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Evaluation of Botanical Mixtures for Insect Pests Management on Cowpea Plants

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Abstract
Studies were conducted at the Research Farm of the Institute for Agricultural Research, Zaria in 1999 and 2000 rainy seasons to evaluate the efficacy and synergistic activity of extracts mixtures from herbal landraces in reducing pests numbers on cowpea plants and ensuring high yield of grains. The extracts mixed in a ratio 10:10 % w/w included: cashew nutshell + garlic bulb; cashew nutshell + African pepper and garlic bulb + chilli pepper. The results indicated that all the herbal extract mixtures reduced the numbers of the tested insect pests (legume flower bud thrips, legume pod borer larvae and pod sucking bugs) and pod damage as well as increased grain yields by 4 - 5 times compared to the untreated control in the two years of investigation. The synergistic advantage of mixing two different plant species in botanical formulations could play a key role in the renewed effort to control pests of agricultural crops using biopesticides.

Keywords: extracts, mixtures, synergism, management, insect pests, cowpea, biopesticides

1 Introduction

Plant based insecticides (PBI) have been used for many centuries (Jacobson, 1958, 1975) among limited resource farmers in developing countries to control insect pests of both field crops and stored produce, but their potential was initially limited and ignored. Nicotine, rotenone and pyrethrum were popular among the PBIs used to some extent for storage pests control and other pests in green houses (Schmutterer, 1981). Some of these plant species possess one or more useful properties such as repellency, antifeedant, fast knock down, flushing action, biodegradability, broad-spectrum of activity and ability to reduce insect resistance (Olaifa *et al.*, 1987; Stoll, 1988). However, most of them are either weak insecticidally or may require other plant species with different mode of action (depending on the ratio and rate of application) to increase their potency (Sommers, 1983; Oparaeke, 2004). For instance, *Xylopia aethiopica* (Dunal) (A. Rich.) is found to be weak insecticidally for control of *Callosobruchus maculatus* Fab. on bruchid (Oparaeke, 1997; Oparaeke and Bunmi, 2004) and on field pests of cowpea (Oparaeke, 2004). However, ground, dried fruit of *X. aethiopica* (African pepper or

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Ethiopian pepper) mixed with chillies (*Capsicum spp.*) and applied to kola nuts was found to have repellent properties against kola weevils (BURKILL, 1985). Extracts of chilli pepper in mixture with garlic (*Allium sativum* L.), onion (*Allium cepa* L.) bulbs extracts and lemon grass (*Cymbopogon citratus* Staph.) leaf extract were found very effective against some leaf eating insect pests of crops (STOLL, 1988). In South East Asia, rice farmers are said to use a mixture of chilli pepper, dried tobacco leaves, Tubli root, and *Croton tiglum* against stem borers (ANONYMOUS, 1977). In the Philippines, farmers have been reported using a mixture of *Derris* roots, seeds of *Jatropha curcas* and *Barringtonia asiatica* to control *Leptocorisa* acuta on rice (BLAUW, 1986 in STOLL (1988).

In South Eastern Nigeria, rural farmers mix chilli pepper and wood ash of *Parkia* spp., *Elaeis guineensis*, *Eucalyptus* spp. or *Azadirachta indica* (A. Juss) to control *Podagrica* sp. on okra plants, *Abelmoschus esculentus* L. AMADI, A. O., 1993, personal communication). The natives in this area also use the mixture of *Chromolaena odorata* L. and *Ocimum gratissimum* L. leaf extracts to repel termites, "tailor ants" and "soldier ants" around their houses. Similarly, an admixture of water from fermented cassava (*Manihot esculentus* Crantz) tubers and bitter leaf (*Vernonia amygdelina* L.) has shown potency against "tailor ants" infesting local pear fruits and leaves in eastern Nigeria. Since there is paucity of documented information on the use of plant extract mixtures in pest control, this study was aimed at assessing the efficacy of mixtures of plant extracts for management of pests of cowpea plants.

2 Materials and Methods

Field trials were conducted in 2000 and 2001 cropping seasons under rain fed conditions on the Research Farm of the Institute for Agricultural Research, Samaru (Lat. 11° 11' N and 07° 38' N) in the northern Guinea Savanna of Nigeria. The rainy season commences in June and lasts till October (first or second week). The amount and distribution of rainfall vary from year to year usually between 150 to 350 mm per annum. Temperatures during the period varied from 25 - 32 °C and in the dry harmattan, harvest period (November - December) the temperature fluctuated from 24 - 18 °C. The soil type is clay-loam with organic matter content less than 0.02 %. The colour of the topsoil varies from light brown to dark brown and the pH ranges from 6.5 - 8.5. The field used for this study had an area of 0.4 ha and was incorporated into the crop rotation (cereals/legumes) management system of the farm. The field was first sprayed with glyphosate (one liter per hectare) post emergent to control grasses and sedges and some broad leaf and creeping weeds. After three weeks, the field was then disc harrowed and ridged.

