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Efficacy of Super neemol® granules for the control of cowpea (*Vigna unguiculata* L.) Walp) insect pests in the forest region of Ghana

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Abstract

Pesticide use is increasing and misuse of synthetic insecticides has gained attention in recent times. Consumer concerns and public outcry over food safety reflect this development. Botanical insecticides provide credible alternative if their efficacy are proven. Field experiments were conducted at the Kwadaso station of the Crops Research Institute, Kumasi in the Forest zone of Ghana in 2010 and 2011 to test the efficacy of Super neemol® granules as botanical insecticide against field pests of cowpea. This was compared with Furadan® granules (carbofuran), Karate + Dimethoate and a no insecticide control. The target insect pests were cowpea aphids, flower thrips, maruca pod borer and the pod sucking bugs complex. There was a complete absence of aphids on furadan treated plots. However, furadan did not have a positive effect on incidence and severity on the remaining target pests. Karate+Dimethoate treatment significantly protected the crop from the target insects and resulted in the highest grain yield. Super neemol® at the rates studied did not protect the crop from any of the target insect pests. The claim that Super Neemol® granules could effectively replace furadan as a systemic pesticide cannot be confirmed.

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Introduction

Cowpeas (*Vigna unguiculata* L. Walp) provide a major source of protein for about 200 million people in sub-Saharan Africa (Adati *et al*., 2007). Dry cowpea seeds contain about 25% protein, comparable to the protein content of meat (Afun *et al*., 1991). Cowpea could therefore be used as a meat substitute especially among the poor where meat prices are beyond reach. Cowpea production is highest in the West African countries of Nigeria, Niger, Burkina Faso and Ghana (ITTA, 2002). Insect feeding damage by over 100 pest species is, however, a major constraint on field production and in grain storage. Annual yields and longevity of grain storage is greatly reduced by feeding damage caused by a complex of insect pests that include the phloem-feeding cowpea aphids, *Aphis craccivora* Koch (Hemiptera: Aphididae), flower thrips, *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae); legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) and a complex of pod sucking insects, *Clavigralla tomentosicollis* Stål (Hemiptera: Coreidae) and *Anoplocnemis curvipes* Fabricius (Hemiptera: Coreidae). Crop damage by these insect pests can be as high as 60 to 100% in the field (Afun *et al*., 1991). Yield is most affected by insect pests that occur during the flowering and seed pod stages (Boker, 1965). These include flower thrips, *M. sjostedti* and pod feeding insects such as *A. curvipes* and *C. tomentosicollis*. Efforts to control these pests remain a challenge and there is a need to understand the structure and movement of these pest populations in order to facilitate the development of integrated pest management (IPM) strategies. Even though much research has been directed towards developing strategies to control the legume pod borer, *M. vitrata,* cowpea crops remain susceptible to continued feeding and plant disease transmission by aphids, thrips and pod sucking pests. Any meaningful cowpea production enterprise therefore depends on an effective insect pest control programme (Purseglove, 1968). In most countries in West and Central Africa, including Ghana, cowpea pests are controlled almost exclusively with synthetic insecticides.

With increasing knowledge in health and environmental hazards associated with synthetic insecticides, there has been a preference in pest management that targets the pests but has little negative impacts on beneficial species. One alternative to conventional insecticides is the use of botanical compounds such as azadirachtin, which has evoked a great deal of interest because of its bioefficacy and biodegradability (Isman, 1999).

Some entomologists now foresee that neem has such remarkable potency for controlling insects that it could usher in a new era of safe natural pesticides. The most active constituent, azadirachtin (triterpenoid) is one of the important plant-derived compounds used in insect control. It combines antifeedant action with growth regulatory and sterilant effects (Blaney *et al*., 1990). Cobbinah and Osei-Wusu (1988) and Smith and Krischik, (2000) have also shown in separate studies that neem has great potential as a field insecticide against cowpea pests.

The Ghanaian market has been flooded with a diverse of preparations that are purported to be extracts of neem. The motivation was the growing demand for reduced usage of pesticides in food production. Super neemol granule, a product of India and formulated from extracts of neem *Azadrichta indica* (A. Juss) with azadiractin as the active ingredient, is advertised as a botanical preparation with similar activity as Furadan® granules.

This product could gain a lot of patronage and reduce the use of Furadan® if it is found to be effective. The objective of the study therefore was to determine the efficacy of super neemol granules for the control of cowpea field pests.

Materials and methods

Experimental site

The experiment was conducted during the main cropping seasons in 2010 and 2011 at the experimental fields of the Crops Research Institute (CRI) Kwadaso, Kumasi, Ghana, West Africa (Lat. 6°

42N; Long. 1° 40W; 262m above sea level).

