International Scholars Journals

International Journal of Agricultural Sciences ISSN 2167-0447 Vol. 7 (2), pp. 1248-1257, February, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effects of variety and insecticide spray application on pest damage and yield of cowpea

[1]Ndiso J. B., [2]Chemining'wa G. N., [2]Olubayo F. M. and [1]Saha H. M.

[1]Department of Crop Sciences, Pwani University, P.O.Box 195 – 80108, Kilifi, Kenya, [2]Department of Plant Science and Crop Protection, University of Nairobi, P.O.Box 30197 00100 GPO, Nairobi, Kenya.

Received 05 October, 2016; Revised 28 January, 2017; Accepted 03 February, 2017 and Published 27 February, 2017

Experiment was conducted at Pwani University farm under irrigation to evaluate the effects of variety and insecticide spray application on pest damage and yield of cowpea. Randomized complete block design with a split plot arrangement was used and replicated thrice. Main plots were two pest management levels while the sub-plots included cowpea varieties. Data collected included: insect pest damage at pre-flowering, flowering, podding and maturity stages, number of pods per plant, number of grains per pod, 100-grain weight and grain yield. Data subjected to analysis of variance using the SAS statistical package. Insecticide application reduced pest damage at pre-flowering, flowering and podding by 23.5%, 20.6% and 52.3%, respectively. Pod borer damage was 49.9% lower in sprayed than unsprayed plots. Insecticide application significantly increased cowpea grain yield, with the increase ranging from 11.6% in Nyekundu to 662.5% in Macho. Varieties such as KVU 419, Macho, Kaima koko and Nyeupe had lower pod borer damage than K80, Mwandato and Nyekundu which had the highest damage under no insecticide spray. All cowpea varieties were similarly affected by insect pests, indicating that application of insecticide is necessary for sustainable cowpea production. Insecticide spray at podding stage is more critical than at pre-flowering and flowering stages.

Keywords: Cowpea, insecticide, pest, spray, varieties.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L)) Walp) is the most important grain legume in many parts of the world (Takim and Uddin, 2010) and its production is regarded as an integral part of the traditional cropping system throughout Africa (Isubikalu *et al.,* 2000). It is mostly grown as an intercrop with maize and is preferred by farmers because of its role in maintaining soil fertility through nitrogen-fixation (Asiwe *et al.,* 2009), and its nutritive value as fodder for livestock (Dzemo *et al*., 2010). The causes of low yields in cowpea production include insect pests, diseases, parasitic weeds, drought and low soil fertility; however, insect pests constitute the major constraint (Karungi *et al.,* 2000). The crop is attacked by a spectrum of pest species (Isubikalu *et al*., 2000). Cowpea production is therefore considered too risky an enterprise by many growers because of the numerous pest problems associated with it (Egho, 2010; Isubikalu *et al.,* 2000).

Over 130 species of insect pests have been recorded on cowpea and they attack virtually every part of the crop including the roots, leaves, flowers and pods (Singh and Jackai, 1995). Different insect pests specialize on

*Corresponding author E-mail: j.ndiso@pu.ac.ke

different parts of a cowpea plant and, in the worst cases, these pests overlap in their incidence and damage. It is not unusual to find four or more pests on the crop at the same time (Singh and Jackai, 1995). Insect pests which severely damage cowpea during all growth stages are the cowpea aphids (*Aphis craccivora* Koch), foliage beetles (*Ootheca sp, Medythia spp*), the flower bud thrips (*Megalurothrips sjostedti Trybom*), the legume pod borer (*Maruca vitrata Fabricius*) and the sucking bug complex, of which *Clavigralla spp, Anoplocnemis spp, Riptortus spp, Mirperus spp, Nezara viridula Fab and Aspavia armigera* L. are the most important and prevalent (Egho, 2010; Jackai and Adalla, 1997).

The most important pre-flowering pests are *Ootheca mutabilis* and *Zonocerus variegates* but the most damaging of all pests are those that occur during flowering and podding stages. They include flower thrips dominated by *Megalurothrips sjostedi*, the legume pod borer *Maruca vitrata; Clavigralla tomentosicollis* and a complex of pod sucking bugs. The legume pod borer, *Maruca vitrata,* is a tropical pest of legume crops, particularly cowpeas (Jackai, 1995). Without control measures, its infestation rate can reach 80% and cause seed damage rates of up to 50% (Dreyer *et al*., 1994). Pod borers are important pests of the reproductive structures of cowpea with early feeding leading to flower bud and flower abortions, hence poor pod set (Tamo *et al.,* 1997). Insect pests are considered to be largely responsible for up to 90 – 100 % yield reduction (Jackai and Daoust, 1986). In Africa, average cowpea yields vary dramatically from 0.05 to 0.55 t ha^{-1} (Cisse *et al*., 1995), due to insect pests which damage cowpea from seedling emergence to storage (Karungi *et al.,* 2000). Losses from insects are associated with 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).

