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Original Research Article

Rate of insecticide formulations on the damage assessment, yield and yield components of cowpea

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A B S T R A C T

Field trials were conducted in two locations (IAR Research Farm Samaru, Zaria, Kaduna State (Lat.11^{o} 11'N and 7^{o} 38'N) and Wase, in Minjibir local government of Kano State (Lat. 12 10^{0} 60.00^{11} and 8 40^{0} 0.00^{11} E), under rainfed conditions in the northern Guinea Savannah and Sudan Savannah of Nigeria. Each plot consisted of seven ridges (five main ridges and two discard ridges, one on either side of the main ridges) and spaced at 0.75 m apart. Each plot size was 26.25 m^2 (gross) and separated by a 1.5 m wide border margin on all sides. Four insecticide formulations: Chlorpyrifos 480 E. C. (Chlorpyrifos 480 g/L E.C), Chlorpyrifos plus (Chlorpyrifos 475 g/L+ Cypermethrin 47.5 g/L), Dimethoate 400 E. C. (Dimethoate 400g/L) Imidacloprid 70WG (Imidacloprid 70 WG.), (each applied at 1.5, 1.0 and 0.5 litre per hectare and 0.5, 1.0 and 1.5 kg/ ha for Imidacloprid), standard check (Cyperdicot) at 1.0 l/ha and an untreated control. All the treatments were replicated three times. The treatments were arranged in a randomized complete block design (RCBD).The damage was assessed by counting the number of aborted flowers/plot, seed damage indices (Sdi) was determined by sorting the seed lot from each plot into 3 categories. Pods harvested from each plot were placed in separate polythene bags, labeled and taken to the laboratory where the pod and seed weights were taken using an electric balance. Grain yield was recorded from threshed grains harvested from each plot. All data were analyzed using Analysis of Variance (ANOVA) with SAS package and treatment means separated by Duncan Multiple Range test at 5 % level of significance. The results showed that all the four insecticides effectively reduced the infestation of insect pests and increase yield compared to untreated control.

Keywords

Applications;
Cowpea;
Formulations,
Grain yield;
Insecticides;
Chlorpyrifos.

Introduction

Cowpea (*Vigna unguiculata* (L) Walp) is a tropical, annual herbaceous legume, which belongs to the family Papilionaceae (Fabaceae), order Leguminosae and genus

*Vigna (*Cobley, 1956; Martin and Leonard, 1956; Singh *et al*, 1997). The genus *Vigna* consists of over one hundred different species widely found in the tropical and subtropical regions, and has great morphological and ecological diversity (Ng and Monti, 1990; Paino D'urzo *et al*, 1990). The common names of this crop include black- eye bean, southern pea, bean, cowpea, china pea and cow grain. In Nigeria, it is commonly referred to as beans, "ewa" (Yoruba), "wake" (Hausa) and "akedi" (Igbo) (Singh and Ajeigbe, 1998), "nyebbe" (Fulani), "ezor" (Ebira), "ezo" (Nupe), "evor" (Gwari), "enje"(Idoma), "jok"(Baju) and "ijik"(Ikulu) (Oyewale,2013). Faris (1965) postulated that, based on the presence of wild progenitors of cowpea in West and Central Africa, the region was the centre of domestication of cowpea. This view was corroborated by Rawal (1975) who also reported that cowpea originated from sub-humid and semi-arid regions of West Africa. This view was also shared and supported by Steele (1965). However, some studies on the genetic exploration of cowpea in Africa suggested that Swaziland may be the primary centre of origin of wild progenitors, because this country has higher species diversity throughout the world (Ng and Monti, 1990; Mongo, 1996). Regardless of its centre of origin, cowpea is extensively cultivated in Africa, Asia, Australia, Brazil, the Caribbean's, India and the United States of America (U.S.A). The major areas of production in Central and West Africa, which account for about 89 % of the total area of world production, are Nigeria, Niger, Mali, Burkina Faso, Senegal, Cameroon and Democratic Republic of Congo, (FAO, 2008). Modest amounts also emanate from Mozambique, Tanzania, Uganda, Sudan, Kenya and Somalia. Other producers are Myanmar, Haiti, Serbia, Sri Lanka and Egypt (FAO, 2008). The main producing areas in Nigeria are within the Guinea and Sudan savannas (Mongo, 1996). However, some appreciable quantities are grown in the rain forest belts, particularly in the South West, which has two (2) growing seasons, namely; early (March – July) and late (August – November) (Ebong, 1965). In general, plant insect pests, diseases and weeds impose a serious threat to crop production in Nigeria. Population of weeds, insect pests and diseases have increased over the years especially by the introduction of monoculture farming in the country (Emosairue and Ubana, 1998).

