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Effectiveness of botanical formulations in vegetable production and bio-diversity preservation in Ondo State, Nigeria

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The study was conducted in the farming communities of Akure North and South Local Government Areas of Ondo State, Nigeria using pre-tested questionnaire/interview schedule, Key Informant Interview (KII), Focus Group Discussions (FGDs) and observation technique to generate data on: the types of vegetables grown, the major pest species, farmers control method in the field with emphasis on plant-based formulations and farmers' perceived efficacy of the plant botanical formulation on field crop pests. The data were analysed and results presented with descriptive statistics. Results indicate that *Telferia occidentale* (Ugwu) ranked first among vegetable grown for food (85%) and income generation followed by *Amaranthus hybridus* (African spinach) and Okra in that order. The major field pests identified were leaf borers (*Dysdercus superstitiosus*), webbers (*Sylepta derogate*), leaf hoppers (*Zonocerus variegatus*), sting bug (*Aspavia armigera*), weevils, leaf caterpillar (*Psara bipunctalis*) and flea beetles (*Podagrica* spp.). The most prominent among the materials used in the preparation of some of the identified botanical formulations are *Azadirachta indica* (Neem) leaves, *Piper guineense* (Black pepper), and *Nicotiana tobaccum* (tobacco). These plants were combined together in the preparation of botanical formulations to prevent and/or control pest in the field. It was ascertained from our FGDs that 75.8% of the farmers were of the opinion that indigenous control methods were as effective as synthetic pesticides. Vegetable farmers in the study area were found to create habitat for insect/bird predators as insect pest control strategy. It is evident from the result that the critical challenge of almost all the farmers was inability to estimate what proportion the ingredients used in plant-based formulations should be combined. As a result, standardized techniques of preparation, bio-safety and environmental guideline for efficacy should form important consideration in formulating botanicals for pest control methods.

Key words: Indigenous knowledge, vegetables, insect pests, botanical formulations, farmers.

INTRODUCTION

Vegetables are of invaluable nutritional value with considerable potentials for ameliorating some of the world's most widespread and debilitating nutritional disorders, birth deters, mental and physical retardation, weakened immune systems and blindness if sufficient quantities are available to the people in the right form, place and price (Ijarotimi et al., 2003). In addition to health significance of vegetable consumption, income

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earned from vegetable production has been identified as important contributor to household welfare, especially female headed households in Nigeria. Akinrinola (2009) stated that vegetable production contributed between 33 and 37% of family income among peri-urban vegetable farmers in 2008 production season and is a veritable source of consumption smoothening during off-season.

Vegetable production in Nigeria is predominantly subsistence and is characterized by cyclic deficits and poverty prompted by unreliable rainfall patterns, declining soil fertility and pest disease infestation (DFID, 2002). The latter however, constitutes one of the greatest challenges to increased vegetable production. In specific terms, insect pest infestations accounts for 20 to 60% pre-harvest vegetable losses (Sithanntham et al., 2003).

Although, the use of synthetic pesticides have been promoted in the Nigerian agriculture for the past 2 decades, vegetable farmers are yet to align the practice into their pest management system, owing to the subsistence nature of production and high poverty levels (Okunlola, 2007). They depend mainly on indigenous knowledge through the use of plant botanical formulations to mitigate the effect of insect pest damage on the farm (Perrin and Phillips, 2006). The indigenous knowledge system (IKS) is very important to the rural poor, vulnerable and marginalized population. More importantly, the high costs of synthetic pesticides and associated toxicity risks discourage vegetable farmers to integrate it into their pest management system (Schwab et al., 1995; Theunissen, 1995; Canhilal et al., 2006).

The fact that subsistence farmers in the tropics use indigenous knowledge (IK) methods to manage insect-pest infestation and the noble promise for the development of suitable, simple, natural and environmental friendly pesticide products call for scientific improvement and packaging of existing IK base and practices. Despite the enormous potential inherent in plant based indigenous pest control, the practices have remained largely under investigated with limited intervention and resources committed.

