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A REVIEW ON THE USE OF PLANT MATERIALS AS PESTICIDES IN AGRICULTURE

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ABSTRACT

Plant materials have substantially been used in the management of pests in agriculture as an alternative to synthetic chemicals which are detrimental to man and environmental health. Some of these effects include; insect pest resistance and pest resurgence, secondary pest outbreak, pollution of surface and underground waters, toxicity to beneficial insects and their non-biodegradable nature among others. This article reviews literature on the preparation and use of plant materials as pesticides in agriculture. Plant parts usually used include leaves, stems, roots, barks, flowers and seeds. Researchers have shown that bio-active ingredients possessed by plants applied in the form of powders, extracts or oils significantly cause feeding and/oviposition deterrent, insect growth regulatory effect, metamorphosis inhibition, reduction in insect populations, reduction in eclosion and development. Some common insect pests controlled include; cowpea bruchids [*Callosobruchus maculatus* (L.)], maize weevils [*Sitophilus oryzae* (L.)], Red flour weevil, [*Tribolium castaneum* Herbst.], Aphids [*Aphis craccivora* Koch], legume pod borer [*Maruca vitrata* (Geyer)] and many others. The use of plant products in soil amendment significantly increases grain yield of millet and assist in the management of Striga. The use of shea butter oil and refrigeration increases shelf life and aroma of fruits. Powders and extracts of plant materials such as neem [*Azadrichta indica* A. Juss], garlic [*Allium sativum* L], ginger [*Zingiber officinale* L], tobacco [*Nicotiana tabacum* (L)] and moringa [*Moringa oleifera* (Lam)] are potential biopesticides that can be exploited by farmers. Bioassays of these plants have shown that they are safe, locally available and eco-friendly and can therefore be recommended for use in the management of insect pests in the field, as well as in storage.

Key words: Plant materials, insect, pesticides, management, and agriculture.

1. INTRODUCTION

Agriculture involves the cultivation of crops and rearing of animals for the benefit of man. This ranges from field crops, vegetables, floriculture to animals. Series of activities are involved in the cultivation of crops from sowing through harvesting to storage. The crops are protected from damage due to pests and diseases at various stages of development in order to achieve the aims and objectives of growing them. The soil contains many soil pests that affect crops growth and development. There are different species of pests that attack seeds and seedlings inthe soil, such as Army worms attacking pearl millet at seedlings (Taylor, 2007) and vegetative growth stage. Some insects attack the leaves e.g. leaf beetles, *Ootheca mutabilis* (Schȍnherr) and spiny pod bug, *Clavigralla tomentosicollis* Stol on cowpea, respectively (Aliyu *et al.*, 2007; Ahmed *et al.*, 2009). Diamondback moth, *Plutella xylostella* (Linnaeus) attacking cabbage leaves (Varela *et al.*, 2003). Some attack the flowers such as cowpea pod-borer, *Maruca vitrata* (Geyer), others attack the fruits such as Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) on Mango.

2. The use of plant products as biocontrol agent in Agriculture.

The use of plant products in pests and diseases control in Agriculture dates back to the Roman Empire. During the Persian King Xeres 400 B.C., children were deloused with powder obtained from dried flowers of a plant known as Pyrethrum (*Tonacetum cinerariaefolium* Trevir, Compositae). The ancient Romans used false hellebore, *Veratrum album* (Verat) as rodenticides, the Chinese were credited with discovering the insecticidal properties of *Derris* spp (Deguellia). The use of plant products that possess biopesticidal activity has been particularly active, especially in the last 30 years (Lale, 2001). Ajayi *et al.* (1987) stated that farmers in many parts of Nigeria use locally available materials of plants origin to treat their grains or seeds before storage and claimed that these materials successfully controlled infestation against storage insect pests.

2.1 Commonly used plants in plant disease control

The use of plant materials in diseases control has also been in use. One of the plant products that was actively researched and was proved lethal to pathogenic organisms was neem. Salako *et al.* (2008) reported the use of neem leaf extract (NLE), mahogany bark extract (MBE) and benomyl (fungicide) to control brown blotch disease of cowpea, late leaf spot ground nut, *Phaseoisaripsis personata* [Bark & Curt] V. Arx.