The insect pests that reduce cowpea yield to zero are those that attack the flowering and the podding stages (Fisher *et al*., 1987). A cowpea grain yield loss of 45 – 52% was recorded in Northern Nigeria during flowering stages, followed by 21 – 26% loss during pod formation, 7 – 9% loss during the pre-flowering and 2 – 3% loss in the establishment stage (Raheja, 1976). According to Jackai *et al.,* (1985), it is not feasible to grow cowpea commercially without the use of insecticide sprays. In Kenya a report indicates grain yield losses of up to 80% in indigenous cowpea varieties as a result of pod borer attack (Okeyo-Owuor *et al*., 1983). Generally, peasant farmers growing cowpea in the region leave cowpea protection to chance or nature. The low yield obtained from such farmers' fields suggests that natural control by itself cannot afford enough protection to enhance profitable commercial production (Jackai and Sign, 1983). Dzemo *et al.,* (2010) reported that insect pest control insecticide sprays led to increased number of cowpea pods per plant, pod weight, number of seeds per pod, seed weight, and grain yield. The use of varieties that are resistant to attack by insect pests is one of the most promising alternative control measures. This strategy is economically and environmentally safe and can easily be integrated with other control measures (Alabi *et al.,* 2003). The objective of this study was to evaluate the effects of variety and insecticide spray application on pest damage and yield of cowpea.

MATERIALS AND METHODS

Study site

The study was carried out at Pwani University (PU) in coastal lowland (CL) Kenya. This site is located 60 km north of Mombasa between latitudes 3^{o} S and 4^{o} S and longitudes 39^{o} E and 40^{o} E. Mean monthly minimum and maximum temperatures are about 22^{0}C and 30^{0}C, respectively, and the mean relative humidity is 80% (Jaetzold *et al*., 2012). The area receives an average annual rainfall of 600–1100 mm that comes in two seasons (Sombroek *et al.,* 1982). The long rains are received in March/April through August while the short rains are received in October, November and December. The long rains season is the most important cropping season, with 75% of the annual rainfall usually received during this time (Saha, 2007). According to Sombroek *et al.,* (1982), the soils in CL Kenya are mostly ferralsols. These soils have low organic matter content, are deficient in essential plant nutrients (especially nitrogen), are prone to leaching, and have a pH range of 5 to 7 (Mureithi *et al*., 1995). The study was conducted in the dry season of 2011 and 2012 under drip irrigation.

Experimental design, treatments and crop husbandry

The experimental design was randomized complete block design, with a split-plot arrangement of treatments, replicated three times. Insecticide spray treatments were assigned to the main plots while the cowpea varieties were assigned to the sub-plots. This was done to avoid wind drift. The main plots had two treatments: no insecticide spray and insecticide spray. The insecticide used in spray treatment was *pestox ® 100 EC*. It was sprayed two weeks after planting then fortnightly up to podding stage. The 11 cowpea varieties tested comprised: (i). KVU 419 (improved variety from Kenya Agricultural and Livestock Research Organization (KALRO)-Katumani); (ii). Khaki (local variety); (iii). K 80 (improved variety for the region); (iv). Macho (local variety); (v). Kaima-koko (local variety); (vi). Nyeupe (local variety); (vii). KVU 27-1 (improved variety from KALRO Katumani); (viii). Nyekundu (local variety); (ix). M 66 (improved variety from KALRO Katumani); (x). Kutambaa (local variety); and (xi). Mwandato (local variety). A drip irrigation system was used to grow the experimental crops. The drip lines were 60 cm apart while the plots were 50 cm apart. Each replication had 11 plots and each plot had two drip lines. Inter-row spacing was 60 cm and within row spacing was 30 cm. Two seeds were planted in each hill. Weeds were controlled manually by hand weeding at two and four weeks after planting respectively. No organic or inorganic fertilizer was applied.

Data collection

Data collected included: insect pest damage at pre-flowering and flowering stages, damage by pod sucking bugs and pod borer, number of pods per plant, number of grains per pod, 100-grain weight and grain yield. Pest damage was scored at vegetative, flowering, podding and maturity stages. Insect pest damage at vegetative stage (two weeks before flowering) was scored by calculating the percent number of the damaged leaves in relation to the total number of leaves. Pod sucking bugs and pod borer damage were determined by sampling 10 plants and calculating % damaged pods. Damage at all the stages was scored according to Baidoo and Mochiah (2014) using a scale of 1 to 5; with 1 = less that 25% damage; 2 = >25% but < 50%; 3 = 50%, 4 = >50% < 75% and 5 = >75% damage. The number of pods per plant and number of grains per pod were determined from 10 plants per plot by counting at harvesting time. Weight of 100-grains was determined by weighing 100 grains of the harvested grains per plot. Grain yield was determined by harvesting mature plants from an area of 6.4 m^2 in the middle part of the drip lines leaving five hills on each end. Harvested grains were sundried, weighed and grain yield adjusted to 14% moisture content as recommended (Mahapatra *et al.,* 2013)

Data analysis

Collected data were analyzed by the general linear model (GLM) procedure for analysis of variance using SAS statistical package (SAS Institute, 1993). Where the F values were significant, means were compared using the least significant difference (LSD) test, at p = 0.05. Linear regression analyses between grain yield and the following parameters were performed: pest damage at pre-flowering, pest damage at flowering, number of pods per plant, pod borer damage, number of grains per pod, and 100-grain weight.

