Management of insect pest complex of cowpea (*Vigna unguiculata*) with phosphorous-enriched soil and aqueous neem seed extract

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ABSTRACT

The study determined the major insect fauna of cowpea and evaluated the effectiveness of neem seed water extract (NSWE) and soil amendments in managing insect pest complex of cowpea at Juaboso in the Western Region. Phospho-compost was applied at the rate of 560 g plot^{-1} (865 kg ha^{-1}). The NSWE was applied at the rate of 50 g 1^{-1} (15 kg ha^{-1}). The phosphate rock and cymethoate were applied at the rate of 195 g plot^{-1} (300 kg ha^{-1}) and 2.5 ml 1^{-1} (750 ml ha^{-1}), respectively. Insect fauna belonging to eight orders were found associated with cowpea in the field. The major insect pests were *Aphis craccivora* (Koch), *Spodoptera littoralis* (F), *Empoasca* spp., *Ootheca mutabilis* (Sahlberg), *Zonocerus variegatus* (L.), *Megalurothrips sjostedti* (Trybom), *Maruca vitrata* (Fabricius), and *Anoplocnemis curvipes* (Fab.). Neem seed extract and cymethoate (synthetic insecticide) significantly reduced the incidence of these insect pests, thereby reducing the damage caused to the leaves and pods in treated plots. The incidence of beneficial insects was higher on NSWE-treated plots than on cymethoate-treated plots. These included *Mantis mantis*, species of *Bombus, Crematogaster* and *Coccinella*, and dragonfly. This suggests that NSWE was less harmful to beneficial insects than cymethoate. The phospho-compost-NSWE treatment recorded grain yield of 1.168 tonnes ha^{-1}, which was 68.5 per cent higher than the no soil amendment-no insecticide treatment (0.368 tonnes ha^{-1}). The phospho-compost-NSWE insecticide treatment had a profit margin of ¢1,804,000.00 ($212.2), whilst the no soil amendment-no insecticide treatment had a loss of ¢373,000.00 ($43.9). The use of phospho-compost and neem seed extract may represent an important component of the integrated crop and pest management strategy in traditional farming systems in Ghana.

RÉSUMÉ

ANNOBIL, R. K., AFREH-NUAMAH, K. & OBENG-OFORI, D.: *La lutte contre l'ensemble d'insectes ravageurs de dolique* (Vigna unguiculata) *avec le sol enrichi de phosphore et d'extrait aqueux de la graine de margousier.* Des études étaient entreprises à Juaboso dans la région ouest du Ghana pour déterminer la faune d'insecte majeure de dolique et pour évaluer l'efficacité de l'extrait d'eau de la graine de margousier (EEGM) et d'amendements du sol dans la lutte contre l'ensemble d'insectes ravageurs de dolique. Le phospho-compost était appliqué à la proportion de 560 g lot^{-1} (865 kg ha^{-1}). Le EEGM était appliqué à la proportion de 50 g l^{-1} (15 kg ha^{-1}). La roche de phosphate et la cyméthoate étaient appliquées à la proportion de 195 g lot^{-1} (300 kg ha^{-1}) et 2.5 ml l^{-1} (750 ml ha^{-1}), respectivement. La faune d'insecte appartenant à huit ordres était trouvée d'être associé avec la dolique au champ. Les insectes ravageurs majeures étaient *Aphis craccivora* (Koch); *Spodoptera littoralis* (F), *Empoasca* spp., *Ootheca mutabilis* (Sahlberg), *Zonocerus variegatus* (L.), *Megalurothrips sjostedti* (Trybom), *Maruca vitrata* (Fabricius), et *Anoplocnemis curvipes* (Fab.). L'extrait de la graine de margousier et la cyméthoate (insecticide sythétique) provoquait une réduction considérable de la fréquence de ces insectes ravageurs avec une réduction qui en a résulté aux ravages faits aux feuilles et aux cosses dans les lots traités. La fréquence d'insectes bénéfiques était plus élevée sur les lots traités d'EEGM que sur les lots traités de cyméthoate. Parmi ceux étaient *Mantis mantis*, espèces de *Bombus, Crematogaster, Coccinella* et la libellule. Ceci suggère qu'EEGM était moins nuisible aux insectes bénéfiques que la cyméthoate. Le traitement de phosphocompost – EEGM enregistrait un rendement de grain de 1.168 tonnes ha^{-1} qui était 68.5 pour cent plus élevé que le traitement de sans-amendement de sol–sans-insecticide (0.368 tonnes ha^{-1}). Le traitement de phospho compost - EEGM avait une marge bénéficiaire de 1,804,000 cedis ($212.2) alors que le traitement de sans-amendement de sol–sans-insecticide avait une perte de 373,000 cedis ($43.9). L'utilisation de phospho-compost et d'extrait de la graine de margousier pourrait représenter un élément important de la stratégie intégrée de l'amenagement de culture et de la lutte contre les ravageurs dans les systèmes d'agriculture traditionnelle au Ghana.

