanna of Nigeria.

Materials and methods

This study was conducted at the University of Ilorin Teaching and Research Farm during the 2008 and 2009 growing seasons. The farm is located at Bolorunduro, Ilorin, in the southern Guinea savanna ecological zone (9^0 29' N, 4^0 35' E) of Nigeria, and is 307 m above sea level. The area is characterized by a bimodal rainfall pattern with peaks in June and September and a dry spell between mid – July and August. The annual average rainfall of the area is 1,250 – 1500 mm and a mean temperature range of 19^0 – 33^0 C and the soil was a sandy clay loam classified as a plinthustaffs. The study was designed as a randomized complete block in a split-plot arrangement and three replications. The main plots consisted of two varieties of cowpea (IT98K-205-8 and IT98K-463-7) while the sub plots made of three weeding regimes (NO-weeding, One –hand weeding at 3 weeks after sowing (WAS) and Two-hand weeding at 3 & 6 WAS). The experimental plot consisted of six (6) ridges of 6 m long and 1.4 m crest to crest distance. The cowpea seeds were sown at a spacing of 1.4 m x 0.25 m per stand to give an approximate density of 57,143 plant ha^{-1}. Neither fertilizer nor insecticidal treatment was applied.

Weed identification, density and biomass were determined within two fixed quadrats (0.5 m^2) randomly placed in each sub plot at 50 % cowpea flowering and prior to harvest. The weeds within each quadrat were harvested at soil level, separated into types and oven dried to a constant weight. Data collection on crop included plant height, number of pods, pod length, and stover weight were obtained using 12 plants from each sub plot. Cowpea pods were harvested from each plot, threshed and the seeds were weighed to obtain grain yield. Insect population was taken trice a week for seven weeks from 2 WAS using hand picking and insect nets for highly mobile insect and this was done during the early and late hours of the day.

The insect pests collected were pooled together and the mean used for analysis. The acquired data were analysed using Gen stat statistical package. The means were separated using the Fisher's Least Significant Difference (LSD). The composition of the weed flora was analysed by calculating the relative abundance (RA) of each species within each experimental unit as follows: RA = (RD + RF) / 2, Where RD (relative density) = number of a weed species per unit area (within a quadrat) in the plot divided by the total number of weed species within the same unit area (quadrat); and RF (relative frequency) = proportion of quadrat in which the species was present per experimental unit divided by the total frequency of all species in the experimental unit (Okore et al., 2001).

Results

Composition of weed species and insect pests population

A total of 22 weed species, belonging to 18 genera, within 9 families, were identified throughout the study period (Table 1). Fifty-nine percent of the weed species encountered were broadleaves, 27 % were grasses while sedges were about 14 % and about 65 % of the entire weed species were annual in life style. *E. heterophylla, Eleusine indica, T. procumbens, Brachiaria deflexa, R. cochinchinensis and Hyptis suaveolens,* had the highest relative abundance. A total of 15 insect pests were encountered across the weeding regimes (Table 2). About 33 % of the total insect species were Coleoptera. *Aphis craccivora* Koch (Homoptera, Aphididae) and *Empoasca* spp population increased with increased in weeding frequency while others decreased with increased weeding regimes. In the total insect population, only three insect pests (*A. craccivora*, *M. sjostedt* and *P. sabeaus*) constituted 70.27 % in the zero weeding regime while only two insect pests (*A. craccivora*, and *M. sjostedt*) constituted 71.97 % in the one weeding regime and only one insect pest (*A. craccivora*) made up 78.21 % in the two-hand weeding regime. Since insect pests could be categorized according to the degree of damage they cause and frequent of occurrence, *A. craccivora* may be considered a major insect pest of cowpea.

Weed density and biomass

The weed parameters were not significantly affected by the cowpea varieties. Weeding regime significantly affected the population of weed at both assessment times. The unweeded (zero-weeding) plots had a significantly higher weed density than the plots that had 1 or 2 hand weeding. Conversely, the one-hand weeded plots had a statistically higher weed density than two hand weeded plots. There was, however, no significantly difference between the density of weeds in those (one and two-hand weeding) plots when assessed at harvest in 2009. In like manner, weed biomass at harvest was significantly affected by weeding regime and unweeded plots had a higher weed biomass than the other plots.