Plants are like natural laboratory where great number of chemicals are biosynthesized and may be considered as the most important sources of chemical compounds. Different parts of plants are used in protecting crops from the menace of pests and diseases. Prakash *et al.* (2008) stated that, direct spray application of various extracts of biologically active plant products can be used such as leaves, stems, roots and whole plants especially for the control of soft bodied insect pests which feed on the leaves and tender plant parts. Lale (2001) found that, of the several plant species screened, *Azadirachta indica* A Juss, *P. guineenses* and *Dennettia tripetla* Bak are among the most effective, with broad spectrum of activity in pest control. Flowers are known to possess pesticidal properties. Adenakan *et al.* (2013) recommended the use of flowers of moringa as they were found to significantly cause mortality on bruchid beetles. A list of plants use in insect pests control is presented in Table 1.

Onolemhemhen *et al.* (2011) reported the efficacy of Ethiopian/Guinea pepper, *Xylopia aethiopica* (Dunal) A. Rich and *Piper guineensis* (Schum & Thorn) seed powder on *Sitophilus oryzae* (L.) These products significantly controlled confused flour beetles applied at the rate of 100gm kg^{-1}. Ahmed *et al.* (2007) identified Tobacco, *Nicotiana tabacum* (L.); sweetsop, *Anona squamosa* L; garlic, *Allium sativum* (L.); neem, *Azadirachta indica* (A. Juss.) ; chilli pepper, *Capsicum frutescence* (L.); ginger, *Zingiber officinale* (L.) as plant materials having potentials as bio-control agents. Adenakan *et al.* (2013) recommended the use of *Moringa oleifera* (Lam) plant parts in the management of bruchid beetles on stored cowpea seeds.

Oils obtained from plants are also another important product for use in pest control. Ajayi *et al.* (1987) and Emeasor and Okorie (2008) independently reported the use of groundnut, *Arachis hypogeae* (L.) and Sweet orange, *Citrus sinensis* (L.) rind oils in suppressing cowpea seed bruchids (CSB) and maize weevils [*Sitophilus zeamais* (Mostchulsky)]. Plant materials with pesticidal properties are known to act on many species of insects. Ahmed *et al.* (2009) recommended the use of Tobacco, *N. tobacum*, Sweetsop, *A. squamosa*. and Garlic, *A. sativum* L. in the control of insect pests of cowpea as they were found to be very promising bio-pesticide. Solako *et al.* (2008) stated that plant materials or extracts can be used in the control of insect pests of stored agricultural commodities such as maize, cowpea, millet and rice. Table 3 shows examples of some of the insects that can be managed with plant materials.

2.2 Research works on botanicals as pesticides, the journey so far

Different plants and their bye-products were screened for use as biopesticides (Table 1). The parts exhibited different toxic actions on insect pests. Khan and Gumbs, (2003); Talukder *et al*, (2004) reported different toxicities to economically important stored product insects that include egg laying inhibition (oviposition), feeding deterrent, repellency, insect growth inhibition or gradual insect death with the use of plant products.

The effect of Permethrin and *Clausena anisata* on reproduction and damage of cowpea seed bruchid (CSB) was tested (Ogunwolu *et al.* 2002). Table 2 indicated that 5% of CSB adults died within seven days in untreated control. Plant parts (leaf, stem bark and root bark) of *C. anisata* except the stem bark significantly (P<0.05) increased adult mortality of Cowpea Seed Bruchid (CSB). Permethrin however proved most toxic but it was not significantly better than the leaf powder of the plant product. Several research results (Ogunwolu and Odunlami, 1996; Anarson *et al.*, 1993; Harborne, 1990) showed that the presence of secondary chemicals in *C. anisata* and in some other rutaceous plants, that apart from direct toxicity and growth inhibition, show repellency and feeding deterrence on some insect pests. The leaf extract of *C. anisata* ia also reported to showed slightly contact action on CSB. The extracts were shown to cause more than twice the level of mortality and also strongly deterred oviposition relative to the control treatment. All the extracts strongly suppressed insects' development to adult with leaf extract performing better (most effective). The leaf extract perform better than stem and root bark in reducing seed perforation by CSB. Root and stem bark extract were however less insecticidal. The order of effectiveness of the plant product is leaf > root bark > stem bark powders. Their extracts were however less insecticidal. The leaf may be richer in volatile/essential oils which shows ovicidal, toxic and deterrent effects on stored product insect Coleopteran and other insects (Ogunwolu *et al.*, 2002).