Studies in Nigeria have identified several indigenous plant based pest management options used for the control of field and storage pest. Adedire and Lajide (1999) studied the effect of some plant extracts on the toxicity and oviposition deterrence of cowpea storage pest *Corymbia maculate.*

Onifade (2000) examined the antifungal effect of *Azadirachta indica* on *Colletrichum lindemuthianum* Aduloju (2000) focused on the use of aqueous plant extracts in the control of field insect pest and Ofuya et al. (2005) affirmed that powders of Eugenia aromatic controlled the pest of stored cowpea seeds.

In another twist, Ofuya and Olowo (2006) investigated the fumigant toxicity of four volatile botanical oils to *Callosobrunchus maculatus* and submitted that it effectively controlled the pest their findings were corroborated by Okunlola (2007) and Ofuya and Longe (2009) when they separately reported that the botanical formulations effectively controlled both stored and field insect pests.

In sum, these findings showed that botanical formulations reduced pest infestations by ≥ 50% and increased crop yield by ≥ 60% compared to orthodox control (Okuku, 2002; Aduloju, 2000; Folorunso, 2004; Ogunjobi and Ofuya, 2007). Thus, in order to enhance improved vegetable production (thereby enhancing consumption of adequate quantity of micro nutrients) and alleviate poverty among rural poor in the peri-urban centers, the plant based IK of insect pest management have to be properly documented, scientifically rationalized standardized, for registration at a later date. It is against this backdrop that this research was conducted as an inventory study to document farmers' IK on management of key field pest.

Furthermore, the study documented farmers and the associated key field insect pests and their pest control methods in specific term, the study aimed to:

1. Identify major vegetable crops grown, their socio economic importance and harvest;
2. Examine major vegetable insect pests problems and their control methods in the field and
3. Highlight the plant based pest management options and their efficacy as control methods among vegetable farmers.

METHODOLOGY

The study was conducted in the farming communities of Akure North and Akure South Local Government Areas of Ondo State, Nigeria as shown in Figure 1. Ondo State is one of the six states in the South-West zone of Nigeria. The State is located in the forest zone with bi-modal rainfall pattern. The temperature ranges from 21 to 29°C with a high relative humidity. The annual rainfall varies between 1150 and 2000mm in the Northern and Southern parts, respectively. The state is endowed with luxuriant vegetation and pockets of swamp (Fadama) land located in different local government authorities in the State. These features provide a favorable environment for production of both cash and food crop. More importantly, pocket of fadama plots in the state supports the growth of different types of vegetables, especially during the dry season.

Data collection method

The study used both primary and secondary data sources. The primary data were collected through the use of pre-tested questionnaire/interview schedule, key informant interview (KII), focus group discussions (FGDs) and observation techniques (OT). The questionnaire served as a guide to the interview schedule, KII and FGDs. The survey instrument was designed to capture: (a) information on respondents' socio-economic data (b) types of vegetables grown, acreage, yield and losses due to pest (c) major pest species and farmers control method in the field with emphasis on plant-based formulations and (d) farmers' perceived efficacy of the indigenous control methods and (e) specimen of individual plant species known to have pesticidal properties on field crops pest were collected, identified and authenticated by experts from the Department of Crop Soil and Pest Management, the Federal University of Technology, Akure, Nigeria.