Traditionally, Nigerian farmers have been relying heavily on pesticides for the control of various weeds, insect pests and diseases, leading to the high importation of these products and their price have become so high that it is becoming impossible for local farmers to afford (Nwanze, 1991; Schwab *et al.*, 1995; Van den Berg and Nur, 1998; Okrikata and Anaso, 2008). The introduction of synthetic pyrethroids to the Agricultural market is a welcome addition to a wide range of pesticides already in use on different crops in Nigeria (Dina, 1979). The advantages have been enumerated by Elliot (1976) and thought the synthetic pyrethroids are generally safe a reduction in the number of applications would not only increase the profit margin accruing to the farmer but would also be in consonance with pest management practices (Dina, 1982). Chemical methods are the only ones employed at present on a large scale for the control of insect pests of cowpea in Nigeria, particularly those infesting the flowers and pods.

The aim of this research work was to assess the influence of different rates of four insecticide formulations on the damage assessment, yield and yield components of cowpea.

Materials and Methods

Study Area

Field trials were conducted in two location: IAR Research Farm Samaru, Zaria (Lat.11 11^0N and 7 38^0N) and Wase (Lat. 12 10^0 60.00^{11} and 8 40^0 0.00^{11} E) in Minjibir local government of Kano state) under rain fed conditions in the Guinea Savannah and northern sudan of Nigeria, respectively, with mean annual rainfall between 150 to 350 mm and temperatures range from 25 – 32 ^{0}C in the dry harmattan and harvest period (November - December).

Site Preparation and Experimental Layout

An area measuring 1,671.9 m^2 each was marked out for the experiment with three replications (blocks) and each replication consisted of 14 plots each measuring 5.25 m x 5 m. Each block was separated from the next by a distance of 1.5 m. Each plot consisted of seven ridges (five main ridges and two discard ridges, one on either side of the main ridges) and spaced at 0.75 m apart. Each plot size was 26.25 m^2 (gross) and separated by a 1.5 m wide border margin on all sides. Four insecticide formulations: Chlorpyrifos 480 g/L E.C, Chlorpyrifos 475 g/L + Cypermethrin 47.5 g/L, Dimethoate 400 g/L, Imidacloprid 70 WG, standard check (Cypermethrin +Dimethoate) and untreated control. Each was applied at 1.5, 1.0 and 0.5 litre per hectare as follows: (Chlorpyrifos; 720 g a.i./ha, (480 g a.i./ha, and 240 g a.i./ha Chlorpyrifos plus; 712.5 g a.i. + 71.25 g a.i./ha, 475 g a.i. + 47.5 g a.i. /ha, and 237.5 g a.i. + 23.75 g a.i. /ha; Imidacloprid; 105 g a.i./ha, 70 g a.i. /ha and 35 g a.i. /ha; Dimethoate; 600 g a.i/ ha, 400 g a.i./ha, and 200 g a.i./ha, standard check (Cyperdicot ; 250+ 30 g a.i. /ha) and an untreated control were also used. All the treatments were replicated three times. The treatments were arranged in a randomized complete block design (RCBD).

Cowpea Variety and Sowing

Cowpea variety, SAMPEA 6 seeds were dressed with Apron Star (Metalaxyl + Thiomethoxam) (1 sachet 10g /2 kg seed) and was sown three seeds per hole at 0.2 m apart intra row in the second week of August in both locations. Seedlings were thinned to two plants per stand two weeks after sowing (WAS). Compound fertilizer (NPK 15:15:15) was applied as side dressing at the rate of 37.5 kg a. i. / ha two WAS. Fungicide, Mancozeb extra 80wp (Mancozeb 650g/kg + Carbendazim 150 g/kg wp) was applied at the rate of 1.5 kg/ha before flowering.