Neem [*Azadirhacta indicaI*], is a promising tree that is use widely in insect pest control and was found to be effective on a number of insect orders including Diptera, Orthoptera, Homoptera, Thysanoptera, Coleoptera, Lepidoptera, Hymenoptera and Heteroptera. Its chemical constituent is a mixture of 3 or 4 related compounds. Significant of these compounds are the limonoids-*azadrachtin*, s*elannin*, m*eliantriol* and n*imbin* (NRC, 1999). Salako *et al.* (2008) reported the use of neem in several ways such as in cowpea seed dressing, control of brown blotch disease of cowpea, yam seed dressing for the control of yam scale insects, evaluation of neem extract for the control of g/nut leaf spot, control of rhizoctonia root-rot (RRR) and root-knot *Meloidogyne* spp in cowpea. Neem compounds were found to act on insects in various ways; disrupting or inhibiting the development of eggs, larvae, or pupae, blocking the moulting of larvae or nymph, disrupting mating and sexual communication, repelling larvae and adults, deterring females from laying eggs, sterilizing adults, poisoning larvae and adults, deterring feeding, blocking the ability to swallow, sending metamorphosis awry at various stages, and inhibiting the formation of chitin (NRC, 1999).

Research on the effect of *X. aethiopica* seed powder on mortality of *S. oryzae* (Table 3) showed that the effect of *X. aethiopica* seed powder was in effect 24 hrs after infestation. The mortality of *S. oryzae* 24 hrs after treatment was reported to increase with increasing rate of application. The differences between the control and the powder treated seeds were significant (P<0.001). The phytotoxic effect of *X. aethiopica* exhibited insecticidal properties hence lethal to *S. oryzae*. It was reported to function more as an insect pest repellent and perhaps caused suffocation and death. Onolemhemhen and Oigiangbe, (199)1; Lale, (1992) ; Emeasor and Okorie (2008), all reported insecticidal potency of *X. aethiopica* extract against a wide range of insect pests.

Research on the effect of different parts of *Moringa oleifera* powder on oviposition, eclosion and development of bruchid beetles on cowpea seeds was carried out (Adenakan *et al.*, 2013). The result (Table 4) indicated that the flower powder of moringa plant recorded the lowest number of eggs laid (oviposition). This they said was significantly (P<0.05) different from the values obtained in the control experiment. The result also showed that application of moringa flower powder significantly (P<0.05) reduces mean number of eggs hatched compared with the control. Further results showed that leaf and stem powder were statistically similar in their efficacy. The same result was obtained when Moringa flower powder and a synthetic chemical (Pirimiphos-methyl) were compared in their capacity to reduce the mean number of eggs hatched. The findings also showed that the mean number of dead bruchids obtained with the application of flower and leaf powders respectively were significantly different with that obtained in the control. There was no significant difference ($P<0.05$) in the number of eggs hatched when leaf and stem powders were compared. (Adenakan *et al*., 2013). Adenikan and Sosanya (2006) reported that the flower powder of *Plumeria rubra* exhibited great potential as a biocontrol agent against *C. maculatus* in storage.

Powdered neem seeds have been used in amending Striga infested field grown with millet crop (Table 5). The plant materials are used in order to increase nutrient status of nutrient-deficient and *Striga* infested soils. Thus, controlling *Striga* and improving millet grain yield. The result showed that increasing powdered neem seed rate significantly increased the grain yield of millet better than the control (without application).