RESULTS

Effects of variety and insecticide spray application on pest damage at pre-flowering and flowering stages

The most common pests at pre-flowering stage were leafhoppers (*Empoasca dolichi*), bean fly (*Ophiomyia phaseoli*), aphids (*Aphis craccivora*), and foliage beetles (*Photinus pyralis*, *Epicauta vittata, Podabrus flavicollis, Osmoderma eremicola* and *Oedemera nobilis)*. At flowering stage the pests at pre-flowering stage were joined by the cowpea flower thrips *(Megalurothrips sjostedti*), green vegetable bud (*Nezara viridula*), Brown bean bug (*Riptortus serripes*) and the Legume pod borer (*Maruca testulalis Gayer*). Insecticide application significantly reduced pest damage at pre-flowering and flowering stages, while cowpea variety and interaction between cowpea variety and insecticide application had no significant effect (Table 1). Pest damage at pre-flowering and flowering stages in insecticide sprayed plots was significantly lower than in unsprayed plots by 23.5% and 20.6%, respectively. Pest damage was over 50% in all the varieties at both stages.

Effects of variety and insecticide spray application on pest damage at podding stage and pod borer damage

The most common pests at podding stage were green vegetable bug (*Nezara viridula*), brown bean bug (*Riptortus serripes*) and legume pod borer (*Maruca testulalis* Gayer). Insecticide application had significant effects on pest damage at podding while, variety and the interaction between variety and insecticide spray had no effect (Table 2). Pest damage at podding stage was significantly higher in unsprayed plots than in insecticide sprayed plots. Insecticide application reduced pest damage at podding stage by 52.3%. Pod borer damage was significantly affected by insecticide application and the interaction between cowpea variety and insecticide spray application (Table 2). Pod borer damage in unsprayed plots was significantly higher than in insecticide sprayed plots for all the varieties. In unsprayed plots, varieties such as K80, Mwandato and Nyekundu had higher pod borer damage than most of the

Table 1: Effects of variety and insecticide spray application on pest damage at pre-flowering and flowering stages.

Cowpea varieties (V)	PDS at pre-flowering stage			PDS at flowering stage		
	Pest management (PM)		V-means	Pest management (PM)		V-means
	NIP	IP		NIP	IP	
KVU 419	4.67	3.67	4.20	4.33	3.33	3.83
Khaki	4.67	3.50	4.10	3.67	3.33	3.50
K 80	4.83	3.50	4.20	4.67	3.67	4.17
Macho	4.67	3.67	4.20	4.67	3.67	4.17
Kaima-koko	4.83	3.67	4.30	4.33	3.67	4.00
Nyeupe	4.17	3.33	3.8	3.67	3.00	3.33
KVU 27 – 1	4.50	3.50	4.00	4.33	3.67	4.00
Nyekundu	4.67	3.33	4.00	4.33	3.67	4.00
M 66	4.50	3.67	4.10	4.00	3.33	3.67
Kutambaa	4.67	3.50	4.00	4.33	3.00	3.67
Mwandato	4.83	3.67	4.30	4.67	3.00	3.83
PM-mean	4.64	3.55		4.27	3.39	
p-value (V)	0.548			0.248		
p-value (PM)	0.0001			0.0001		
p-value (V x PM)	0.967			0.769		
$LSD_{0.05}$ V	Ns			Ns		
$LSD_{0.05}$ PM	0.18			0.28		
$LSD_{0.05}$ V x PM	Ns			Ns		
CV (%)	8.98			14.89		

PDS – Pest damage scores, NIP – No insecticide spray and IP – Insecticide spray.

other varieties. Majority of the varieties were not significantly different in pod borer damage in sprayed plots except that KVU 419 and Nyekundu had lower pod damage than K80. Insecticide application reduced pod borer damage by an average of 49.9%. Pod borer damage ranged from 37.5% in Macho and Kaima koko to 66.8% in Nyekundu. Varieties such as KVU 419, Macho, Kaima koko and Nyeupe had low pod borer damage scores under no insecticide spray treatment.