Also plants that farmers perceived to be nest for birds/insect

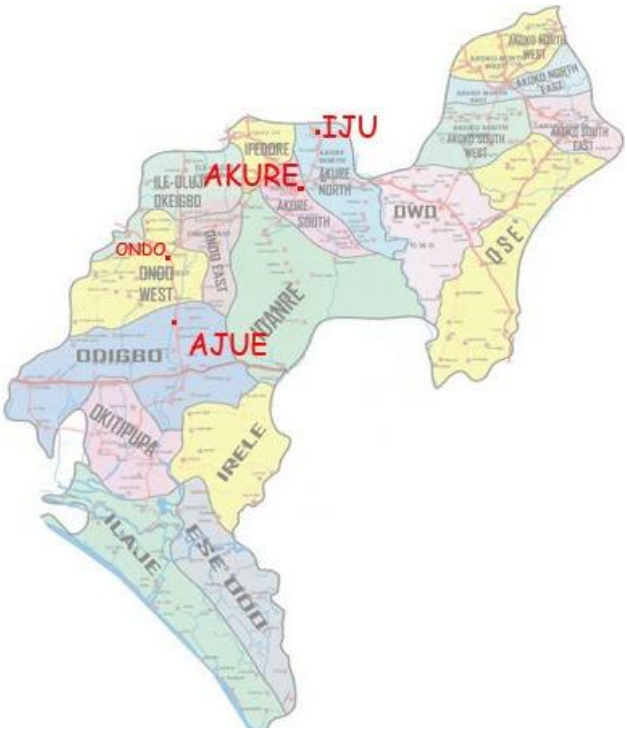

Figure 1. Ondo State Map.

predators that feed on vegetable pest were identified, the types of birds/insect predators they attracts were also collected. The questionnaire was pre-tested so as to ensure that respondents' have clear understanding and able to provide appropriate answers to issues contained in line with the objectives of the study.

Sampling techniques

Two Local Government Authorities (LGAs), Akure South and Akure North were purposively selected. In addition, fadama sites (wet land) located in Ayedun, Ago Alaye and Olode communities in Akure South LGA and Bolude camps, Bankemo, Ayadi and Loda communities in Akure North LG were also purposively selected. The selection was based on their proximity to the state capital, and the location of fadama sites which make vegetable production prominent and profitable than other local authorities in the state. In order to obtain a representative sample, 200 vegetable farmers were selected and interviewed based on the population of vegetable growers from the various fadama sites. This was distributed as follow: 25 from Ayedun, 30 from Ago Alaye, 38 from Olode, 40 from Bolude camp, 20 from Bankemo, 27 from Ayadi and 20 from Loda.

Data analysis

Data collected were analysed using descriptive statistics.

RESULTS

This section presents the findings of the study and discussed the implications of the research outputs. A total of two hundred respondents were interviewed, out of the respondents, 70% were females. The age of the respondents ranges between 25 and 60 years (Mean = 37.2 years). Their primary occupation was farming and it was subsistence in nature. The respondents' farming experience ranged from 5 to 40 years (mean 8 years). Majority of the respondents (75%) had primary education and only 10% had no formal education. A further analysis of respondents revealed that 80% of them were household heads owning farms and out of these 65% were female as shown in Table 1.

The significance of female headed households dominating vegetable production in the study area may not be unconnected with the view that vegetable production is a low income generating venture; hence most men are not favorably disposed to its cultivation as noted by Adebola (2008). This traditional belief may have contributed to small scale nature of vegetable production which has been particularly left in the hand of females using traditional production methods.

Major vegetable grown, their socio-economic importance, acreage and harvest

The result in Table 2 showed the varieties of vegetable grown in the study area and all were categorized as follows: Leafy vegetables (*Amaranthus hybridus*, *Corchorus olitorius*, *Telferia occidentale*, *Celosia argentea,*

Table 1. Demographic characteristics of vegetable farmers.

S/N	Socio-economic characteristics	Frequency	Mean value
	Age distribution		
	≤20 years	5	
	21 – 30	20	
A	31 – 40	35	38.7
	41 – 50	25	
	51 - 60	10	
	>60	5	
	Gender distribution	**%**	
B	Male	30	
	Female	70	
	Occupational distribution	**%**	
C	Farming	75	
	Trading	20	
	Artisan	5	
	Farming experience		
	< 10 years	15	
D	10 - 20	35	28.6
	21 - 30	25	
	31 - 40	20	
	>40	5	
	Educational distribution	**%**	
E	No formal education	10	
	Primary education	75	
	Secondary education	15	
	Gender of household head	**%**	
F	Male	35	
	Female	65	

Source: Field Survey, 2007.