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Introduction

Cowpea has widespread use and acceptability in Ghana and other West African countries. It is grown in all parts of Ghana, with the major production areas being the savanna and transitional zones. It is mostly grown by peasant farmers with small holdings (0.4-2.0 ha). The yield of cowpea in Ghana averages 360 kg ha^{-1}, which is considered the lowest in the world (IITA, 1979, 1993).

The major constraints to cowpea production in the country include declining soil fertility and damage due to the incidence of diseases and pests at the various developmental stages of the crop. About 150 different species of insects are recorded to be associated with cowpea production in Ghana, but only a few are of economic importance (Marfo, 1985). About 50 per cent of the yield of the crop could be lost in the field as a result of pest attack (IITA, 1993). These pests are controlled in Ghana as in other West African countries by applying synthetic insecticides regularly throughout the growing season.

However, extensive use of synthetic insecticides results in pest resistance problems, pollution of the environment, residues in the food chain and water bodies, and the destruction of non-target organisms in most cowpea-growing areas in Ghana. Aqueous neem seed extract is a home-made biopesticide and cheaper than the conventional synthetic insecticides. It had been used effectively to control insect pests of cowpea and other food crops (Cobbinah & Osei-Wusu, 1988; Schmutterer, 1990, 1995; Tanzubil, 1992; Abu-Safiyanu, 1999; Baffoe-Asare, 2000; Obeng-Ofori & Kelly, 2001; Akakpo, Obeng-Ofori & Wilson, 2001; Owusu-Ansah *et al.*, 2001; Obeng-Ofori & Ankrah, 2002). The active compound interferes with the feeding activity of pests which consume the compound. They have their moulting and growth delayed and may eventually die (Schmutterer, 1990). The natural extract is strongly repellent (Schmutterer, 1990; Barnby & Klocke, 1987). It has distinct anti-feedant, growth and metamorphosis disrupting, anti-ovipositional, fecundity and fitness-reducing properties on insects (Schmutterer & Ascher, 1984; Schmutterer, 1990, 1995). The use of neem insecticides could be augmented with other compatible control methods to ensure optimum protection of cowpea (Jackai & Adalla, 1997; Afreh-Nuamah, 1996).

Phosphorus fertilization, using triple superphosphate, had been shown to increase the vigour and yield of cowpea (Singh & Lamba, 1971). Because this source of phosphorus is expensive, it is not being used by cowpea farmers. Therefore, cheaper sources of phosphorus, including phosphate rock and phospho-compost, must be used. The organic matter content of phospho-compost may improve soil structure, water-holding capacity as well as supply nutrients to the soil, which are essential for the growth and development of the plants (Sinnadurai, 1992). Kayitare (1993) reported that a good balance between nitrogen and phosphorus improved dry matter accumulation in French beans more than in plants in unfertilized plots.

This study aimed to determine the potential of incorporating phosphate rock and phospho-compost into the soil to cultivate cowpea, and to evaluate the effectiveness of aqueous neem seed extract and phospho-compost for managing insect pest complex of cowpea.

Materials and methods

The study area

The study was at Juaboso in the Juaboso-Bia District of the Western Region of Ghana during the minor growing season between September 2001 and January 2002. Phosphate rock, cocoa pod husk, sawdust, and poultry manure were used in preparing the phospho-compost (Ofosu-Budu, Quaye & Danso, 2002).