Effects of variety and insecticide spray application on number of cowpea pods per plant and grains per pod

Cowpea variety, insecticide application and interaction between cowpea variety and insecticide application had significant effects on the number of pods per plant (Table 3). The number of pods per plant was significantly higher in insecticide sprayed plots than in unsprayed plots for all the varieties tested. The increase in number of pods per plant due to insecticide application ranged from 6.6% in Mwandato to 135.5% in Macho. Under no insecticide spray, Nyekundu had the highest number of pods per plant while under insecticide application Macho had the highest number of pods per plant. Varieties such as Mwandato, K80, Kaima koko and Nyeupe did not respond significantly to insecticide spray application with respect to number of pods per plant. Cowpea variety and insecticide application had significant effects on the number of grains per pod (Table 3). The number of grains per pod under sprayed plots was significantly higher than the number of grains per pod under no spray plots. Cowpea varieties with the highest number of grains per pod under no spray plots were M66, K80 and Kutambaa. The varieties with the highest number of grains per pod in sprayed plots were KVU 419, Kaima koko, Khaki, M66 and Nyekundu. Insecticide application increased the number of grains per pod by an average of 102.1%, with a range of 75.0 % (Nyeupe and Kutambaa) to 208.3% (Mwandato).

Effects of variety and insecticide spray application on cowpea 100-grain weight and grain yield

There were significant effects on cowpea 100-grain weight due to cowpea variety, insecticide spray

Table 2: Effects of variety and insecticide spray application on pest damage at podding stage and pod borer damage scores.

Cowpea varieties (V)	PDS at podding stage			Pod borer damage scores		
	Pest management (PM)		V-means	Pest management (PM)		V-means
	NIP	IP		NIP	IP	
KVU 419	4.67	2.33	3.50	2.67	1.33	1.67
Khaki	5.00	2.33	3.70	3.33	1.67	2.00
K 80	4.67	2.33	3.50	4.33	2.33	1.83
Macho	5.00	2.33	3.70	2.67	1.67	2.17
Kaima-koko	5.00	2.67	3.80	2.67	1.67	2.17
Nyeupe	5.00	2.00	3.50	2.33	1.33	1.67
KVU 27 – 1	5.00	2.33	3.70	3.67	1.67	1.83
Nyekundu	4.67	2.33	3.50	4.00	1.33	1.67
M 66	5.00	2.33	3.70	3.33	1.67	2.00
Kutambaa	5.00	2.00	3.50	3.33	1.67	1.67
Mwandato	4.67	2.67	3.70	4.33	2.00	1.67
PM-mean	4.88	2.33		3.33	1.67	1.85
p-value (V)	0.87			0.31		
p-value (PM)	0.0001			0.0001		
p-value (V x PM)	0.48			0.003		
$LSD_{0.05}$ V	Ns			Ns		
$LSD_{0.05}$ PM	0.19			0.23		
$LSD_{0.05}$ V x PM	Ns			0.75		
CV (%)	10.58			24.47		

PDS – Pest damage scores, NIP – No insecticide spray and IP – Insecticide spray

application and their interaction (Table 4). The 100-grain weight in sprayed plots was significantly higher than in unsprayed plots. Cowpea varieties with the highest 100-grain weight in unsprayed plots were K80 and Kaima koko. The varieties with the highest 100-grain weight in sprayed plots were Nyeupe and KVU 27-1. Insecticide application increased weight of 100 grains by an average of 41.43%, with a range of range of 2.83% (K80) to 125.76% (Kutambaa).

Cowpea variety, insecticide spray application and their interaction significantly affected cowpea grain yield (Table 4). Insecticide application significantly increased grain yield of all the varieties except for Nyekundu where there was no effect. Insecticide application increased grain yield by an average of 119.1%, with a range of 11.6% (Nyekundu) to 662.5% (Macho). Variety KVU 419 had the highest grain yield under no spray treatment followed by Nyekundu, while Macho and Kaima koko had the lowest yield under the same treatment. In sprayed plots, Macho, KVU 419 and Nyeupe had the highest grain yield while K80, Kutambaa, Khaki and Nyekundu had the lowest. Grain yield varied from 0.16 t ha^{-1} (Macho) to 0.88 t ha^{-1} (KVU 419) in unsprayed plots and from 0.64 t ha^{-1} (K80) to 1.22 t ha^{-1} (Macho) in insecticide sprayed plots.

DISCUSSION

Effects of variety and insecticide spray application on pest damage of cowpea at pre-flowering, flowering and podding stages

The major pests at pre-flowering stage included leafhoppers, bean fly, aphids and foliage beetles. The presence of many insect pest species at pre-flowering stage is a feature of cowpea (Karungi *et al.*, 2000). In the current study, all the varieties tested had more than 50% pest damage. According to Asante *et al*., (2001), losses in foliage attributed to field pests of cowpea ranged from 20% to almost 100%. Insecticide application reduced pest damage at pre-flowering stage by 23.5%. This finding is in agreement with previous reports by Egho (2010) and Isubikalu *et al.,* (2000) who indicated that spraying with an insecticide significantly reduced cowpea pest damage at pre-flowering stage. That there were no differences in pre-flowering pest damage among the varieties suggests that none of the 11 varieties tested was resistant to the pre-flowering pests. Insecticide spray application is therefore an important strategy for reducing pre-flowering insect pests in coastal lowland Kenya. At

Table 3: Effects of variety and insecticide spray application on the number of cowpea pods per plant and grains per pod.