The layout consisted of five ridges per plot (three main ridges and two discard ridges, one on either side of the main ridges) spaced at 0.75 m apart. Each plot size was 18.75 m^2 (gross) and was separated by a 1.5 m wide border margin on all sides. The materials used included a mixture of cashew nutshell + garlic bulb, cashew nutshell + African pepper (*X. aethiopica*), chilli pepper + garlic bulb. These were purchased from the local market in Samaru and mixed at 10:10 % w/w. There were a synthetic insecticide and

untreated control checks and all the treatments were replicated three times. The plots were arranged in a randomized complete block design.

SAMPEA 7, cowpea variety seeds dressed with Apron plus (1 sachet / kg seed) were sown three seeds per hole at 0.2 m apart in the first week of August in both years. A mixture of Galex (metalachlor 250 g a.i. and metobromuron 250 g a.i.) and Gramoxone (paraquat) was applied at a rate of 2.5 kg a.i./ha immediately after sowing to control weeds. The seedlings were thinned to two plants per stand at two to three 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. Four WAS, the plants received a tank mixture of Benlate (benomyl) and Dithane M45 (mancozeb) at 0.33 kg a.i. /ha to control fungal diseases. Fresh materials (500 g or 10 % w/w) of cashew nutshell, garlic bulb, African pepper were weighed separately into a wooden mortar and pounded while only 2 % chilli pepper was used due to its phytotoxicity at higher rates. The pounded materials were mixed in different buckets according to their respective treatments and 3.5 litre hot water (60 $^{\circ}$C) was added to each bucket, thoroughly stirred and allowed to stand overnight. The solutions were filtered with muslin cloth using 1.0 litre hot water. A 250 ml solution of 20 % w/v starch and bar soap each was added to the extracts and stirred. The buckets were labeled and taken to the field for spraying.

Field applications of extract mixtures and Uppercott (Cypermethrin + Dimethoate at 250 g a.i./ha. each) commenced at 7 WAS which coincided with the period of onset of flowers in this cowpea variety. Spraying started from 10.00 a.m to 12.00 p.m each day after insects sampling using a CP-3 Knapsack sprayer. All the pesticides were sprayed once every week for four weeks and whenever it rained within two hours of spraying, the extract mixtures were re-sprayed the next day.

Insect pests sampling was taken from 6.30 a.m to 9.30 a.m every seven days. Flower bud thrips (*Megalurothrips sjostedti* Trybom) and legume pod borers (*Maruca vitrata* Fab.) were sampled by random picking of 20 flowers from plants in each plot. The flowers were placed in vials containing 30 % alcohol and taken to the laboratory where they were dissected the next day and the number of each pest found was recorded. *M. vitrata* larvae were also assessed from 20 pods randomly picked from 10 plants in each plot. Assessment of both nymphs and adult coreid bugs (*Clavigralla tomentosicollis* Stal.) was based on visual observation of three plants randomly selected within three 1.0$\times$1.0 m quadrants, which were located randomly within the main ridges on each plot.

Pod density (a measure of efficacy of insecticide against thrips / borer larvae infestation on flowers) was assessed at 10 WAS by counting pods produced from a random sample of 10 plants per plot. Pod damage assessment involved counting the number of damaged pods per plant and dividing by the total number of pods produced per plant in a random sample of 10 plants per plot. These were expressed in percentages by multiplying by 100. Grain yield was recorded from threshed grains harvested from each plot. Ten plants were randomly inspected visually per plot for signs of phytotoxicity two days after each spraying.

All data were analyzed using Analysis of Variance (ANOVA) and treatment means were separated by Student Newman Keuls test at 5% (SAS Institute, 1989).

3 Results

In 2000 and 2001, the mean numbers of *M. sjostedti* in cashew nutshell + garlic bulb and chilli pepper + garlic bulb extracts were lower than the values in cashew nutshell + African pepper and cashew nutshell + West African black pepper extracts. Although, Uppercott (Cypermethrin + Dimethoate at 250 g a.i./ha. each) treatment recorded the lowest number of thrips in both seasons, the figures did not significantly differ from the first two extract mixtures. All the extract mixtures treatments had significantly ($P < 0.05$) lower thrips numbers than the untreated control (Table 1). *M. vitrata* numbers were lower in Uppercott treated plots but were not significantly lower than in the extracts mixtures treated plots. However, all the treated plots had significantly lower numbers of *M. vitrata* than in the untreated check in both seasons. Uppercott caused the highest reduction in pod sucking bugs infestation but did not perform better than plant extracts mixtures. However, the number of pod sucking bugs in cashew nutshell + African pepper, African pepper + bitter leaf extract mixtures were not significantly lower compared with the untreated control in both seasons (Table 1).