Experimental design

The experiment was a factorial in a randomized complete block design (RCBD) involving two factors, insecticides and soil amendment. There were three insecticides and four soil amendments as follows:

I_0 – No insecticide
I_1 – Neem seed water extract (NSWE)
I_2 – Cymethoate
S_0 – No soil amendment
S_1 – Phosphate rock
S_2 – Phospho-compost
S_3 – Triple superphosphate

In all, the 12 treatment combinations were as follows:

S_0I_0 – No soil amendment × No insecticide
S_0I_1 – No soil amendment × Neem seed water extract
S_0I_2 – No soil amendment × Cymethoate
S_1I_0 – Phosphate rock × No insecticide
S_1I_1 – Phosphate rock × Neem seed water extract
S_1I_2 – Phosphate rock × Cymethoate
S_2I_0 – Phospho-compost × No insecticide
S_2I_1 – Phospho-compost × Neem seed water extract
S_2I_2 – Phospho-compost × Cymethoate
S_3I_0 – Triple superphosphate × No insecticide
S_3I_1 – Triple superphosphate × Neem seed water extract
S_3I_2 – Triple superphosphate × Cymethoate

There were four blocks (replications) of 12 experimental plots per block. The size of an experimental plot was 3.2 m × 2.0 m (6.40 m^2), and the plots were separated from each other by a path of 1.0 m. A distance of 1.5 m also separated the blocks from each other.

Preparation of neem seed extract

Dropped neem fruits were collected at Boinzan, a village 10 km from Juaboso and sorted out to remove mouldy ones. The fruits were depulped and dried in the shade for 10 days. The dried neem seeds were stored in baskets in a dry and well-ventilated room. The dried neem seeds were ground with laboratory mill. For all neem seed extract treatments, 50 g of ground neem seeds were dissolved in 1 l of water and allowed to stand overnight. A fine white cloth was used to filter the neem seed extract. The clear extract containing the active ingredient (azadiractin) was used for spraying.

Application of cymethoate

Cymethoate (cypermethrin + dimethoate), a product of Zeneca Agro-Chemicals Limited, is marketed in Ghana by Aglow Company, an agro-based input shop in Accra. For field spraying, the recommended dosage of 2.5-ml cymethoate was mixed with 1 l of water (750 ml ha^{-1}) and applied, using a knapsack sprayer.

Land preparation and application of soil amendment

The land was prepared and fenced to keep away vertebrate pests and also to reduce pilfering. The phospho-compost was applied at the rate of 560 g $plot^{-1}$ (865 kg ha^{-1}) and worked into the soil 1 week before planting. The phosphate rock was applied at the rate of 195 g $plot^{-1}$ (300 kg ha^{-1}) 1 week before planting. The triple superphosphate was applied as band placement at 90 g $plot^{-1}$ (130 kg ha^{-1}), 7 days after sowing. These application rates gave 60 kg P_2O_5 ha^{-1} (Panwar & Yadav, 1980).

Agronomic practices

Seeds of the cowpea cultivar, Asontem, were in rows. Between row and within row spacings were 60 and 20 cm, respectively. Three seeds were planted in a hill and later thinned to two seedlings per stand after germination. Weeding and other routine cultural practices were applied when necessary. Three chemicals were applied at 2-week intervals from 21 days after sowing when insect infestation was detected. Two different 15-l knapsack (Model CP 15) spraying machines with cone nozzle tips were used to spray the two insecticides (one for neem seed extract and the other for cymethoate).

Sampling of insects

Insects were sampled every other day with water traps, sweep nets, and by handpicking. Yellow plastic bowls (35 cm × 5 cm × 6 cm) with carbolic soapy water were placed in the middle of each plot. The insects in the traps from each plot were picked individually with a pair of forceps and preserved in 70 per cent ethyl alcohol. Additionally, insects on experimental plants were handpicked and preserved for identification. The arthropods collected were prepared, air-dried for 24 h, and pinned up in insect collection box. The box was sent to the Entomology Laboratory of the Department of Crop Science, University of Ghana, Legon, for identification.

Data collection

Data collected included the insect fauna associated with the developmental stages of the plant in each of the different treatments, pod damage, grain weight, and the final grain yield.

Leaf and flower insects

Four plants from the middle row in each experimental plot were tagged for data collection. Four leaves randomly selected from each tagged stand were used for sampling for leaf feeders. Sampling was applied early in the morning from 0630 to 0830 h GMT, using sweep net or by handpicking. The insects collected were sorted out, counted and recorded. The larvae of defoliators were handpicked from the leaves and put into perforated cups. Leaves from untreated plots were used to feed them and reared to maturity. Flower thrips were sampled by picking three flowers at random from each of the tagged plants in the middle row of each plot. The flowers were put into 70 per cent alcohol in plastic containers and sent to the laboratory. With the help of hand lens, the number of thrips was counted.