Basella alba, Solanum nigrum; fruit vegetables (*Lycopersicon esculentum*, *Capsicum* spices, *Solanum melongena*, *Hibiscus esculenta*, *Cucumis melo*) and seed vegetables (*Phaseolus vulgaris*, *Arachis hypogea*, *Vigna unguiculata*, *Cucurbita pepo*). Leafy vegetables were most grown (77.8%) followed by fruit vegetables (8.7%) and seed vegetables (3.5%). Ugwu (*T. occidentale*), African spinach/amaranth (*A. hybridus*), Jute (*C. olitorius*) and okra (*H. esculenta*) were the most important vegetables grown in the study area. Ugwu ranked first among vegetable grown as food (85%), followed by African spinach, Ugwu, and Okra in that order were the most important vegetable grown for income generation (75%) (Table 2). Ugwu contributed the highest (between 55 and 49%) to households' income and amaranths contribute 15 to 25%. These vegetables were grown on an area ranging from 1000 to 1800 m^2. Crop yield from within this hectare varies from 0 to 200 kg/ha. It was anticipated that a hectare should produce between 120 to 350 kg. This discrepancy was due majorly to pest damages/losses and vagary rainfall pattern. From the FGDs, it was ascertained that the former however contributed a very significant proportion on the loss.

Vegetable pest problem and their control methods

As shown in Table 3, the major field pests identified were leaf borers (*Dysdercus superstitiosus*), webbers (*Sylepta derogata*), leaf hoppers (*Zonocerus variegatus*), sting bug (*Aspavia armigera*), weevils, leaf caterpillar (*Psara bipunctalis*), flea beetles (*Podagrica* spices). In *A. hybridus*

Table 2. Major vegetable grown, their socio-economic importance, acreage and harvest/loss.

S/A	Item	Frequency		
A	Major vegetable grown	%		
	Leafy vegetable	77.8		
	Fruit vegetable	8.7		
	Seed vegetable	3.5		
B	Socio-economic importance	Vegetable		
	Food	*Telferia occidentale* (85%)		
	Food and income	*Telferia occidentale*, African spinach, Okro (75%)		
C	Vegetable	Contribution to household income (%)		
	Telferia occidentale	49 - 55		
	Amaranths	15 - 25		
	Okra	7 - 10		
	Jute	3 - 6		
D	Vegetable	Area cultivated (ha)	Average yield/ha (kg)	Loss (kg)
	Telferia occidentale	1.3 – 1.8	200	150
	Amaranths	1.0 – 1.3	80	70
	Okra	1.0 – 1.1	60	60
	Jute	1.0 - 1.05	50	70

Source: Field Survey, 2007.

Table 3. Ranking of pest infestation on respondents farm.

Type of crop	Type of pest		Ranking
A. hybridus	Leaf borer	*Dysdercus superstitiosus*	1st
	Webbers	*Sylepta derogatus*	2nd
	Grasshopper	*Zonocerus variegatus*	3rd
	Sting bug	*Aspavia armigera*	4th
	Weevils	*Gasterodisus rhomboidalis*	5th
	Leaf caterpillar	*Psara bipunctalis*	6th
C. argentea	Webbers	*Sylepta derogatus*	1st
	Leaf borers	*Dysdercus superstitiosus*	2nd
	Leaf hoppers	*Zonocerus variegates*	3rd
	Weevils	*Lixus camerumuss*	4th
	Caterpillars	*Hymunia recurvalis*	5th
C.olitorus	Flea beetle	*Podagrica sp*	1st
	Leaf worm	*Acraea Terpsichore*	2nd
	Leaf hopper	*Zonocerus variegates*	3rd