Cowpea varieties (V)	Number of pods per plant			Number of grains per pod		
	Pest management (PM)		V-means	Pest management (PM)		V-means
	NIP	IP		NIP	IP	
KVU 419	4.33	9.00	7.50	7.33	16.00	11.67
Khaki	4.33	7.33	8.50	7.00	15.33	11.17
K 80	6.00	8.00	8.00	8.00	14.67	11.33
Macho	4.67	11.00	7.83	7.00	14.33	10.67
Kaima-koko	6.33	8.00	8.00	7.00	15.67	11.33
Nyeupe	4.00	6.00	6.00	6.67	11.67	9.17
KVU 27 – 1	5.00	8.00	6.50	7.67	14.00	10.83
Nyekundu	8.33	10.67	10.50	7.33	15.00	11.17
M 66	5.33	10.33	8.17	8.33	15.33	11.83
Kutambaa	3.33	5.67	5.67	8.00	14.00	11.00
Mwandato	5.00	5.33	5.33	4.00	12.33	8.17
PM-mean	5.15	8.12	7.50	7.12	14.4	10.76
p-value (V)	0.0001			0.0001		
p-value (PM)	0.0001			0.0001		
p-value (V x PM)	0.0001			0.074		
$LSD_{0.05}$ V	1.45			1.25		
$LSD_{0.05}$ PM	0.62			0.53		
$LSD_{0.05}$ V x PM	2.05			Ns		
CV (%)	16.09			9.92		

PDS – Pest damage scores, NIP – No insecticide spray and IP – Insecticide spray.

flowering stage the major pests were cowpea flower thrips (*Megalurothrips sjostedti*), which joined forces with the pests that were already causing insect damage from the pre-flowering stage. Jackai and Daoust, (1986) reported that the yield of cowpea is low in tropical Africa due to major post flowering pests such as flower bud thrips, *Megalurothrips sjostedti Tryb*. In the current study, insecticide application significantly reduced cowpea pest damage at flowering by 20.6%. Oparaeke *et al.,* (2005) reported that complete crop failure may occur where insecticide protection is not introduced especially for improved, high yielding varieties. All the cowpea varieties tested had more than 50% pest damage and none of them showed resistance to insect damage at flowering. Control of these pests using insecticides or other methods is therefore crucial for sustainable cowpea production.

The major pests at podding stage were the legume pod borer (*Maruca testulalis*) and the pod sucking bugs, particularly the green vegetable bug (*Nezara viridula*), large brown bean bug (*Riptortus serripes*), and small brown bean bug (*Melanacanthus scutellaris*). Karungi *et al.* (2000) and Amatobi (1995) have shown that pod borers and pod sucking bugs are the most important pests of cowpeas. The legume pod borer (*Maruca testulalis)* is the most important lepidopterist cowpea pest and causes severe damage (Singh and Allen, 1980). Insecticide application significantly reduced insect damage at podding by 49.9%, with decreases in damage ranging from 37.5% in Macho and Kaima koko to 66.8% in Nyekundu. Under insecticide spray the insect damage ranged between >25% and <50% for all the varieties. The reduction in pest damage due to insecticide spray was higher at podding stage than at pre-flowering and flowering stages. The finding of the current study indicates that insecticide spray at podding stage is more critical than at pre-flowering and flowering stages. This finding is in agreement with the findings of Egho and Enujeke (2012) who reported significant reduction in pod borer damage in Nigeria when cowpea plants were treated with dimethoate pesticide. In Kenya a report indicates losses of up to 80% occur on indigenous cowpea varieties as a result of pod borer attack (Okeyo-Owuor *et al*., 1983). The observations in the current study imply that application of pesticide is necessary for sustainable cowpea production in the region. There were

Table 4: Effects of variety and insecticide application on 100-grain weight and grain yield of cowpea.

Cowpea varieties (V)	100-grain weight (g)			Grain yield (t/ha)		
	Pest management (PM)		V-means	Pest management (PM)		V-means
	NIP	IP		NIP	IP	
KVU 419	8.87	13.60	12.82	0.88	1.18	1.04
Khaki	9.50	13.60	13.72	0.51	0.71	0.69
K 80	15.07	15.50	14.27	0.44	0.64	1.10
Macho	8.53	16.40	15.80	0.16	1.22	0.70
Kaima-koko	13.50	14.33	14.58	0.18	0.92	0.91
Nyeupe	11.83	19.30	15.60	0.33	1.16	0.74
KVU 27 – 1	12.33	18.00	15.17	0.33	0.74	0.62
Nyekundu	10.40	12.90	14.12	0.69	0.77	0.89
M 66	9.30	14.60	11.95	0.34	1.05	0.67
Kutambaa	6.60	14.90	10.17	0.30	0.68	0.45
Mwandato	12.03	13.70	12.87	0.48	1.05	0.74
PM-mean	10.72	15.17	13.73	0.42	0.92	0.78
p-value (V)	0.0001			0.0001		
p-value (PM)	0.0001			0.0001		
p-value (V x PM)	0.0001			0.0001		
$LSD_{0.05}$ V	1.12			0.08		
$LSD_{0.05}$ PM	0.48			0.04		
$LSD_{0.05}$ V x PM	1.59			0.12		
CV (%)	7.17			9.28		