Assessment of pod damage

For pod borers, harvested pods were separated into damaged and undamaged pods. A pod was considered damaged if it had feeding scar, frass or emergent hole on it. The number of damaged pods was recorded and percent pod damage was calculated. The damaged pods were dissected and examined for larvae of the pod borer. The number of larvae per damaged pod was counted and recorded.

Yield determination

An area of 3.84 m^2 in the centre rows was demarcated and harvested, as recommended by IITA (1979) for grain yield estimation. The harvested pods were dried, shelled, and the grains sun-dried to moisture content of 12 per cent. The grains were later weighed and the yield per hectare was estimated.

Determination of cost benefits

The cost associated with preparing and applying soil amendments and insecticides were determined based on market prices. The cost of seeds, labour, land preparation, planting and maintaining experimental plots were similar (fixed costs) for all treatments. Yield recorded was estimated on per hectare basis. The yield was multiplied by ¢3,500,000.00 ($411.8), being the cost of one metric ton of cowpea at Juaboso market, to determine total output. Net profits (returns) were then determined as the total output from each treatment minus the cost of production.

Statistical analysis

The data were subjected to a two-way classification Analysis of Variance (ANOVA). Leaf data on pod damage were estimated as percentages which were transformed to Arscine before they were subjected to ANOVA. For significant difference, means were separated using Least Significant Difference (LSD) at the 5 per cent level ($P<0.05$).

Results

Insect fauna of cowpea observed in the field

The underlisted insect species were found to be associated with the three major developmental stages (vegetative or pre-flowering, flowering and podding) of the cowpea plant (Table 1). The major insect pests were *Aphis craccivora* (Koch), *Spodoptera littoralis* (F), *Empoasca* spp., *Ootheca mutabilis* (Sahlberg), *Zonocerus variegatus* (L.), *Megalurothrips sjostedti* (Trybom), *Maruca vitrata* (Fabricius), and *Anoplocnemis curvipes* (Fab.). The beneficial organisms collected included *Mantis mantis*, species of *Bombus*, *Crematogaster* and *Coccinella*, and dragonfly.

Leaf and stem feeders

The soil amendment treatments did not have significant effect on the incidence of any of the leaf and stem feeders. Cymethoate and NSWE, however, significantly ($P<0.05$) reduced the numbers of *A. craccivora, Empoasca* spp., Z. *variegatus*, *O. mutabilis*, and *S. littoralis* recorded on treated plants compared to control plots (Table 2). *A. craccivora* was the most abundant while *O. mutabilis* was the least abundant leaf and stem feeder collected.

Flowering and podding pests

The application of NSWE and cymethoate significantly ($P<0.05$) reduced numbers of *M. sjostedti*, *M. vitrata*, and *A. curvipes* recorded on treated plants compared to control (Table 3). Soil amendment alone did not significantly ($P>0.05$) affect the incidence of post-flowering pests collected on cowpea plants.

Beneficial arthropods

Beneficial arthropods collected included species of *Bombus*, *Crematogaster, Coccinella* and *M. mantis*, and dragonfly (Table 4). The soil amendment did not affect the numbers of beneficial arthropods found on the cowpea plants.