Experimental design and procedure

The experiments were laid out in a randomized complete block design (RCBD). There were three blocks consisting of six treatments each. The plots and blocks were separated by 1m and 2m wide alleys respectively.

Land preparation and planting

The land was zero-tilled using Glyphosate (Round up®) to kill the vegetation. The experimental site was divided into four blocks of six plots each. A plot measured 2.25m x 5m. 'Asontem' an improved erect early maturing (65 days) cowpea variety was planted a week after application of the herbicide and thinned to two seedlings/hill after germination. One hand hoeing was done before flowering to control weeds.

Monitoring of insect pests infestation and damage

Aphid and flower thrips infestation

Aphid infestation was monitored at weekly interval beginning from 15 days after planting (DAP). All plants in the two middle rows of each plot were examined for the presence or absence of infestation and scored on a scale of 0 - 5 (Salifu, 1982) signifying no aphid infestation to highest infestation.

Flower thrips damage was recorded by examination of damage to flower buds and terminal buds using the 5-point scale described by (Salifu, 1982). Scoring was done on the middle rows and was carried out weekly for three weeks. Flower thrips population was assessed at 33, 36 and 39 DAP by picking 20 racemes at random from the two central rows. These were preserved in vials containing 30% ethanol. The process was repeated for flowers at 42 and 45 DAP. These reproductive parts were teased in the laboratory and the thrips counted under a magnifying glass.

Damage by Maruca pod borer and pod sucking bugs

Maruca pod borer (MPB) damage on flowers was assessed by picking 20 flowers at random from each plot at 5 days interval, beginning from 40 DAP. The flowers were split open in the field and the percent MPB infestation was assessed. MPB damage on green pods was carried out at 50 and 55 DAP. A total of 20 pods per plot were inspected at random and pods that had one or more feeding/emergence holes were considered damaged by *M. vitrata* and recorded.

Pod sucking bugs (PSB) infestation was assessed by counting all PSB visible on the two middle rows of each plot between 1400 hours and 1600 hours (Salifu, 1982). Counting was done at 50, 55 and 60 days after planting (DAP). Pod sucking bugs damage on seed for each plot was assessed by determining the damage to the seed of 20 randomly harvested pods. Aborted seeds, wrinkled seeds and seeds that showed feeding lesions were considered damaged by PSB as described by (Afun *et al*., 1991).

Pesticides

The granular pesticides (super neemol and carbofuran 3G) were applied either in a single dose or in two splits. Super neemol® was applied at a single dose of 10g per plant or two 5g splits. Furadan granules were applied in similar fashion but at 5g and 2.5g for the single and split applications respectively.

In each case, the single application was done 7 days after planting to protect the crop from pre-flowering pests and the split application 21 days after first application. A treatment of Karate® (Lambda cyhalothrin) followed with Dimethoate at 2.4ml/l and 4.0ml/l of water respectively, this is what most farmers use) was applied as the recommended conventional insecticidal check. Karate® was applied as spray to control pre-flowering and flowering pests such as aphids, thrips and MPB while Dimethoate was used against post-flowering pests mostly PSB.

Grain yield

Grain yield (kg ha^{-1}) was estimated at maturity from the two central rows of each plot.

Statistical analysis

Data were analyzed for variance (ANOVA) using the

SAS (SAS, 2005) package. Count and percent data were square root and arcsine transformed respectively. Where the ANOVA showed significant differences, means were separated with the least significance difference test (LSD).

Results and discussion

Aphids infestation and control

The Super neemol® granules could not protect the cowpea plants from aphids resulting in heavy attack and damage during the first year (Table 1).

Table 1. Comparative effectiveness of soil applied granular pesticides for control of pre-flowering insect pests of cowpea.

Treatment	% Aphids infestation for 2010	2011	Mean thrips damage score for 2010	2011	Mean thrips damage/10 flowers for 2010	2011
Neemol split	0.65	2.00a	2.65	5.89a	2 24.5	128.89a
Neemol Single	0.63	0.41a	2.73	6.55a	210.3	98.33a
Furadan Split	0.03	1.09a	1.68	0.33b	160.3	31.33b
Furadan Single	0.00	0.00a	1.78	0.56b	240.5	32.00b
Karate+Dimethoate	0.05	1.03a	1.23	0.44b	96.5	19.11b
LSD (0.05)	0.24	1.85	0.19	3.71	61.84	43.95

According to Kocken and Roozendaal (1997), Azadirachtin the active ingredient in neem seed can be ineffective especially when the seeds are not well dried and properly stored. The single application of furadan on the other hand was able to protect the crops effectively. Thus, no aphids were observed on those plots. Our findings corroborate those of Singh and Allen (1980) who intimated that soil application of furadan granules gave good control of aphids at seedling stage of cowpea development. The split application of furadan also adequately protected the crops from the insects (Table 1). Ganguli and Raychaudhuri (1984) also reported that side dressing with Dimethoate granules after germination of cowpea significantly reduced aphid populations. The poor performance of the neem extracts could be attributed to several factors that resulted in the ineffectiveness of the product. These might include inactivation in the soil, leaching through the soil, poor systemic and persistent activity and thus poor uptake by the plants. Botanical insecticides are natural and easily degradable in the eco-system upon exposure to sunlight, air and moisture (Buss and Park-Brown, 2002; Dubey *et al.*, 2011).