PDS – Pest damage scores, NIP – No insecticide spray and IP – Insecticide spray.

no varietal differences in pod borer damage for all cowpea varieties evaluated. In contrast, Veerappa (1998) reported significant differences in pod borer damage among 45 cowpea varieties. The author noted that tolerant genotypes had higher phenol and tannin content than the susceptible ones. Phenol compounds are mainly concentrated in the seed coat (Preet and Punia, 2000). Based on seed coat color, the white varieties in the current study were expected to be more susceptible to pod borer damage than the black, red, and light brown varieties which are associated with high phenol and tannin contents (Morrison *et al*., 1995). This implies that phenol and tannin contents in the pods of the 11 varieties may not have been significantly different. There is need to breed for resistance to cowpea pod borer by introgressing genes from resistant cowpea germplasm into existing high yielding, farmer preferred cowpea varieties.

Effects of variety and insecticide spray application on number of pods per plant, grains per pod, 100-grain weight and grain yield of cowpea

Insecticide application significantly increased the average number of pods per plant, grains per pod, 100-grain weight and grain yield of cowpea by 57.7%, 102.1%, 41.43% and 119.1%, respectively. These findings are in agreement with Dzemo *et al*., (2010) who indicated that application of insecticides once at flower budding, early podding and pod filling significantly reduced pod and seed damage, resulting in substantial increase in the number of pods per plant, seeds per pods, seed weight and grain yield. According to Ahmed *et al.,* (2014), insecticide sprays adequately protected cowpea pods from damage by the insect pests, thereby significantly increasing grain yield. The response of grain yield and yield components to insecticide applicaction varied with variety. The percent increase due to spray application ranged from 6.6% (Mwandato) to 135% (Macho) in number of pods per plant, 2.83% (K80) to 125.76% (Kutambaa) in 100-grain weight and 11.6% (Nyekundu) to 662.5% (Macho) in grain yield. This suggests that some varieties were either less affected by pests than others or less responsive to insecticide application. The varieties that showed modest response to insecticide application were Nyekundu (11.6%), KVU 419 (34.1%), Khaki (39.2%) and K80 (45.5%) whereas those that exhibited huge responses were Macho (662.5%), Kaima koko (411.1%), Nyeupe (251.5%) and M66 (208.8%).

The cowpea varieties which were highly responsive to insecticide application could be used to stabilize cowpea grain yield in the coastal region of Kenya.
Linear regression relationship between grain yield and pod borer damage was negative while that between grain yield and pest damage (at both pre-flowering and flowering stages) highly positive. The positive linear regression relationship between grain yield and pest damage at pre-flowering and flowering stages observed in this study is in agreement with the findings of Rahman *et al*., (2008) who reported impressive crop grain yields due to 50% defoliation intensity imposed at the flowering stage. This could be attributed to the fact that pest damage at pre-flowering may stimulate compensatory growth in cowpea (Jackai *et al.,* 2001). Many studies on crop growth have concluded that the impact of defoliation on crop yield depends on the extent of insect pest damage (Ibrahim *et al*., 2010). Pest control in cowpea at pre-flowering and flowering stages may not be very critical due to the compensatory growth. Abudulai and Shepard (2001) reported that early pod-fill is the most susceptible stage to damage by pod-sucking bugs in cowpea. The results of these studies suggest that if insecticides must be applied, it would be most effective when it is done at early pod-fill stage. The increase in yield components such as the number of pods per plant, number of grains per pod and 100-grain weight as a result of insecticide spray application contributed to increased grain yield. This is supported by the positive linear regression relationship between these yield components and grain yield. Ceyhan and Aliavci (2005) made a similar observation.

CONCLUSION

Insecticide application significantly reduced insect pest damage at pre-flowering, flowering and podding stages resulting in increase in cowpea growth parameters, yield and yield components. All the cowpea varieties evaluated were similarly affected by insect pests. For successful production of cowpea in the region, application of insecticides is necessary. The cowpea varieties which were highly responsive to insecticide application namely Macho, Kaima koko, Nyeupe and M66 could be used to stabilize cowpea grain yield in coastal lowland Kenya.

REFERENCES

Abudulai, M. and Shepard, B.M. 2001**.** Timing insecticide sprays for control of pod-sucking bugs (Pentatomidae, Coreidae, and Alydidae) in cowpea, (Vigna unguiculata [L.] Walpers). J Agric and Urban Entomology 18: 51–60.