TABLE 1

Insect Fauna Observed on Cowpea in the Juaboso-Bia District of Ghana

Scientific/Common name	*Family*	*Function*
***Vegetative or pre-flowering stage**		
Coleoptera		
Lagria cuprina (Thoms)	Lagriidae	Leaf feeder
Coccinella spp.	Coccinellidae	Predator
Ootheca mutabilis (Sahlberg)	Chrysomelidae	Leaf feeder
Heteroptera		
Aspavia armigera (Fab)	Pentatomidae	Leaf feeder
Dysdercus spp.	Pyrrhocoridae	Leaf feeder
Halymorpha annulicornis (Sign)	Pentatomidae	Leaf feeder
Homoptera		
Aphis craccivora (Koch)	Aphidae	Sap feeder
Empoasca spp.	Cicadellidae	Leaf feeder
Hymenoptera		
Crematogaster spp.	Formicidae	Predator
Bombus spp.	Apoidae	Pollinator
Lepidoptera		
Spodoptera littoralis (F)	Noctuidae	Leaf feeder
Odonata		
Dragonfly	-	Predator
Orthoptera		
Brachytrupes membranaceous (Drury)	Gryllidae	Cut seedlings
Mantis mantis	Mantidae	Predator
Zonocerus variegatus (L)	Pyrogomorphidae	Leaf feeder
Atractomorpha acutipennis (G-M)	Pyrogomorphidae	Leaf feeder
Christa compta (Walker)	Pyrogomorphidae	Leaf feeder
***Flowering and Post-flowering stage**		
Heteroptera		
Nezara viridula (L)	Pentatomidae	Sap feeder
Anoplocnemis curvipes (Fab)	Coreidae	Sap feeder
Riptortus dentipes (F)	Coreidae	Sap feeder
Lepidoptera		
Maruca vitrata (Fabricius)	Pyralidae	Pod borer
Thysanoptera		
Megalurothrips sjostedti (Trybom)	Thripidae	Flower feeder

TABLE 2

Effect of Soil Amendment, Neem Seed Extract, and Cymethoate on the Incidence of Major Leaf and Stem Feeders of Cowpea

Soil amendment	*Number of insects collected*		
	No insecticide	*NSWE*	*Cymethoate*
		A. craccivora	
No soil amendment	297.0 ± 7.1[b]	28.5 ± 2.2[a]	13.3 ± 1.8[a]
Phosphate rock	287.3 ±11.5[b]	26.8 ± 2.7[a]	10.8 ± 0.9[a]
Phospho-compost	283.5 ±13.5[b]	26.8 ± 2.7[a]	12.3 ± 0.9[a]
Triple superphosphate	290.5 ±13.9[b]	24.8 ± 1.3[a]	11.8 ± 0.9[a]
LSD		20.4	
		Empoasca spp.	
No soil amendment	74.8 ± 3.7[c]	35.8 ± 2.4[a]	1.8 ± 0.3[a]
Phosphate rock	74.0 ± 2.9[c]	33.3 ± 2.9[b]	2.0 ± 0.4[a]
Phospho-compost	71.0 ± 2.7[c]	32.5 ± 2.0[b]	1.8 ± 0.3[a]
Triple superphosphate	69.5 ± 3.0[c]	33.8 ± 2.0[b]	2.0 ± 0.4[a]
LSD		6.9	
		Z. variegatus	
No soil amendment	9.3 ± 0.8[c]	3.5 ± 0.3[b]	2.0 ± 0.4[a]
Phosphate rock	9.8 ± 0.5[c]	3.4 ± 0.4[b]	1.8 ± 0.3[a]
Phospho-compost	71.0 ± 2.7[c]	32.5 ± 2.0[b]	1.8 ± 0.3[a]
Triple superphosphate	10.0 ± 0.7[c]	3.8 ± 0.3[b]	2.5 ± 0.3[a]
LSD		1.4	
		O. mutabilis	
No soil amendment	7.8 ± 0.6[c]	3.3 ± 0.3[ab]	2.0 ± 0.4[a]
Phosphate rock	7.8 ± 0.9[c]	2.5 ± 0.3[a]	1.8 ± 0.3[a]
Phospho-compost	9.3 ± 0.5[c]	3.5 ± 0.3[b]	2.3 ± 0.3[a]
Triple superphosphate	8.5 ± 0.6[c]	3.3 ± 0.6[b]	2.0 ± 0.4[a]
LSD		1.4	
		S. littoralis	
No soil amendment	9.0 ± 0.4[c]	3.8 ± 0.3[b]	2.8 ± 0.3[ab]
Phosphate rock			
Phosphate-compost	8.3 ± 0.5[c]	3.5 ± 0.3[b]	2.3 ± 0.5[a]
Triple superphosphate	10.0 ± 0.7[c]	3.3 ± 0.3[b]	2.5 ± 0.3[a]
LSD	9.5 ± 0.6[c]	3.8 ± 0.5[b]	2.3 ± 0.4[a]
		1.3	

Means ± SE four replicates; NSWE = Neem seed water extract. Means for each species followed by different letter (s) are significantly different at the 5 % level (LSD)

Cymethoate and NSWE significantly (P<0.05) reduced the numbers of species of *Bombus*, *Crematogaster* and *Coccinella* and dragonfly recorded on treated plots compared to control plots (Table 4). Plots treated with NSWE recorded significantly higher numbers of beneficial arthropods than cymethoate-treated plots.