Table 1. Relative abundance of weed species encountered on cowpea field in Ilorin, Nigeria

Family	Weed species	Relative abundance	
		2008	2009
Asteraceae	*Aspilia Africana* pers. C.D.Adams	0.145	0.129
	Chromoleana odorata(L) R.M.Kings	0.048	0.063
	Tridax procumbens Linn	0.302	0.282
Cleomaceae	*Cleome viscose* Linn	0.008	0.019
Commelinaceae	*Commelina benghalensis* Linn	0.021	-
	C. diffusa Burm	0.006	0.003
Cyperaceae	*Cyperus escelentus* Linn	-	0.182
	C. rotundus Linn	-	0.028
	C. tuberous Rottb	0.014	-
Euphorbiaceae	*Euphobia heterophylla* Linn	0.412	0.327
	E. hirta Linn	-	0.041
	Phyllantus amarus Schum et Thonn	0.035	-
Lamiaceae	*Hyptis suaveolens* Poit	0.224	0.143
Poaceae	*Brachiara lata* (Schumach) C.E.	0.271	0.473
	Cynodon dactylon (Linn) P.B.	0.128	0.107
	Digitaria horintalis Willd	0.064	0.028
	Eleusine indica Gaertn	0.335	0.203
	Rottboellia cochinchinensis (Lour) C	0.217	0.154
	Seteria barbata (Lam) Kunth	0.010	-
Rubiaceae	*Diodia scandens* S.W	-	0.092
	Mitracapus villosus (SW) DC	0.186	0.173
Verbenceae	*Vernonia galamensis* (Cass) Less	0.152	0.094

Table 2. Relative prevalence of some insect pests recorded on cowpea field in Ilorin, Nigeria

	Relative prevalence (%) of insect pests			
Insect pests	Zero-weeding	One-hand weeding	Two-hand weeding	Pest Status
Aphis craccivora Koch	32.68	57.96	78.21	++
Aspavia armigera Fabricius	9.50	6.22	2.51	++
Chelomenis spp.	5.62	6.12	2.03	++
Chrysodeixia chalactes Esp	0.98	0.44	0.05	+
Chrysolagria spp.	0.67	0.68	0.06	+
Chravigralla tomentosicollis Stal	2.32	2.22	1.88	++
Conocephalus conocephalus Thun	0.98	0.56	0.23	+
Empoasca spp.	2.71	3.89	5.06	++
Lagria villosa Fabricius	0.28	0.00	0.00	+
Maruca vitrata Fabricius	2.81	2.66	0.62	++
Megalurothrips sjostedti Trybon	19.67	12.01	4.60	++
Nezara viridula Linnaeus	1.44	1.00	0.79	+
Paederus sabeaus Er.	17.92	4.02	3.28	++
Podagrica spp Jacq.	1.36	1.89	0.39	+
Zonocerus variegatus Linnaeus	1.06	0.33	0.29	+

++ = Major insect pest, + = Minor insect pest

Cowpea morphological characteristics

The yield components of cowpea were not significantly affected by the two varieties of cowpea cultivated in this trial at both years except plant height (Table 3). Cowpea variety, IT98K205-8 had significantly higher plant height in both trial years whereas those parameters were significantly affected across the weeding regimes except pod length in the first year trial. The two-hand weeded plots had significantly higher cowpea plant height, pod length and pod number compared to the other weeding levels. The cowpea stover weight did not differ significantly across the cowpea varieties although IT98K205-8 had a higher stover weight on both trial sites. The weeding levels differ significantly, unweeded plots had significantly lower stover weight except in 2009 where similarities were observed with one-hand weeded plots. The cowpea grain yields were similar across the cowpea varieties but significant difference was observed across the weeding treatments. The unweeded plots had significantly lower grain yield except in 2008 where yield was similar with one-hand weeded plots (Fig. 2).