Source: Field Survey 2007

field, leaf borers, Webbers, leafhoppers, sting bug, weevils (*Gasterodisus rhomboidalis*) and leaf caterpillars were the most problematic and ranked the highest field pest in the studied area. In *C. argentea* field leaf hoppers were found to be most notorious pest, also leaf borer and webbers were found to constitute major constraint to production. Leaf borers were key problem to 48.3% of the respondents while Webbers, leaf worms (*Acrae terpischore*), leaf hoppers and grasshoppers were problems to 25.2, 15.5 and 11% of the respondents, respectively. The pest problem emerged mostly during the rainy season.

Table 4. Plant products used to prepare the botanical pesticide formulation to control field pests.

S/N	NAME of plants (English, Local and/or Scientific name)	Mode of preparation to get the formulation and its application
1.	Diospyros affinin, *Anamirta cocculus*, *P. guineense*	The leaves of these plants are grinded, soaked in water for twenty four hours or more, after which the mixture is filtered and sprayed to act as repellant and or poison to vegetable insect-pest
2.	*Azadirachta indica*, *Cycas circinalis*, Cymbopogon and *Nicotiana tobaccum*	The leaves of *Cycas circinalis*, Cymbopogon and tobacco are parboiled and soaked for some time. After this, the mixture is filtered and kept for between 2 and 4 days, before being used. The solution produces repugnant odour that repells insect pest.
3.	*Azadirachta indica*, *Piper* guineense and *Carica papaya*	The leaves of these plant species are soaked in water and boiled for some time. Thereafter, the mixture is filtered and kept for 5 days. After the time, the filtrate is sprayed on the field.
4.	Tobacco leaves/powder with red pepper fruit and neem leaves	The leaves of neem leaves and tobacco together with red pepper fruits are sun-dried, grinded separately soaked in water in an air tight container. After 3 days the mixture is filtered and sprayed to crops.
5.	Carica papaya unripe fruit, back and leaves, Neem leaves and *Piper guineense*	Two handful of carica papaya backs are taken and soaked in a container for three days until the colour of the solution becomes greenish-yellow. Then, the leaves of neem and Piper-guineense are added to the solution and boiled for one hour. The resulting solution is later applied to crops in the field.
6.	Wood ash	The ash is put in a cloth bag, tied to the end of plant stock and by the beating the bag, the ash sprinkled on the crops.
7.	*Artocarpus heterophyllus*	Extracts from *Artocarpus heteroplyllus* is mixed with wood ash and spread on the vegetable field to trap insect pest attacking vegetable.

Source: Field Survey 2007.

This is the period when the crops are in the productive or vegetative stages, which is the stage necessary for good yield. However, during the dry season, leaf borers, webbers, leaf eating caterpillars and flea beetles, weevils, and leaf hoppers play significant roles in defoliating the leaves of vegetables.

The botanical formulations and efficacy of their control among vegetable farmers in Nigeria

In bid to mitigate the damaging effect of pests on the vegetables, farmers used variety of means, ranging from planting some indigenous plants that harbor birds/insect predators which feed on the dominant vegetable pests, using specific plant part, whole plant or animal product ash. Plants used in the field included *A. indica* (Neem plant), *Piper guineense* (black pepper), Diospyros affinin (persimmon), *Anamirta cocculus (*Fish berry*)*, *Ananas comosus* (pineapple), *Cycas circinalis* (Queen sago), *Cymbopogon* spp.(lemon grass), *Artocarpus heterophyllus* (Jackfruit). Neem leaves, red pepper (*Capsicum* spp), tobacco (*Nicotiana tobaccum*), and *Carica papaya* (pawpaw leaves) these plants were combined together in the preparation of botanical formulations to prevent and/or control pest in the field. Table 4 presents inventory of different botanical pesticide products formulated by farmers.