Pod damage

Cymethoate and NSWE significantly (P<0.05) reduced damage caused by pod borers to cowpea pods compared to the control plots (Table 5). However, cymethoate significantly (P<0.05) controlled pod borers better than NSWE.

Grain yield and the cost/benefit ratio

Soil amendment-insecticide interaction

TABLE 3

Effect of Soil Amendment, Neem Seed Extract, and Cymethoate on the Incidence of Post-flowering Pests of Cowpea

Soil amendment	*Number of insects collected*		
	No insecticide	*NSWE*	*Cymethoate*
		M. sjostedti	
No soil amendment	37.3 ± 0.9[c]	11.3 ± 1.0[b]	7.0 ± 0.4[a]
Phosphate rock	36.3 ± 2.1[c]	12.0 ± 0.7[b]	7.0 ± 0.7[a]
Phospho-compost	36.3 ± 2.5[c]	12.3 ± 0.9[b]	7.5 ± 0.9[a]
Triple superphosphate	34.5 ± 2.1[c]	14.0 ± 0.9[b]	7.5 ± 0.6[a]
LSD		3.7	
		M. vitrata	
No soil amendment	12.0 ± 0.4[c]	5.0 ± 0.4[b]	2.3 ± 0.3[a]
Phosphate rock	11.5 ± 0.6[c]	5.0 ± 0.4[b]	2.8 ± 0.3[a]
Phospho-compost	12.5 ± 0.6[c]	4.8 ± 0.3[b]	2.3 ± 0.3[a]
Triple superphosphate	11.5 ± 0.6[c]	5.3 ± 0.5[b]	2.3 ± 0.3[a]
LSD		1.3	
		A. curvipes	
No soil amendment	10.0 ± 0.8[b]	3.5 ± 0.3[a]	2.3 ± 0.3[a]
Phosphate rock	10.5 ± 0.6[b]	4.0 ± 0.4[a]	2.8 ± 0.3[a]
Phospho-compost	9.5 ± 0.6[b]	3.3 ± 0.3[a]	2.3 ± 0.3[a]
Triple superphosphate	10.5 ± 0.6[b]	3.5 ± 0.3[a]	2.3 ± 0.3[a]
LSD		1.3	

Means ± SE four replicates; NSWE = Neem seed water extract. Means for each species followed by different letter (s) are significantly different at the 5 % level (LSD)

increased grain yield. Plots with no soil amendment and no insecticide treatment recorded the lowest grain yield, whilst triple superphosphate-cymethoate-treated plots recorded the highest yield. The grain yield of phospho compost-cymethoate-treated plots compared favourably with that of triple superphosphate-cymethoate-treated plots. Grain yield recorded on insecticide-treated plots were 3-fold over that of no insecticide-treated plots. The combined application of soil amendment and insecticide increased profit margins (Table 6). Treatments with no insecticide application recorded losses. Cymethoate-treated plots recorded higher profit margin than NSWE-treated plots. The triple superphosphate-cymethoate treatment recorded the highest profit margin of ¢3,359,000.00 ($395.2) ha^{-1}. The phospho-compost-cymethoate treatment had profit margin of ¢3,102,000.00 ($364.9) which compared favourably with the triple superphosphate-cymethoate treatment. The lowest return was recorded in phosphate rock-no insecticide treatment, which had negative net returns of ¢781,000.00 ($91.9).

Discussion

The insect fauna observed on cowpea in the field belonged to 8 orders, 16 families, and 22 genera. The orders were Heteroptera, Thysanoptera, Coleoptera, Hymenoptera, Homoptera, Lepidoptera, Orthoptera, and Odonata.

The nymphs and adults of *Aphis craccivora* infested seedlings. They were usually found in clusters on the stems, young shoots, and leaves. They sucked sap from the stem, young leaves and shoots, resulting in stunted plants and distorted leaves. They were the most abundant of all the leaf feeders met. Aqueous neem was less effective against the leafhopper, *Empoasca* spp. This had earlier been observed by Feuerhake

TABLE 4

Effect of Soil Amendment, Neem Seed Extract, and Cymethoate on the Incidence of Beneficial Arthropods