Insect pest population

The insect pest population was not influenced by cowpea varieties but differ significantly across the weeding treatments (Fig. 2). The two-hand weeded plots had significantly lower insect pest population compared to the unweeded plots

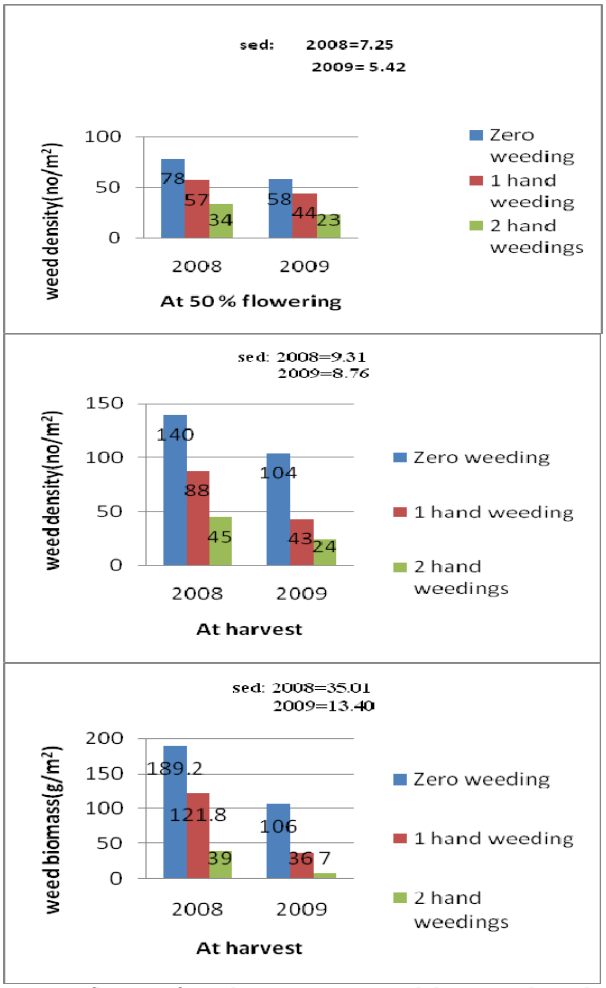

Fig 1. Influence of weeding regime on weed density and weed biomass

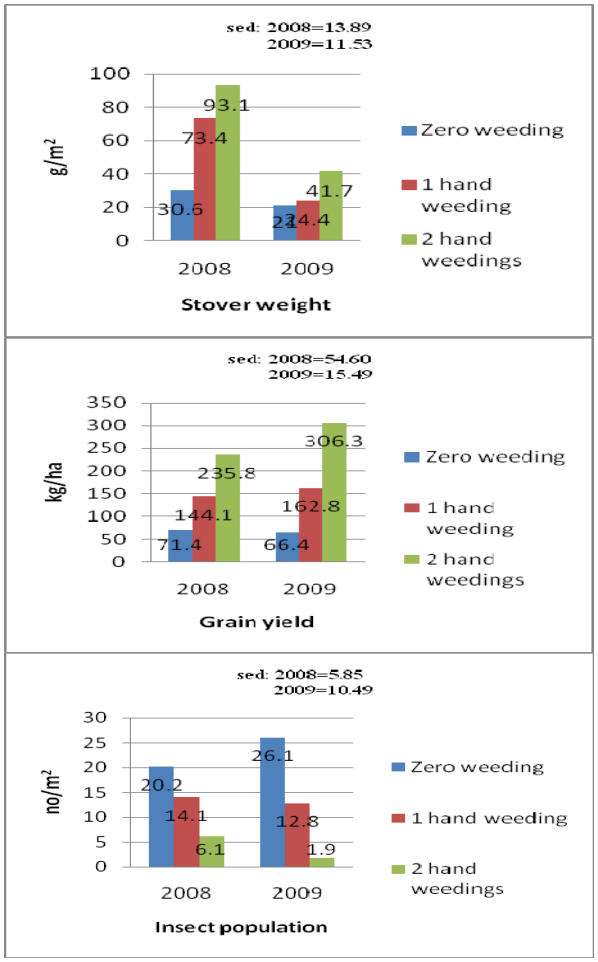

Fig 2. Effect of weeding regime on yield of cowpea and insect population

while the one-hand weeded plots had a similar insect population with the other weeding regime plots.