Insecticide Treatment

Field applications of insecticides at varying levels (dosages); 0.5, 1.0, and 1.5 lha^{-1} using a 20 litre CP3 Knapsack sprayer commenced at 8 WAS which coincided with the period of onset of flowers in this cowpea variety. Foliar spraying started from 9.00 a.m. each day after insects sampling. All the insecticides were sprayed once every week for three weeks.

Damage Assessment.

The damage was assessed based on the following:

- Number of aborted flowers/plant by

counting the number of flowers that drop on the ground from five stands selected randomly at 10 WAS.

Pod damage assessment involves counting the number of damaged pods per plant and divided by the total number of pods produced per plant in a random sample of 10 plants per plot. These were expressed in percentages according to the method used by Oparaeke, 2005.

Seed damage indices (Sdi), was determined by sorting the seed lot from each plot into 3 categories as described by Gilman *et al.*, (1982). Category A consisted of seeds with no feeding damage; category B, seeds with obvious feeding punctures but with mild wrinkles and category C, seeds with holes and/or seeds that are severely wrinkled and shrunken to small sizes. The proportion of each category from each treatment subplot were counted, weighed and expressed as percentage of the total weight of seeds assessed. To compute the Sdi, weights was used as illustrated below: Sdi = 0.5 (% seed weight in category B) + (% seed weight in category C).

Percentage seed weight in each category = 100 (seed weight in that category) ÷ total seed weight per plot

Yield Assessment

Harvesting of cowpea dried pods commenced when more than 50 % of the pods dried. Subsequent harvesting was also carried out to ensure that the cowpea was fully harvested. Pods harvested from each plot were placed in separate polythene bag, labelled and taken to the laboratory where the pod and seed weights were taken using an electric balance. Grain yield was recorded from threshed grains harvested from each plot. The pods and seed weights were calculated using the following formula (Aliyu *et al.*, 2011).

$$\text{Seed/pod weight (kg/ha)} = \frac{a \times 10{,}000}{b \times 1000}$$

where a = plot yield in grams (g),
b = Net plot size.

Pod density (a measure of efficacy of insecticide against thrips and borer larvae infestation on flowers) were assessed at 11 WAS by counting pods produced from a random sample of 10 plants per plot.

Data Analysis

All data were analyzed using Analysis of Variance (ANOVA) with SAS package (SAS, 2003) and treatment means separated by Duncan Multiple Range Test (DMRT) at 5% level of significant (SAS Institute, 2003).

Results and Discussion

Effect of insecticide rates on pods production and damage at Samaru and Wase

Table 1.0 showed no significant difference among the insecticidal treatments and also between the insecticidal treatments and untreated control for number of pod produced in Samaru. Although plots treated with Chlorpyrifos at 240 g a.i./ha had highest number of pods produced but no significant difference ($p<0.05$) only existed between it and Dimethoate at 400 g a.i./ha in Samaru. In Wase, there was significant difference ($p<0.05$) in pod produced between plots treated with Chlorpyrifos at 240 and 720 g a.i./ha, Imidacloprid (105 g a.i./ha), on one hand

and Chlorpyrifos plus at 475+47.5 g a.i /ha,on the other. On pods damage, Table 1.0 showed significant difference ($p< 0.05$) among the insecticide treatments and between insecticide treatments and untreated control. Plots treated with Chlorpyrifos at 240 g a.i./ha, 720 g a.i./ha, Cyperdicot (standard) at 250+30 g a.i./ha showed significant difference ($p< 0.05$) from other insecticide treatments except for Chlorprifos plus at 237.5+23.75 and 712+71.2 g a.i./ha, Dimethoate (200 and600 g a.i./ha and Imidacloprid at 105 g a.i./ha in Samaru. Also in Wase, there were significant difference ($p<0.05$) among the insecticidal treatments and between insecticidal treatments and untreated control.