2.3 Forms of plant materials are prepared for application

1. Powders

Parts of the plant used are leaves, stems, seeds, roots or the whole plant. These are air dried (Adenakan *et al*., 2013), shade dried (Ahmed *et al*. 2007; Ahmed *et al*., 2009), sun dried or oven dried (Ogunwolu and Oludami 1996). The materials are grounded into powder using mortar and pestle or grounded electronically using blender or Culatt TZ grinder (Ahmed *et al*., 2009; Ogunwolu and Idowu, 1997). It will then be sieved using sieve of appropriate sizes (Ahmed *et al*., 2009). The resulting fine powder is used in dusting the surface of the plant intended to control the insect such as leaf feeding beetles, *O. mutabilis*. Plant products mainly in the form of powders were used as protectants of both grains and dried fish. Powders were obtained from leaves, roots, flowers, fruits and seeds and to a lesser extent from bark and stem (Lale, 2001). Ogunwolu *et al*. (2002) reported the toxicity of *Clausena anisata* Hook leaf powder and its extract to cowpea seed bruchid (CSB) as found in Table 2 and 6.

2. Extracts

Plant materials to be prepared are pulverized and the appropriate quantity soaked in water and the mixture is shaken and stirred thoroughly and applied directly (Ahmed *et al*., 2007) or allowed to stand overnight (Ahmed *et al*., 2009), and the mixture is filtered over a muslin cloth. The filtrate obtained now gives the extract (Table 2 and 7) that can be diluted with an appropriate quantity of water to give the spray solution (Oparaeke *et al*., 2005; Ahmed *et al*., 2009). Ogunwolu and Idowu (1997) reported that the crude extract is homogenized in methanol: water solvent. The suspension is evaporated, acidified and extracted with chloroform.

3.0. Mode of action of botanicals

An insecticide is any substance that performs a biocidal action on insects due to the nature of its chemical structure (Talukder, 2006). According to Prakash *et al*. (2008), botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides as they possess an array of properties including toxicity to the pest, repellency, antifeedant and insect regulatory activities against pests of agricultural importance. Talukder (2006) reported that much work has been carried out in the isolation and identification of biologically active natural products that in some ways affect the behaviour, development and/or reproduction of pests including insects.

1. Feeding Deterrent/Antifeedant

Antifeedant is sometimes referred to as feeding deterrent. It is defined as the action of a chemical that inhibits feeding although does not kill the insect directly (Manukata, 1977). Saxena *et al*. (1988) defined antifeedants as chemicals which retard or disrupt insect feeding by rendering the treated materials unattractive or unpalatable. In this situation, the pests get starved to death.

2. Repellency

This is the use of plant products having a pungent or irritating odour. Takulder (2006) defined repellency as a chemical stimulus which causes the insects to make oriented movements away from the source of the stimulus. The use of plants such as Pine tree, *Eucalyptus globules* Labille, rue, *Ruta graveolens* Linn., Garlic, *A. sativum* as repellant has been reported Ahmed *et al.* (2009). Talukder (2006) reported the use of essential oil of *Artemisia annua* L. as repellant against storage pests such as *Tribolium castenum* Herbst and *Callosobruchus maculatus* (L.).

3. **Insect Growth Regulatory plant products**

Plant products are used as biopesticides in arresting insect growth. The effect of growth regulatory plant products can be seen in several ways. There are those molecules inhibiting metamorphosis. That is compounds preventing completion of life cycle from taking place at the right time or force the insect to go through an early metamorphosis, so that development takes place at a time not favourable for the insect National Research Council (NRC) (1992). The plant products showed deleterious effects on the growth and development of insects and reduced larval and pupal weight significantly, lengthened the larval and pupal periods and reduced pupal recovery and adult eclosion (NRC, 1992; Talukder, 2006). Others have been observed to alter hormones related to this function so that insects suffer malformation, are made sterile, or killed. NRC (1992) reported action of neem extract on some insect pests by way of disrupting their life cycle.

4. Toxicants

Toxicants are specific types of chemicals, which directly kill insects. Addor (1995) referred to as insecticides. Prakash *et al.* (2008) reported toxicity of plant products against soft bodied insects such as aphids. Oils from such product were found to have toxic effect on some insect pests such as *Sitophilus oryzae* (L.), *S. zeamais*, *T. castenum* and a number of post-flowering pests of cowpea (Emeasor and Okorie, 2008; Sule and Ahmed, 2009; Ahmed *et al.*, 2009; Onolemhemhen *et al.*, 2011). Table 4 and 5 further explained some of the plant materials that showed toxicity to some insect pests.