Discussion

Competition between weeds and crops is expressed by altered growth and development of both species. The most obvious a consequence of weed competition in crops is reduction in the economic yield of affected crop plants and this implies that the competitive ability of weed species out-weigh the crop plants thus its capacity to capture and exploit resource rapidly. In this study, when weeds were controlled, the performance of cowpea was greatly enhanced leading to substantial grain yield increase over the no-weeding treatments; the effect of weed control on cowpea performance was greatly manifested. Yield reduction due to uncontrolled weed growth (Zero-weeding) in cowpea was estimated to be 50-60 % and 70-80 % compared to one-hand weeding and two-hand weeding, respectively. This findings is in agreement with Tijani-Eniola (2001), who reported cowpea yield losses ranging from 50-80 %, Akinyemiju & Olaifa (1991) estimated 70 % losses in cowpea yield, Ezueh & Amusa (1988) had 53 % loss in yield of cowpea in IITA, in an uncontrolled weed field.

The second consequence of such competition is harbouring of insect pests by weed species and these insect pests feed on reproductive plant parts causing more economic damage to the crops (Adebayo et al., 2007). In this study, *A. craccivora*, *M. sjostedti*, *P. sabeaus*, *M. vitrata*, *Chelomenis spp.* were the most abundant and serious insect pests within the cowpea cropping system. The major insect pests encountered in this study are in conformity with those reported by various authors (Hassan, 2009; Malgwi & Onu, 2004; Karungi et al., 2000; Jackai & Adalla, 1997; and Ezueh, 1991). The insect pests of cowpea encountered in this study appeared in two categories in relation to the weed situation in the cowpea agro-ecosystem. *Aphis craccivora* and *Empoasca spp* population increased when the crops experienced weed free situation; this could be due the optomotor landing response of *A. craccivora*. A'brook (1968) reported the effect of planting spacing on the increased number of the insect caught, that, the contrast of plants and soil in widely spaced agro ecology could also attract more *A. craccivora*. In this study, weed free plot created more space between plant in the cowpea agro-ecosystem while the weedy plot inhibits the landing response of A. craccivora through close spacing (Ofuya, 1997). The findings on *Empoasca spp* agreed with Lam and Pedigo (1998) who reported that population

Table 3. Influence of weeding regime and cowpea varietals difference on yield components of cowpea

	Plant height (m) @ 50% flowering		Pod length (m) @ harvest		Pod number/m^2 @ harvest	
Variety (Var)	2008	2009	2008	2009	2008	2009
IT 98K-205-8	0.401	0.356	0.136	0.137	9.25	10.36
IT 98K-128-2	0.280	0.281	0.132	0.134	9.58	8.61
Sed	0.024	0.072	0.005	0.004	1.032	1.023
LSD	0.052	0.123	NS	NS	NS	NS
Weeding Regime (WR)						
Zero-weeding	0.303	0.291	0.132	0.128	6.75	6.96
One-hand weeding	0.293	0.273	0.138	0.131	9.58	9.21
Two-hand weeding	0.425	0.393	0.136	0.143	11.92	12.29
Sed	0.028	0.088	0.007	0.005	1.264	1.253
LSD	0.064	0.195	NS	0.012	2.817	2.791
Interaction						
Var x WR	NS	NS	NS	NS	NS	NS

densities of leaf beetles, potato leafhoppers and *Empoasca fabae* were significantly greater in reduced tillage plots with fewer weeds compared with no-till plots. The difference corresponded to similar findings about *Empoasca* spp. (Akinyemiju & Olaifa, 1991; Buckelew et al., 2000). This study advocates the need for appropriate Pest Management, which is dynamic and environmental friendly, an approach entailing knowledge of the biology of weeds, the level of insects infestation, the effect of husbandry practices and the quantitative understanding of the dynamic of weed and insect population outflow in cowpea agro-ecosystem in the humid tropics.

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