Table 1: Effects of botanical mixtures on pest's infestation on cowpea.

Treatment	*Mean number of insects 2000*			*Mean number of insects 2001*		
	Thrips / flower	*Maruca spp./ flower and/or pod*	*Clavigralla spp. / plant*	*Thrips / flower*	*Maruca spp./ flower and/or pod*	*Clavigralla spp. / plant*
CNC + XLP	1.83 ^{b}	0.92 ^{b}	2.42 ^{ab}	2.0 ^{b}	0.92 ^{b}	2.0 ^{ab}
CNC + BLP	2.25 ^{b}	0.50 ^{b}	1.50 ^{b}	2.17 ^{b}	0.50 ^{b}	1.67 ^{b}
CNC + GLB	0.83 ^{bc}	0.68 ^{b}	0.92 ^{b}	0.83 ^{bc}	0.67 ^{b}	1.17 ^{b}
CPP + GLB	0.84 ^{bc}	1.92 ^{b}	1.16 ^{b}	0.83 ^{bc}	1.17 ^{b}	1.33 ^{b}
XLP + BTL	2.0 ^{b}	1.25 ^{b}	2.17 ^{ab}	2.17 ^{b}	1.34 ^{b}	2.33 ^{ab}
Uppercott	0.17 ^{c}	0.17 ^{b}	0.25 ^{b}	0.25 ^{c}	0.25 ^{b}	0.42 ^{b}
Control (0.0)	3.83 ^{a}	3.83 ^{a}	4.59 ^{a}	4.84 ^{a}	4.42 ^{a}	5.84 ^{a}
S. E. $\pm$	0.51	0.83	0.79	0.47	0.75	0.74

Means followed by the same character(s) in a column are not significantly different by SAS-SNK test at ($P < 0.05$).
Keys: *CNC* – Cashew nutshell, *XLP* – African pepper, *BLP* – West African black pepper, *CPP* – Chilli pepper, *GLB* – Garlic bulb, *BTL* – Bitter leaf (*Vernonia* sp.)

Generally, higher pod density was obtained per plant in all the treated plots compared with the untreated plots (Table2). Uppercott treatment recorded the highest ($P < 0.05$) pod density per plant compared with plant extracts mixture treatments. Chilli pepper + garlic bulb and cashew nutshell + garlic bulb extract mixtures gave higher pod density than the other two plant extract mixtures. The extent of damage caused by hemipterous insects on cowpea pods sprayed with different mixtures of plant extracts is presented in Table 2. The highest reductions of pod damage among plant extracts

were observed on plots treated with cashew nutshell + West African black pepper which were significantly ($P < 0.05$) lower than in the other extract mixtures sprayed plots. Next to this was cashew nutshell + garlic bulb treated plots. Uppercott sprayed plots recorded the least pod damage of all the treated plots while the untreated control had the highest ($P < 0.05$) pod damage in the two seasons. Grain yields were substantially increased ($P < 0.05$) over the untreated control check following the application of plant extracts mixtures (Table 2). Yields obtained from plots sprayed with cashew nutshell + West African black pepper, cashew nutshell + garlic bulb were superior ($P < 0.05$) to those of chilli pepper + garlic bulb, African pepper + bitter leaf while cashew nutshell + garlic bulb mixture was not superior to cashew nutshell + African pepper. However, Uppercott sprayed plots recorded the highest ($P < 0.05$) grain yield compared to the other plant extracts mixture treatments in the two seasons.

Table 2: Effects of botanical mixtures on mean pod density, pod damage (%) and grain yield of cowpea.

Treatment	*2000*			*2001*		
	Pod density per plant	*Pods infested per plant (%)*	*Grain yield (kg/ha)*	*Pod density per plant*	*Pods infested per plant (%)*	*Grain yield (kg/ha)*
CNC + XLP	32.94 ^{b}	20.78 cd	640.26 d	32.28 ^{b}	20.57 ^{cd}	633.86 ^{d}
CNC + BLP	30.39 ^{b}	15.07 ^{e}	723.33 ^{e}	29.78 ^{b}	14.92 ^{e}	716.10 ^{e}
CNC + GLB	41.33 ^{c}	18.62 ^{d}	690.66 ^{de}	40.50 ^{c}	18.43 ^{d}	683.75 ^{de}
CPP + GLB	42.28 ^{c}	22.69 ^{c}	587.98 ^{c}	41.43 ^{c}	22.46 ^{c}	582.10 ^{c}
XLP + BTL	32.89 ^{b}	25.71 ^{b}	480.67 ^{b}	33.23 ^{b}	25.45 ^{b}	475.86 ^{b}
Uppercott	49.83 ^{d}	11.36 ^{f}	1273.33 ^{f}	48.83 ^{d}	11.25 ^{f}	1201.20 ^{f}
Control (0.0)	8.62 ^{a}	89.29 ^{a}	193.78 ^{a}	8.45 ^{a}	88.40 ^{a}	192.04 ^{a}
S. E. $\pm$	1.61	0.98	17.64	1.33	0.69	12.67

Means followed by the same character(s) in a column are not significantly different by SAS-SNK test at ($P < 0.05$).
Keys: *CNC* – Cashew nutshell, *XLP* – African pepper, *BLP* – West African black pepper, *CPP* – Chilli pepper, *GLB* – Garlic bulb, *BTL* – Bitter leaf (*Vernonia* sp.)