Soil amendment	*Number of insects collected*		
	No insecticide	*NSWE*	*Cymethoate*
		Bombus spp.	
No soil amendment	13.3 ± 0.5[c]	10.0 ± 0.4[b]	4.0 ± 0.4[a]
Phosphate rock	12.8 ± 0.9[c]	8.8 ± 0.5[b]	4.8 ± 0.5[a]
Phospho-compost	13.5 ± 0.6[c]	9.5 ± 0.6[b]	4.8 ± 0.5[a]
Triple superphosphate	13.0 ± 1.3[c]	9.0 ± 0.4[b]	5.0 ± 0.4[a]
LSD		1.9	
		Dragonfly	
No soil amendment	15.0 ± 1.1[c]	8.0 ± 0.9[b]	4.0 ± 0.4[a]
Phosphate rock	14.0 ± 1.5[c]	8.5 ± 0.6[b]	4.8 ± 0.5[a]
Phospho-compost	14.8 ± 0.9[c]	7.3 ± 0.5[b]	4.8 ± 0.5[a]
Triple superphosphate	14.5 ± 1.0[c]	8.3 ± 0.5[b]	5.0 ± 0.4[a]
LSD		2.2	
		Crematogaster spp.	
No soil amendment	70.8 ± 2.9[c]	50.0 ± 2.7[b]	12.0 ± 0.9[a]
Phosphate rock	68.3 ± 3.4[c]	49.5 ± 2.3[b]	12.3 ± 1.3[a]
Phospho-compost	66.8 ± 3.2[c]	55.8 ± 2.2[b]	12.0 ± 0.0[a]
Triple superphosphate	70.0 ± 2.0[c]	50.8 ± 1.5	11.5 ± 1.3[a]
LSD		6.4	
		Coccinella spp.	
No soil amendment	11.0 ± 0.4[c]	4.3 ± 0.6[b]	2.5 ± 0.3[a]
Phosphate rock	11.3 ± 0.8[c]	4.3 ± 0.6[b]	2.8 ± 0.5[a]
Phospho-compost	13.8 ± 0.5[c]	4.5 ± 0.3[b]	2.5 ± 0.3[a]
Triple superphosphate	13.5 ± 0.6[c]	4.4 ± 0.3[b]	2.8 ± 0.3[a]
LSD		1.4	

Means ± SE four replicates; NSWE = Neem seed water extract. Means for each species followed by different letter (s) are significantly different at the 5 % level (LSD)

TABLE 5

Effect of Soil Amendment, Neem Seed Extract, and Cymethoate on Borer Damage to Cowpea Pods

Soil amendment	*% pod damage*		
	No insecticide	*NSWE*	*Cymethoate*
No soil amendment	39.5 ± 1.3[c]	12.8 ± 1.1[b]	4.0 ± 0.4[a]
Phosphate rock	39.8 ± 1.9[c]	12.5 ± 0.3[b]	4.5 ± 0.6[a]
Phospho-compost	40.0 ± 2.1[c]	11.8 ± 0.9[b]	4.0 ± 0.4[a]
Triple superphosphate	39.8 ± 1.7[c]	11.5 ± 0.6[b]	3.8 ± 0.3[a]
LSD		3.1	

Means ± SE four replicates; NSWE = Neem seed water extract. Means for each species followed by different letter (s) are significantly different at the 5 % level (LSD)

TABLE 6

Net Returns (Profit) Per Hectare Based on Prevailing Market Prices for Each Treatment (in Cedis)

Soil amendment	*Insecticide*		
	No insecticide	*NSWE*	*Cymethoate*
No soil amendment	-373,000 (-$43.8)	1,171,000 ($137.8)	2,606,000 ($306.6)
Phosphate rock	-781,000 (-$91.8)	1,176,000 ($138.4)	2,177,000 ($256.1)
Phospho-compost	-458,000 (-$53.8)	1,804,000 ($212.2)	3,102,000 ($364.9)
Triple superphosphate	-537,000 (-$61.02)	1,917,000 ($225.5)	3,359,000 ($395.2)