Table 2. Effect of soil application of super neemol and furadan on the infestation and damage of cowpea by some post-flowering insect pests.

Treatment	% MPB damage/10 flowers for 2010	2011	%MPB damage on green pods for 2010	2011	PSB Counts/ meter row for 2010	2011	%PSB damage on pods for 2010	2011	%PSB damage on seeds for 2010	2011
Neemol Split	57.5	57.8	48.8	5.35	0.50	1.76	100	9.60	96.3	8.12
Neemol Single	47.5	56.1	53.8	5.26	0.63	1.47	100	9.59	98.3	7.78
Furadan Spli	43.3	66.7	62.5	5.90	0.75	1.69	100	9.51	99.5	7.07
Furadan Single	65.0	64.4	63.8	5.97	1.25	1.78	98.8	9.86	96.3	7.68
Karate+ Dimethoate	6.3	6.7	11.0	3.06	.63	2.60	46.3	7.08	16.3	4.58
LSD (0.50)	29.8	9.28	12.5	1.58	1.11	0.89	5.8	0.80	7.4	0.97

Flower thrips infestation, damage and control

There were significant differences between the farmers practice (Karate and Dimethoate) and both furadan and Super neemol® granules in the populations of flower thrips. The Karate and Dimethoate treated plots rerecorded significantly lower flower thrips population of 96.5 (Table 1) compared with other treatments. No significant differences in flower thrips population were observed among the granular preparations in the two application regimes (split and single dose) (Table 1). Significant differences occurred between the three groups of insecticides. Plants treated with Super neemol® granules suffered the highest thrips damage while the farmers practice pesticides recorded the lowest damage (Table 1).Thrips are the most important flowering pest of cowpea in Africa, being the first in the complex of pests that attack the reproductive structures and cause significant yield loss. Singh and Allen (1980) attributed 20 - 80 % yield loss in cowpeas to thrips. The high populations of thrips and the subsequent significant damage probably contributed to reduced grain yield of plots treated with Super neemol®.

Table 3. Monitoring cowpea insect pests damage under various insecticide applications.

Treatment	Flower thrips Damage score	Maruca flower damage	Maruca green pod damage†	PSB pod damage†	PSB seed damage†
Neemol Split	1.35	57.78	5.35	9.60	8.12
Neemol Single	1.36	56.11	5.26	9.59	7.78
Furadan Split	1.06	66.67	5.90	9.51	7.07
Furadan Single	1.03	64.44	5.97	9.86	7.68
Karate+ Dimethoate	1.06	6.67	3.06	7.08	4.58
(Water blank)	1.53	61.67	5.66	10.03	8.47
LSD (0.50)	0.09	9.28	1.58	0.80	0.97

† *Square root transformed data [√(x + 0.05)].*

Maruca pod borer (MPB) damage and control

Maruca pod borer damage in flowers was high for both furadan and Super neemol® granules. According to Liu and Liu (2006), Neemix a neem-based insecticide could not repel or deter females of diamond back moth (DBM) from ovipositing. Similarly, foliar and soil applications of NeemAzal-TS and NeemAzal-MD 5, respectively, did not cause any oviposition deterrence against DBM (Liu and Liu, 2006). However, neither second larval stage (L2) nor adult survival of diamond back moth was influenced by both neem products (Premachandra *et al.*, 2005).The Karate® and Dimethoate treated plots, however, showed significantly lower MPB infestation and damage (Table 2). Only 6.3% and 6.7% damage were recorded in 2010 and 2011 seasons respectively. The trends in MPB infestation and resultant damage on green pods for the pesticide treatments were similar to those of the flower thrips. MPB population and damage was significantly lower for only plots sprayed with Karate® + Dimethoate (Table 2). MPB damage on green pods was 11% and was statistically better than other treatments which were between 48% and 64% in 2010 (Table 2). Similarly, in 2011, the Karate® + Dimethoate treated plots showed 3% MPB infestation as against 5.3% and 6.0% for the granular preparations. This rise in damage levels of green pods from Super neemol® treated plots could be attributed to the ineffectiveness of the granular preparations to prevent attack by the legume pod borer (Table 2).This could probably be as a result of poor translocation of the granular formulations to the reproductive structures of those plants.

Pod sucking bugs (PSB) infestation, damage and control.