5. Soil amendment

Amendment of soil with effective plant materials is intended to control soil inhibiting pests like fungi, grubs, root-nematodes or to increase fertility status of soils. Amendment of soil with de-oiled cakes of neem, *A. indica*, groundnut, *Arachis hypogeae* L., sesame *Sesamum indicum* L. are well known potential examples to minimize root-knot nematode populations and losses (Prakash, *et al.*, 2008). Yar'adua *et al.* (2005) identified Striga as one of the most destructive of all weeds and is found endemic in the whole of Africa, South of the Sahara, particularly in the Sahel and Savanna ecological zones. Amendments of Striga infested soils as found in Table 6 with powdered fruits of neem at the rate of 4-8 kg/m^2 significantly increased yield and yield components of pearl millet better than the control (Yar'adua *et al.*, 2005).

4.0 Role of oil from plant materials in reducing microbial activity and extending shelf life of fruits

It is a known fact that fruits are still living even after detachment from the mother plant. As such, physiological processes are still continuing (Lymam, 2000). The use of fungicide and other chemicals has been carried out to arrest metabolic activity of micro-organisms and control diseases of crops (Opadokun and Onwugulun, 1984). Tsado (2012) observed that it seems better to slow down the metabolic/physiological changes that lead to loss of the fruits, thus extending the shelf life of such fruits. However, search for botanical-products that can be used was actively undertaken. Use of waxes of various compositions in coating fruits to extend shelf life was reported (Kolattukudy, 2003). Tsado (2012) reported the use of shea nut (*Vitteleria paradoxom* C.F. Gaertn.) butter as skin coat for retarding ripening and storage of banana, *Musa* spp. Table 8 showed that coating banana fingers with shea nut butter and refrigerating at 10°C significantly extends the days to ripening of bananas. This was achieved by the lenticels being sealed, there by impairing rate of respiration. Coating pine-apple with shea nut butter was also reported to be use in reducing post-harvest field heat, loss of water, extends pineapple aroma and its appearance, thus making it more appealing than the other treatments (Tsado, 2013).

CONCLUSION

Search for an alternative method of pest control over the use of synthetic chemicals in agriculture has yielded positive results. Many bioassays of plant materials such as neem, garlic, Ethiopian/Guinea pepper and moringa proved potent in the management of insect pests in the field as well as in storage. These materials are cheaply sourced locally, no development of pest resistance and resurgence, non-toxic to man and beneficial insects, highly biodegradable and eco-friendly. The use of plant materials as pesticides is hereby recommended.

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Table 1: Insect species controlled by different plant products

Plant species	Family	Plant parts	Activity	Kind of insect control	Source
Clausena, *Clausena anisata* Hook	Rutaceae	L, S, R – P	Mor	*Callosobruchus maculatus* (Fab)	Ogunwolu *et al.* (2002)
Sweetsop, *Anona squamosa* (L.)	Annonaceae	E	Ins	*Clavigralla tomentosicollis* (Stol)	Ahmed *et al.* (2009)
Chilli pepper, *Capsicum frutescence*	Solanaceae	E	Insl	*Maruca vitrata* (Geyer)	Ahmed *et al.* (2009)
Ginger, *Zingiber officinale* (L.)	Zingebraceae	E	Ins	*Aphis craccivora* Koch	Ahmed *et al.* (2007)
Garlic, *A. sativum* (L.)	Liliaceae	E	Ins	*Riptortus dentipes*	Ahmed *et al.* (2007)
Neem, *Azadrichta indica* (L.)	Meliaceae	E	Ins	*Anoplocnemis curvipes*	Ahmed *et al.* (2007)
Tobacco, *Nicotiana tabacum* (L.)	Solanaceae	E	Ins	*Megalurothrips sjostedi* (Tryb),	Ahmed *et al.* (2009)
Guinea pepper, *Xylopia aethiopica* (Dunal)	Annonaceae	S P	Ins	*Sitophilus oryzae* (L.)	Onolemhemhen *et al.* (2011)
Drumstick, *Moringa oleifera* Lam	Leguminoceae	L, S, R, F	Ovd	*Callosobruchus maculatus* (Fab)	Adenakan *et al.* (2013)
Sweet orange, *Citrus sinensis* L.	Rutaceae	O	Mor	Cowpea seed bruchid	Emeasor and Okorie (2008)
Groundnut, *Arachis hypogeae* L.	Leguminoceae	O	Mor	Cowpea seed bruchid	Ajayi *et al.* (1978)
Oleander, *Nerium oleander*	Apocynaceae	S	Ins	white flies, *Bemisia tabaci*	Stol (2005)
Coriander, *Coriandrum sativum*	Umbelliferae	L, S	Rep	spider mite	Stoll (2005)
Bitter yam, *Dioscorea hispida*	Dioscoreaceae	T	Ins	white peach scale	Stoll (2005)
Eupatorium, *Eupatorium odoratum*	Asteraceae	P	Rep	snail and fish poison	Stoll (2005)