Ahmed, A., Sambo, B. E., Arunah, U. L. and Odion, E. C. 2014. Response of farmyard manure and inorganic Fertilizers for sustainable growth of carrot (Daucus carota L.) in Northern Nigeria. J Agric and Veterinary Sci 7 (2): 18-25

Alabi, O.Y., Odebiyi, J.A., and Jackai, L.A.N., 2003. Field evaluation of cowpeas cultivars (*Vigna unguiculata* (L.) Walp) for resistance of flower bud thrips (*Megalrothrips sjostedti* Tyborn) Thysanoptera: Thripidae. Intern J Pest Manage 49 (4): 287 – 291.

Amatobi, C. I. 1994. Field evaluation of some insecticides for the control of insect pests of cowpea (Vigna unguiculata (L) Walp.) in the Sudano savannah of Nigeria. Intern J Pest Manage 40 (1): 13 – 17.

Asante, S.K., Tamo, M. and Jackai, L.E.N. 2001. Integrated management of cowpea insect pests using elite cultivars, date of planting and minimum insecticide application. Afric Crop Sci J. 9 (4): 655 – 665.

Asiwe, J.A.N. 2009. The impact of phosphate fertilizer as a pest management tactic in four cowpea varieties. Afric J Biotechnol *8: 1684 - 5315*

Baidoo, P.K and Mochiah, M.B. 2014. Varietal Susceptibility of Improved Cowpea *Vigna unguiculata* (L.) (Walp.) cultivars to field and storage pests. Sustainable Agriculture Research 3 (2): 69 – 76.

Ceyhan, E. and Aliavci, M. 2005. Combining ability and heterosis for grain yield and some yield components in peas (Pisum sativum L.). Pak J Biol Sci 8 (10): 1447 – 1452.

Cisse N, Ndiaye M, Thiaw S, Hall A.E 1995. Registration of “Mouride” cowpea. *Crop Science* 35: 1215 – 1216.

Dreyer, H., Baumgartner, J. and Tamo, M. 1994. Seed damaging field pests of cowpea (*Vigna unguiculata* (L) Walp) in Benin: Occurance and pest status. Intern J Pest Manage 40: 252 – 260.

Dzemo, W.D., Niba, A. S. and Asiwe, J.A.N. 2010. Effects of insecticide spray application on insect pest infestation and yield of cowpea (*Vigna unguiculata* (L.) Walp.) in the Transkei, South Africa. Afric J Biotechnol 9 (11): 1673 – 1679.

Egho, E. O. Enujeke, E. C. 2012. Effect of Native Soap on Insect Pests and Grain Yield of Cowpea (Vigna unguiculata (L) Walp) in Asaba and Abraka during the Late Cropping Season in Delta State, Nigeria. Sustainable Agriculture Research, 1 (2): 87 – 95.

Egho, E.O. 2010. Management of major field insect pests and yield of cowpea (Vigna unguiculata (L) Walp) under calendar and monitored application of synthetic chemicals in Asaba, Southern Nigeria. Afric J General Agric 6 (3): 177 – 186.

Fisher, N.M., Raheja, A.K. and Elemo, K.A. 1987. Insect pests control for cowpeas in crop mixtures.

Experimental Agriculture 2: 7–20

Ibrahim, U., Auwalu B. M and Udom G. N. 2010. Effect of stage and intensity of defoliation on the performance of vegetable cowpea (*Vigna unguiculata* (L.) Walp). Afric J Agric Res 5 (18): 2446-2451

Isubikalu, P., Erbaugh, J.M, Semana, and A.R, Adipala, E. 2000. The influence of farmer's perception on pesticide usage for management of cowpea field pests in Eastern Uganda. Afric Crop Sci J 8 (3): 317 – 325.

Jackai, L.E.N and Adalla C.B. 1997. Pest management practices in cowpea: A review In: Singh B. B, Mohan Raj D. R, Danshiel K. E and Jackai L. E. N (eds.) Advances in cowpea Research. International Institute of Tropical Agriculture (IITA) and Japan International Research Centre for Agricultural Sciences (JIRCAS), IITA, Ibadan, Nigeria.

Jackai, L.E.N, and Signh, S.R. 1983. Varietal resistance in the integrated pest management of cowpea pests. *Insect Science and Application* 4: 199 – 204.

Jackai, L.E.N. 1995. Integrated pest management of borers of cowpea and beans. Insect Science and Its Application 16: 237 – 250.

Jackai, L.E.N. and Daoust, R.A. 1986. Insect pests of cowpeas. Annual Review of Entomology 31: 96 – 119.

Jackai, L.E.N. Goudou, C., Asiwe, J.A.N. and Tayo, B.O. 2001. Integrated control of the cowpea aphid using seed dressing and varietal resistance. Samaru J Agric Res 17: 13 – 23.

Jackai, L.E.N., Singh, S.R., Raheja, A.K. and Wiedijk, K. 1985. Recent trends in the control of cowpea pests in Africa. In: Cowpea Research, Production and Utilization. Singh, S.R. and Rachie, K.O. (Eds.), 233 – 243. Chickester, John Wiley and Sons, U.K.