Plots treated with Chlorpyrifos at 240 g a. i./ha showed significant difference ($p<0.05$) from plots treated with Imidacloprid at 70 g a.i./ha, Dimethoate at 600 g a.i./ha, Chlorpyrifos plus (475+47.5 and 712+71.2 g a.i./ha) and Chlorpyrifos at 480 and 720 g a.i./ha but not significantly different from plots treated with Cyperdicot (250+30 g a.i./ha), Imidacloprid (35 and 105 g a.i./ha), Dimethoate at 200 and 400 g a.i./ha. Percentage pod damage was higher ($p<0.05$) in plot treated with Chlorpyrifos at 480 g a.i. /ha than at 240 and 720 g a.i. /ha, Chlorpyrifos plus at 475+47.5than at 237.5+23.75 and 712+71.2 g a. i. /ha, lower percentage pod damage ($p<0.05$) was recorded in Dimethoate at 200 g a. i. /ha than at 400 and 600 g a. i. /ha as well as in Imidacloprid at 105 g a. i. /ha than at 35 and 70 g a. i. /ha in Samaru. Similarly in Wase plot treated with Chlorpyrifos at 240 g a. i. /ha had lower ($p<0.05$) pod damage than at 480 and 720 g a. i. /ha. Chlorpyrifos plus at 237.5+ 23.75 was lower ($p<0.05$) than at 475+47.5 and 712+ 71.2 hg a.i. /ha.

Effect of insecticide rates on seed damage index of cowpea at Samaru and Wase

Table 2.0 indicated that Category A showed no significant difference among the insecticide treatments and between the insecticide treatments and untreated controls, although plots treated with Imidacloprid at 35 g a.i./ha had the highest undamaged seeds (2.37). In category B, there was significant difference ($p< 0.05$) between the insecticide treatments and untreated control except for plots treated with Chlorpyrifos plus at 237.5+ 23.75 and 712+71.2g a.i./ha, Imidacloprid at 35 g a.i./ha and 70 g a.i./ha. In category C, there were no significant difference among the insecticide treatments but there was significant difference ($p<0.05$) between insecticide treatments and untreated control at Samaru. However at Wase, there were significant differences ($p<0.05$) among the insecticide treatments in category A as plots treated with Chlorpyrifos plus at 237.5+23.75 g a.i./ha were significantly different from plots treated with Imidacloprid at 70 g a.i./ha and Cyperdicot (standard) at 250+30 g a.i./ha. Similarly, plot treated with Chlorpyrifos plus at 237.5+ 23.75 g a.i./ha, Dimethoate at 200 g a.i./ha were significantly different ($p<0.05$) from untreated control. At the same Wase location, Category B showed significant difference ($p<0.05$) between insecticide treatments and untreated control but no significant difference was recorded among the insecticide treatments. The same trend was followed in category C, where there was no significant differences among the insecticide treated plots but untreated control had significantly higher ($p<0.05$) severely damaged seeds in the untreated control than in insecticide treated plots.

Table.1.0 Effect of insecticide rates on number of pod and pod damaged at Samaru and Wase

Treatment (ga.i./ha)	Mean Number of pods produced/plot	Mean % Pod Damage / Plot	Mean Number of pods produced/plot	Mean % Pod Damage / Plot
Chlorpyrifos 240	186.00[a]	3.00[gh]	128.33[a]	3.17[e]
480	118.33[ab]	6.00[bc]	106.67[abc]	4.93[b]
720	176.00[ab]	3.00[gh]	135.33[a]	4.67[bcd]
Chlorpyrifos plus 237.5+23.75	153.00[ab]	4.00[efg]	106.67[abc]	3.33[e]
475+47.5	131.00[ab]	5.33[cd]	80.00[c]	5.37[b]
712+71.2	176.67[ab]	3.30[fgh]	96.33[abc]	5.33[b]
Dimethoate 200	179.67[ab]	2.67[h]	130.33[a]	3.73[cde]
400	114.67[b]	6.67[b]	100.33[abc]	4.43[bcde]
600	126.33[ab]	4.00[efg]	107.00[abc]	5.37[b]
Imidacloprid 35	127.67[ab]	4.67[de]	105.00[abc]	3.67[cde]
70	138.00[ab]	4.33[def]	98.33[abc]	5.13[b]
105	168.00[ab]	3.33[fgh]	127.67[a]	4.43[bcde]
Cyperdicot 250+30	147.00[ab]	3.00[gh]	121.00[ab]	3.57[de]
Control	128.67[ab]	9.00[a]	81.67[bc]	9.10[a]
S.E +	20.06	0.33	11.84	0.40