L = leaf, S = seed, R = root, P = whole plant, E = extract, P = powder, F = flower, O = oil, Mor = mortality, Ins = insecticidal, Ovd = oviposition deterrent, Rep = repellent

Table 2: Effect of treatment of cowpea seeds with Permethrin and *Clausena anisata* on *Callosobruchus maculatus* reproduction and damage within 7 days after treatment

Treatment	% mortality	No. of eggs/females	No. of perforations	% seed
		Powder		
Control	5.00	47.20	45.00	96.70
Permethrin	100.00	0.00	0.00	0.00
Leaf	76.80	12.40	0.30	2.00
Root bark	63.20	13.20	4.00	8.90
Stem bark	29.50	21.60	4.70	27.40
		Extracts		
Control	15.00	42.50	34.11	92.70
Leaf	38.80	6.60	0.30	1.40
Root bark	11.80	11.30	3.30	22.80
Stem bark	15.30	24.90	10.00	49.20

Rate of application was 2.5% concentration. ** Percentage corrected by Abbot's formula for mortality control. Means within columns with different letter(s) are significantly differ @ p = 0.05. Source: Ogunwolu *et al.* (2002)

Table 3: Effect of *Xylopia aethiopica* seed powder on adult *Sitophilus oryzae* hours after treatment

Xylopia aethiopica	24hrs	48hrs	72hrs	96hrs	120hrs
Powder (20ml kg^{-1})	←	mean number of dead adult			→
0	0.0^{d}	0.33^{d}	1.33^{d}	2.66^{d}	3.33^{d}
10	0.0^{d}	1.00^{c}	2.33^{d}	3.00^{d}	4.00^{d}
20	1.33^{e}	2.64^{b}	5.00^{e}	6.67^{e}	8.31^{e}
50	3.33^{b}	4.67^{a}	10.00^{b}	13.67^{b}	15.33^{b}
100	4.67^{a}	5.33^{a}	11.67^{a}	14.67^{a}	17.53^{a}
Overall	1.87^{a}	2.80	5.80	8.13	9.60
LSD	0.69	0.81	1.86	0.49	1.26
CV%	19.6	1.53	17.00	3.20	7.0

Means followed by the same letter(s) within a column are not significantly different at 1% (P>0.01) by Duncan's Multiple Range Test. Source: Onolemhemhen *et al.* (2011)

Table 4: Pesticidal effects of *Moringa* plant parts and Pirimiphos-methyl on oviposition, eclosion and development of bruchid beetles on cowpea seeds

M. oleifera Products	Mean no. of eggs laid ± SE	Mean no. of eggs hatched ± SE	Mean no. of dead bruchids beetles ± SE
Leaf	14.32± 2.12b	2.64 ± 0.94c	2.10 ± 0.20c
Stem	13.61 ± 3.61b	2.30 ± 1.23c	2.01 ± 0.38c
Root	11.38 ± 4.32b	4.21 ± 1.23b	3.04 ± 1.01b
Flower	6.40 ± 2.10c	0.31 ± 0.11d	4.13 ± 1.46b
Actellic dust+	0.12 ± 0.03d	0.00 ± 0.00d	6.00 ± 1.36a
Control	48.15 ± 6.17a	43.31 ± 3.16a	1.20 ± 1.23c