Jackai, L.EN., Singh, S.R., Raheja, A.K. and Wiedijk, K. 1985. Recent trends in the control of cowpea pests in Africa. In Cowpea research, production and utilization. Singh, S.R. and Rachie, K.O (Eds), 233 – 243. Chickester, John Willey and Sons. UK.

Jaetzold, R., Schmidt, H., Hornetz, B and Shisanya, C. 2012. Farm Management handbook of Kenya. Vol. II/ Part C, Sub-Part C2, Coast Province. Ministry of Agriculture, Kenya, in corporation with the German Agency of International Cooperation (GIZ).

Karungi, I., Adipala, E., Ogenga-Latigo, M.W., Kyamanywa, S and Oyobo, N. 2000. Pest management in cowpea. Part 1. Influence of planting time and planting density on cowpea field pests infestation in eastern Uganda. *Crop Protection* 19: 231–236.

Mahapatra A.K., Melton S.L., and Isang E.M. 2013. Effect of moisture content on thermal properties of cowpea flours. Agricultural Engineering international: Center for Interdisciplinary Geriatric Research (CIGR) Journal. 15(2): 251.

Morrison, I. M., Asiedu, L. A., Stuchburg, T. and Powel, A. A. 1995. Determination of lignin and tannin contents of cowpea seed coats. *Annals of Botany* 76: 287 - 290

Mureithi, J.G., Tayler, R.S. and Thorpe, W. 1995. Productivity of alley farming with leucaena (*Leucaena leucocephala* Lam. de Wit) and Napier grass (*Pennisetum purpureum* K. Schum) in coastal lowland Kenya. *Agroforestry Systems* 31: 59 - 78.

Okeyo-Owuor, J.B., Agwardo, P.O., Simbi, C.O.J. 1983. Studies on the legume pod-borer, *Maruca testulalis* (Geyer)-V. Larval population. *Insect Science and its Application* 4: 75 - 81.

Oparaeke, A.M., Dike, M.C. and Amatobi, C.I. 2005. Field evaluation of extracts of five Nigerian spices for control of post-flowering insect pests of cowpea, Vigna unguiculata (L) Walp. Plant Protection Science 41: 14 – 20.

Preet, k. and Prunia, D. 2000. Proximate composition, phytic acid, polyphenols and digestibility (*in vitro*) of four brown cowpea varieties. *International Journal of Food Science and Nutrition* 50: 189 - 193.

Rahman, S.A., Ibrahim, U. and Ajayi, F.A. 2008. Effects of defoliation at different growth stages on yield and profitability of cowpea (Vigna unguiculata (L) Walp). Electronic J Environ Agric and Food Chem 7 (9): 3248 – 3254.

Raheja, A.K. 1976. Assessment of losses caused by insect pests of cowpea in Northern Nigeria. *Pesticide Action Network*. 22: 299 – 333.

Saha, H.M. 2007. Improving Resource use Under Maize – Green legume systems in coastal lowland Kenya. Ph.D Thesis, Jomo Kenyatta University of Agriculture and Technology.

SAS Institute 1993. SAS/STAT users' guide. Release 6.08. Ed. SAS Cary. NC.

Schoonheven, L.M., Jermy, T., and van Loon J.J. 1998. Insect-plant biology: from physiology to evolution. Chapman and Hall: New York, pp 409.

Singh, S.R. and Allen, D.J. 1980. Pest, diseases, resistance and protection in cowpea. In: Biology and Breeding for Resistance of Arthropod and Pathogens in Agricultural Plants, Ed. M. K. Harris. College Station, Texas. Texas Agricultural and Mechanical University Bulletin MP 1451, pp 605.

Singh, S.R. and Jackai, L.E.N. 1985. Insect pests of cowpea in African: their life cycle, economic importance and potential for control. In Cowpea Research, Production and Utilization. Singh, S. R. and K. O. Rachie (Eds); John Wiley and sons limited: Chi Chester. African Crop Science Conference Proceeding 3: 1421 – 1430.

Sombroek, W.G., Braun, H.M.H. and van der Pouw, B.J. 1982. Exploratory Soil Survey Report No. E1, Kenya Soil Survey, Nairobi.

Takim F.O and Uddin R.O. 2010. Effect of weed removal on insect populations and yield of cowpea (Vigna unguiculata (L.) Walp). Aust J Agric Eng 1 (15): 194 – 199.

Takim, F.O. 2012. Advantages of maize-cowpea intercropping over sole cropping through competition indices. J Agric and Biodiver Res 1(4): 53-59

Tamo, M., Bottenberg, H., Arodekoum, D. and Adeoti, R. 1997. The feasibility of classic biological control of two major cowpea insects. In. Singh, B.B., Mohan Ray D.R., Dashiell, K.E. and Jackai, L.E.N (Eds). Advances in cowpea Research.Co publication of International Institute of Agricultural and Japan International Center for Agricultural Sciences. Nigeria pp 259 – 270.

Veerappa, R.1998. Phenol and tannin reduce the damage of cowpea pod borer Maruca testulalis. *Insect environment* 4: 5-6.