Effect of insecticide rates on yield of cowpea at Samaru and Wase

In Table 3.0, there was significant difference ($p<0.05$) in the yield of cowpea among the insecticidal treated plots in Samaru. Plots treated with Chlorpyrifos at 240 g a i/ha had higher ($p<0.05$) grain yield than plots treated with Chlorpyrifos plus at 237.5+23.75 and 712+71.2 g a i/ha, Dimethoate at 200 and 400 g a i/ha, Imidacloprid at 35 and 105 g a i/ha and untreated control. Similarly, in Wase, Chlorpyrifos at 240 g a i/ha had higher ($p<0.05$) grain yield than plots treated with Dimethoate at 400 and 600 g a i/ha, Imidacloprid at 35 and 105 g a.i./ha and control having the lowest grain yield.

Pod set could be affected by other factors such as growing conditions, soil fertility, moisture content and pod damage by insect pests. Pod and seed damage as observed in this study, is clearly related to the effects of the insecticide sprays on insect infestation. Results from this study showed the importance of insect pests as limiting factors to increased and sustainable cowpea production.

Table.2.0 Effect of insecticide rates on seed damage index of cowpea at Samaru and Wase

	Mean seed Damage Index					
Treatment	SAMARU			WASE		
(g a.i./ha)	A	B	C	A	B	C
Chlorpyrifos 240	1.94[a]	0.31[bc]	0.11[b]	1.87[abc]	0.39[b]	0.08[b]
480	1.31[a]	0.27[c]	0.14[b]	1.69[abc]	0.24[b]	0.09[b]
720	1.72[a]	0.31[bc]	0.16[b]	1.70[abc]	0.35[b]	0.20[b]
Chlorpyrifos plus 237.5+23.75	2.29[a]	0.44[ab]	0.17[b]	2.25[a]	0.41[b]	0.17[b]
475+47.5	1.49[a]	0.35[bc]	0.14[b]	1.65[abc]	0.31[b]	0.12[b]
712+71.2	1.83[a]	0.41[abc]	0.18[b]	1.83[abc]	0.40[b]	0.18[b]
Dimethoate 200	2.14[a]	0.34[bc]	0.12[b]	2.06[ab]	0.25[b]	0.12[b]
400	1.85[a]	0.29[bc]	0.13[b]	1.82[abc]	0.34[b]	0.12[b]
600	2.08[a]	0.35[bc]	0.14[b]	1.86[abc]	0.28[b]	0.14[b]
Imidacloprid 35	2.37[a]	0.40[abc]	0.12[b]	1.80[abc]	0.30[b]	0.09[b]
70	1.89[a]	0.38[abc]	0.18[b]	1.43[bc]	0.33[b]	0.12[b]
105	1.51[a]	0.32[bc]	0.12[b]	2.04[abc]	0.27[b]	0.18[b]
Cyperdicot 250+30	1.50[a]	0.28[c]	0.12[b]	1.49[bc]	0.37[b]	0.12[b]
Control	1.50[a]	0.53[a]	0.48[a]	1.34[c]	0.59[a]	0.54[a]
S.E +	0.41	0.05	0.03	0.21	0.06	0.04

Mean followed by different letter (s) in the same column are significantly different at 5% probability level of significance.