N = 30g of cowpea seeds, r = 4 replications, rate = 0.5g powder/30g cowpea, + = Pirimiphos-methyl

Source: Adenakan *et al.* (2013)

Table 5: Effect of amending *Striga* infested soil with powdered fruits of neem tree on mean grain yield of millet at Katsina during the 2002-2003 rainy seasons

	Mean grain yield (g)/plot			
	2002		2003	
Treatment Dose (kg/m^2)	Site 1	Site 2	Site 1	Site 2
0.00 (control)	354.40c	323.95c	667.50b	427.50b
4.00	765.84b	891.20b	1840.00a	1372.50a
6.00	1299.70ab	1373.63ab	1908.50a	1482.50a
8.00	2040.18a	2084.88a	2012.50a	1915.00a
LSD (P = 0.01)	622.73	514.63	756.24	833.85
Coefficient of Linear correlation, r	0.95	0.97	0.84	0.98
Multiple Determination Coefficient, R^2	1.00	0.99	0.95	0.99

* = Treatment means followed by common letter(s) within columns are not statistically different at 1% level of significance by LSD. Source: Yar'adua (2005)

Table 6: Effect of plant extracts on the population of some post flowering insect pests of cowpea plant, 24 hours post treatment during the 2005 planting season in Bauchi.

Treatments	*C. tomentosicollis*		*M. vitrata*	
	24 HBS	24 HAS	24 HBS	24 HAS
A. squamosa (sweetsop)	0.67	0.01[a]	50.3	3 27.0[bc]
C. frutescence (Chili pepper)	2.3	0.7[ab]	41.33	22.67[a]
A. sativum (garlic)	2.67	0.0[a]	53.33	29.67[c]
Z. officinale (ginger)	4.0	3.7[b]	71.67	26.67[bc]
A. indica (neem)	2.7	2.67[ab]	59.33	24.67[ab]
N. tabacum (tobacco)	5.0	2.01[ab]	99.0	23.33[a]
Control	1.67	7.7[c]	72.67	43.33[d]
NSK (0.05)	NS	2.86	NS	2.48

HBS = Hours Before Spray, HAS = Hours After Spray, Means within a column followed by the same letter(s) do not significantly differ according to Student Newman Keuls ($p<0.05$) test. Source: Ahmed *et al.* (2009).

Table 7: Effect of plant derived biopesticides on the population of some insects of cowpea at podding stage 24 hrs post treatment during the 2004 planting season at Katsina

Treatment	*A. craccivora*		*C. tomentosicollis*		*R. dentipes*		*A. curvipes*	
	24 HBS	24 HAS	24 HBS	24 HAS	24 HBS	24HAS	24 HBS	24 HAS
Sweetsop	125.00	47.67a	26.00	4.67a	4.67	4.53a	14.67	2.33a
Chill pepper	0.00	0.00a	28.30	1.33a	3.67	0.33a	35.00	0.67a
Garlic	0.00	0.00a	30.67	2.00a	8.67	0.00a	19.67	1.00a
Ginger	0.00	0.00a	46.67	4.00a	2.67	1.00a	16.00	1.33a
Neem	27.33	36.70a	37.33	5.67a	0.67	1.00a	19.33	1.00a
Tobacco	0.00	0.00a	45.33	0.00a	4.67	0.33a	17.00	0.67a
Control	161.33	158.33b	54.00	20.33b	4.67	6.67a	20.67	4.96
NSK ($p<0.05$)	NS	57.65	NS	6.25	NS	2.96	NS	1.80

HBS = Hours Before Spray, HAS = Hours After Spray,

* Means within a column followed by same letter(s) do not significantly differ according to Students' Newman Keuls ($P<0.05$), ** NS Not significant. Source: Ahmed *et al.* (2007).

Table 8: Effect of wax treatment on number of days to fruit ripening

Treatment	Storage temperature (°C)		
	10	25	35
Coated Bananas	53	15	11
Uncoated Bananas	53	8	6

Source: Tsado (2012).

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