The most prominent among the materials used in the preparation of some of the identified botanical formulations are *A. indica*, *P. guineense*, and tobacco leaves. In addition to the aforementioned materials, wood ash is also a common botanical product used among vegetables farmers. Vegetable farmers in the study area were found to create habitat for insect/bird predators in their insect pest control strategy. Predatory wildlife such as bats, birds, gliders, predatory insect (sugar gliders) were found to consume large variety of insects as shown in (Table 5).

Apart from creating habitat for insect pest predators, under story plants increase the effectiveness of shelterbelts, improve soil fertility and reduce erosion, thus improving farm productivity. It was ascertained from our FGDs that 75.8% of the farmers were of the opinion that

Table 5. Species of birds and the insect they consume.

Bird species	Insect consumed
Ibis	Grasshoppers, caterpillars, beetle larvae
Honey eaters	Scale insect, ants, flies
Fairy-wirens	Caterpillars, beetles and ants
Thrushes	Weevils and larvae
Cuckoos	Caterpillars

Source: Field Survey 2007.

indigenous control methods were as effective as synthetic pesticides. A very small proportion (4.3%) had their indigenous control method not effective. The remaining proportion did not provide the estimated rating although they were using plant botanicals formulations for the control of field insects/pests.

DISCUSSION

The results indicated that vegetable farmers in the South west Nigeria grow among other vegetables leafy vegetables in small plots primarily for sale and the crops were mostly attacked by field pest that damage the vegetative part of the crops. These pests attack the leaves and inflict much injury by making small round holes in them, thereby reducing, the leaf area which affects plant assimilation and leaf surface for photosynthesis and consequently economic loss due to reduced yield (Ogbalu and Ekweozor, 2002; Ogbalu et al., 2005; Akinlosotu, 1983; Egwuatu, 1982). This significantly reduced crop harvest vis-à-vis yield vis-à-vis income. The fact that vegetables are grown primarily for sale especially by female headed households implied that the crops have great implication on their welfare and food/nutrient security.

Results have revealed that 75.8% of the respondents were using plant-based control method on the field making it an important control method among vegetable farmers, especially in traditional agriculture where majority of the farmers do not have sufficient income to meet the large cost of synthetic pesticides.

It is evident from the result that the critical challenge of almost all the farmers was inability to estimate in what proportion the ingredients used in plant-based formulations should be combined. This failure could be attributed to the fact that (a) varied amount of plant parts were used in the preparation of their formulations, (b) No common standardized method of preparation (c) Lack of specific time of treatment/application of prepared botanical formulation (d) Different preparation time before application (e) No unified application rates of the same type of formulation to the same crop and (f) Use of same type of prepared plant-based formulation to treat different types of pests. The field observations revealed that farmers depended mostly on sight-seeing and guess work to estimate the amount of material taken and the level of concentration for a specific plant based pesticide formulation. In most cases, attainment of a definite color was regarded as having reached a required concentration. Under the current practice, these plant-based formulations will have a diverse efficacy at a given time even to the same farmer.

Thus, in absence of specific amount taken, allocated time and method of preparation coupled with no standard application method and rates, ranking of the effectiveness and efficiency of any botanical formulation may be undermined.

Conclusion

The findings from the study have revealed that vegetable farming is the main economic activity of most female headed households, who majorly operate on meso-scale and grow leafy vegetables. The major field pests of these crops were leaf borer, leaf hopper, webber, sting bug, weevils, caterpillar and flea beetles.

The IK based botanical formulation of vegetable farmers in South-west Nigeria varied with mixture of the following plant parts: *D. affinin*, *A. cocculus*, *P. guineense*, *C. papaya, Capsicum spp*., *A. heterophyllus*. These IK based pesticides were used as repellent, poison and or attractants. Farmers' formulation however is devoid of specific and appropriate preparation and layout, which subject them to varied efficacy and make their rating to be compromised. As a result, standardized techniques of preparation, bio-safety and environmental guideline for efficacy should form important consideration in formulating IK based pest control methods.

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