A=Undamaged seeds B= Damaged seeds C= Severely damaged seed

Table.3.0 Effect of insecticide rates on yield of cowpea at Samaru and Wase

Treatment (g a.i./ha)	Grain yield (kg/ha) SAMARU	WASE
Chlorpyrifos 240	784.91[a]	728.30[a]
480	754.72[ab]	622.64[ab]
720	630.19[abcd]	520.75[ab]
Chlorpyrifos plus 237.5+23.75	486.79[bcd]	494.34[ab]
475+47.5	547.17[abcd]	558.49[ab]
712+71.2	456.60[cd]	471.70[ab]
Dimethoate 200	483.02[bcd]	471.70[ab]
400	479.25[cd]	479.25[b]
600	516.98[abcd]	460.38[b]
Imidacloprid 35	479.25[cd]	420.00[b]
70	535.85[abcd]	543.40[ab]
105	430.19[cd]	415.09[b]
Cyperdicot 250+30	713.21[abc]	513.21[ab]
Control	403.77[d]	396.21[b]
S.E +	90.57	116.98

Means followed by different letter(s) in the same column are significantly different at 5% probability level

Protecting the crop with insecticide application increased yields several fold (Tanzubil, 2000). In nature, peak populations of pod pests do not occur at early flowering unless the crop is planted late. Therefore, high levels of pod pests could lead to total loss of the crop, especially where there is little or no rain to trigger new flushes or re-growth. The different insecticides at various concentrations were very effective. The percentage of pod damage to number of pods obtained was very minimal. Chlorpyrifos at 240 and 480 g a. i. /ha recorded higher number of pods in Samaru and Wase respectively compared to other treatments.

Furthermore, results from aborted flowers and damaged pods (damage assessment) indicated that the insecticides spray treatments influence number of pod and grain yields. This resulted in decreased aborted flowers and damaged pods compared to untreated control plots particularly in Wase. Results from this study then indicate that insecticide application remains an important strategy for suppressing cowpea insect pests on the field if properly managed. The results of the seed damage index also confirmed the effectiveness of the four new insecticides at different rates in reducing the infestations of cowpea pests in both locations because highest proportion of seeds were recorded in category A (seeds with no feeding damage) compared to seeds with obvious feeding punctures but with mild wrinkles and the lowest seeds were obtained in seeds with holes and/ or seeds that are severely wrinkled and shrunken to small sizes in all insecticide treatments. Untreated plots had the lowest in category A and highest in category B and C. Doubtless, the yield is the ultimate goal of the farmers and therefore, the quantity and quality of the harvested farm produce will depend on the soil fertility and insect pests infestation levels (Dent, 1991). Most of the yield related components such as number of pods per plot, pod damage, pod evaluation index and wrinkled seeds from different treatments had values which suggested that the insecticides variation both in term of types and concentrations had effects on yield output. Highest pest infestation and lowest yield were recorded in untreated plots, although number of pod per plot and grain yield per hectare were low in Wase, the relatively low yield was due to low amount of rainfall and other environmental conditions such as humidity, temperature, sunshine and soil type of the area compared to Samaru. The yield obtained supports earlier reports by Jackai, (1997) that cowpea yield is increased when treated with synthetic chemicals and unprotected plots usually have the lowest yields. The data also suggested that Samaru -Zaria and Wase- Minjibir ecological zones favour cowpea production. Results indicate therefore, that insect pest infestations at flowering and podding stages are significant limiting factors to increased and sustainable cowpea grain production in Samaru and Wase. This study showed that Chlorpyrifos at 240 (0.5 l/ha) and 720 g a.i./ha (1.5l/ha) had the highest number of pod produced at Samaru and Wase respectively and Chlorpyrifos at 240 g a. i. /ha gave the highest grain yield in both locations. Hence, the lower concentrations (0.5 and 1.0 l/ha) of all the insecticides would be adequate to effectively manage the flowering and post flowering insect pests of cowpea such as *M. sjostedti*, *M. vitrata* and *C. tomentosicollis* and increase productivity.

Recommendation

The four new insecticides could be used at the application rate of 0.5 l/ha - 1.0 l/ha to effectively reduce infestation of insect pests of cowpea and increase grain yield. They could also be used complementarily with other pest control options to significantly improve cowpea grain yields, thereby generating income for resource poor farmers in rural areas. Chlorpyrifos at 240 g a.i. /ha could be used for optimum grain yield of cowpea.

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