(1984), who explained that leafhoppers whose mouthparts cannot penetrate beyond the outermost layer of the conductive tissue (phloem) of plants are little affected by the active ingredient in neem which is systemic in certain crop plants. The nymphs and adults of *Z. variegatus* attacked the leaves, resulting in widespread defoliation. Neem extract was effective against *Z. variegatus* because of its anti-feedant properties (Gill & Lewis, 1971; Schmutterer & Ascher, 1984; Schmutterer & Hellpap, 1988; Schmutterer, 1990). The caterpillars of *S. littoralis* were serious leaf feeders, damaging the leaves extensively. The neem extract was also effective against *S. littoralis* and *M. sjostedti*. *Megalurothrips sjostedti* was the major flower thrips found on cowpea in the study area. The nymphs and adults sucked the flower sap that induced flower drop. Eziah (1999) reported the efficacy of aqueous neem seed extract against *Thrips palmi* on aubergine in the University Farm, Legon. In the same study, cymethoate was found to be ineffective against *T. palmi*, and the possibility of the insect developing resistance to the chemical was speculated. *Maruca vitrata* was the most important pod borer found in the field, with the larvae damaging cowpea pods extensively. The effectivesness of aqueous neem seed extract against *M. vitrata* confirmed earlier work at IITA, where aqueous neem extract was found to be effective against *M. vitrata* and *Clavigralla tomenticollis* (Jackai & Oyediran, 1991.)

Many of the main pollinating insect, *Bombus* spp., were found on the neem-treated plants. The dragonfly was a predator of the larvae of insect species. The control plot had the most dragonflies, and the cymethoate-treated plot the lowest. *Crematogaster* spp. were seen attending to the aphids, and were the most abundant of all the beneficial insects. They removed honeydew, thus preventing the formation of sooty mould. The NSWE-treated plots recorded significantly ($P<0.05$) higher numbers than the cymethoate-treated plots. This suggests that NSWE had less effect on the insect compared to the cymethoate. The higher numbers of beneficial insects collected from the NSWE-treated plots showed that NSWE, when compared to cymethoate, was less harmful to beneficial and other ecologically important non-target organisms.

The application of NSWE could not protect the pods adequately against pod borer damage compared to the cymethoate treatment. Ken, Leo & Murray (1994) have suggested that the active ingredient, azadirachtin, may not remain in the stem and other tissues of the plant long enough to affect all the larvae before being carried far up the crop, because it may be broken down rapidly. The reduced protection could also be due to the high temperatures experienced during the podding stage, because the active ingredient in neem is degradable in sunlight (Schmutterer, 1995).

Soil amendment increased grain yield. Triple superphosphate and phospho-compost-treated plots had higher yields than the control plots. Plants on soil amendment-treated plots grew vigorously because they had enough nutrients, which helped them to compensate for damaged parts (Hill, 1993; Kayitare, 1993). However, they still required additional protection from insecticides to produce economic yield. Higher yields and significant reduction in pest infestation in soil amendment-insecticide-treated plots resulted in greater net profits. The greatest economic loss was recorded by phosphate rock-no insecticide treatment. For increased economic returns in cowpea production, soil amendment should be complemented with insecticide application.

Researchers, IPM trainers, and farmers continued with field trials in the use of aqueous neem extracts for managing insect pests of cereals, legumes, vegetables, and fruits throughout the country. Some farmers are gradually adopting the use of neem extracts in a variety of crop production systems, including irrigated rice, cowpea, pepper, cabbage, okra, eggplant and onions (Youdeowei, 2000). Indeed, the potential for using neem products is high, and farmers need to be educated on the economic and environmental benefits of neem products. However, neem seeds are unavailable throughout the year for use by farmers. Therefore, potent commercial neem products need to be made available in the Ghanaian market to ease their application against some destructive insect pests attacking crops in Ghana. It is important to obtain the commercial neem products from a reputable source because some so-called commercial neem products have been found to be ineffective in field trials in Ghana (Youdeowei, 2000).

Conclusion

The study has shown that the main insect fauna of cowpea in the Juaboso-Bia District are *A. craccivora, Empoasca* spp., *Z. variegatus, O. mutabilis, M. sjostedti, M. vitrata, A. curvipes, M. mantis*, species of *Bombus, Crematogaster* and *Coccinella*, and dragonfly. The insect pests observed damaged leaves and pods of plants significantly, especially on the control plots. Cymethoate and NSWE were effective against the pests of cowpea, and significantly higher yields were recorded from treated plots compared to the control plots. Soil amendment also influenced most agronomic characteristics measured. The use of phospho-compost and NSWE increased profit margins. Improving the fertility status of the soil with organic or inorganic manures and applying biopesticides such as neem products could increase the yield of cowpea and the incomes of resource-poor cowpea farmers.

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