4 Discussion

Different formulations of plant extracts mixtures caused various degrees of reductions of the target pests and also offered various levels of protection to the flowers and pods against damage by thrips, pod borer larvae and pod sucking bugs. Although, the mixtures of cashew nutshell + garlic bulb, chilli pepper + garlic bulb controlled thrips and pod sucking bugs better than cashew nutshell + West African black pepper, they were inferior to the latter on pod borers control. Thus, while there were higher pod densities in the former, the latter (cashew nutshell + West African black pepper) caused drastic reduction of pod damage and higher grain yield on treated plots. This study ranked cashew nutshell + West African black pepper, cashew nutshell + garlic bulb, and cashew nutshell + African pepper (in that order) superior to chilli pepper + garlic bulb, African pepper + bitter leaf extract mixtures in grain yields.

These findings confirmed earlier work done by some researchers (Allen *et al.*, 1944; Snoek, 1984; Jung, 1938), which indicated that combining two or more plant materials in botanical formulations is more potent than when only one plant material is used. However, the performance of chilli pepper + garlic bulb mixture in this study was contrary to the findings of Yepsen (1976) who reported that mixing two finely grated garlic bulbs and two teaspoon chilli peppers into four liters of hot water in which a small nut sized piece of soap was dissolved was effective against caterpillars infesting fruit trees. In Nigeria, some of the plant materials used in this study have been found individually effective in storage pest's control (Oparaeke, 1997; Oparaeke and Bunmi, 2004; Oparaeke and Daria, 2004; Olaifa and Erhun, 1988; Ivbijaro, 1990; Okonkwo and Okoye, 1996). Information on the use of plant extracts for field pests control is limited. However, Oparaeke (2004), Olaifa *et al.* (1987) and Amatobi (2000) have shown that these plant extracts exhibited varying degrees of efficacy on pests of field cowpea. This is the first time a mixture of plant extracts are employed to effectively checkmate the nuisance of pests on cowpea plants in Nigeria.

The results of the present study indicate that extract mixtures of cashew nutshell, garlic bulbs and West African black pepper can significantly reduce thrips, pod borers and pod sucking bugs on cowpea plants. Although, during the investigations the untreated control harboured more pod sucking bugs, there were no statistical difference between it and the treated plots. This could be attributed to the high mobility of the coreid bugs and the weeklong interval between treatment applications, which might have allowed reinfestation of the treated plots. Another reason might be that the bugs prefer to feed on cowpea pods and are easily attracted to pods whether sprayed or unsprayed, though without causing much damage to the latter as observed in this study. The major active principles contained in the plant materials include, West African black pepper - piperine and chavicine, phenylpropanoid, myristicine (sarisan, safrole and elemeicin) and 5 1-mono-sesquiterpenoids (Oliver, 1959; Su, 1977); garlic bulb - mainly sulphur compounds such as Allicin, Di-allyl-disulphide, Allim (Khritchevsky, 1991), thioacrolein, ajoene, 2-propene sulfenic acid, 2-propene thiol and propylene (Jain and Apitz-Castro, 1993). African pepper contains annonaceine (Watt and Breyer-Brandwijk, 1962; Kerharo and Adams, 1974), which may have repellent activity (Burkill, 1985). Cashew on the other hand contains cardole (which is caustic and vesicant on skin) and anacardic acid (Burkill, 1985). These active principles contained in the respective materials when in combination with each other may act synergistically to enhance the toxic substances in the extract mixtures either by increasing or prolonging their effects.

5 Conclusion

The results of this investigation shows that botanical mixtures could form the basis for a successful formulation and commercialization of Biopesticides in developing countries, where low input agriculture is in vogue. In Nigeria, these plants are readily available in the local markets all the year round for farmers' use to protect their crops. Since the materials are used in ethno-botany for the treatment of various ailments, they are safe,

cheap, easily biodegradable, and technologically and environmentally friendly. They could provide valuable alternatives to the synthetic insecticides in the management of post flowering insect pests of cowpea in limited resource farmers farms. Further studies are required to ascertain their optimum mixture levels and spraying schedules for optimum grain yield.

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