Pod sucking bugs constitute another important group of the cowpea pest complex (Jackai *et al.*, 1985) that migrates continuously from their wild host to the cowpeas. The adults and nymphs of some species suck sap from the green immature pods, causing premature drying of pods and malformed seeds. Generally, PSB populations were low and appeared not to be affected by the treatments. However, damage levels for pods and seeds were high. Unexpectedly, the Karate +Dimethoate treated plots recorded the highest number of PSB for both years (Table 2). This situation could arise either because of the efficacy of the pesticide used which resulted in larger numbers of fresh pods that attracted more of the sucking bugs. These results were consistent with that of Afun *et al*. (1991) who claimed that well treated plots attract more pod sucking bugs because of readily available of fresh pods. The higher populations of PSB did not translate into higher pod and seed damage scores for the Karate and Dimethoate treatment (Table 3).

Assessment of pods and seeds revealed that damage was significantly lower for the Karate and Dimethoate treated plots (Table 3). Although more PSBs were found on the Karate and Dimethoate treated plots, their presence could not inflict much damage on the crop. There were no significant differences in pod damage between the granular pesticides. This is seen as a reflection of the ineffectiveness of the granular formulations, especially their inability to protect the crop through the season.

Table 4. Effect of soil application of super neemol and furadan on grain yield of cowpea for 2010 and 2011 Major cropping seasons.

Treatment	Grain Yield (kg/ha)	
	2010	2011
Neemol Split	0.02b	450.67b
Neemol Single	0.02b	524.33b
Furadan Split	0.01b	676.33b
Furadan Single	0.02b	439.33b
Karate+ Dimethoate	1.67a	1615.67a
LSD (0.50)	0.22	311.97

For the Karate + Dimethoate treatment, the Dimethoate was aimed at controlling the PSB but with the granular pesticides it was expected that the active ingredient would be released slowly and adequately to protect the crop over the whole growing season and protect pods and seeds from PSB damage. Our results confirm reports by Mmbaga, (2002) indicating that neem-based products (Triact and NeemGold) were not effective in most cases in preventing Japanese beetle and other insects feeding damage. Similarly, Smith and Krischik (2000) and Tanzubil (1992) observed that all biorationals including neem-based products caused less mortality than a conventional pesticide, carbaryl.

Grain Yield

Grain yields for both years were very low (Table 4). There were no differences in grain yield between the furadan and neem granule treatments even though the split application of furadan resulted in the worst yield (0.01 tons/ha). This result confirms the assertion that yields obtained from cowpea sprayed with neem leaf extract are much less when compared to plots sprayed 2-3 times with synthetic pesticides (Jackai and Adalla, 1997).

Grain yield was highest in the Karate + Dimethoate treatment (Table 4), which recorded mean grain yield of over 1.6 tons/ha for both years. These yields were still below the yield potential of the variety used (1.8 tons/ha). With the low flower bud, flower and pod pests, higher yields were expected but this was not realized, which underlines the complexity of factors that interact to control crop development and yield.

Conclusion

Furadan reduced the populations and damage of early season pests such as aphids and flower thrips but did not impact on the populations of later season pests such as maruca pod borers and pod sucking bugs. On the other hand, Super neemol® granules did not have any impact on any of the pests of cowpea.

The farmers practice (Karate + Dimethoate) was overwhelmingly better than both furadan and Super neemol® for pest control on cowpea recording lower pest populations and correspondingly higher grain yield. It is therefore stressed that neither of the granular pesticides is suitable for cowpea pest control and could therefore not be used in place of the farmers practice. Again Super neemol® as in the formulation tested is not a suitable alternative for furadan.

Future research in this field should be intensified so that more of these novel products can be evaluated as viable alternatives to the persistent, less environmentally friendly products on the market currently. The granular formulations whether applied as a single dose or in splits reduced damage to cowpea by pre-flowering pests such as aphids and thrips but was ineffective against post flowering pests (MPBs and PSBs) at the rates applied. The application of Karate as a vegetative stage and early flowering stage insecticide followed with Dimethoate for post flowering pests (as practiced by farmers in the area) protected the cowpea crop comparatively better than both Furadan and Super neemol® granules.

The Super neemol® granules used in this study did not affect any of the target pests of our study. Although the poor performance of the granular insecticides as a whole could have been affected by environmental factors such as excessive rainfall during the study period as well as physiological factors of the mobility and transportability of the active ingredients in the cowpea crop, the inability of Super neemol® granules to adversely affect the population build up and damage of even early season pests such as aphids raises serious doubts about its efficacy. Claim that Super neemol® granules could effectively replace furadan as a systemic pesticide was not observed in this study and therefore cannot be supported. It is therefore recommended that a serious technical review of the effectiveness of Super neemol® granules undertaken and standards set to ensure that similar granular botanical formulations are only imported when they can meet the set standards.

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