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*REVIEW ARTICLE*

# MANAGEMENT OF INSECT PESTS OF OKRA (*Abelmoschus esculentus* L.)

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**ABSTRACT**

Insect pests of okra constitute a great threat to the crop all over the world which not only exerts quantitative loss but also qualitative loss. They are a major problem in crop production in Nigeria, limiting crop potential in a country that is often faced with food shortages. Although, chemical insecticides play an important role in the management of insect pests but it has been discovered to have long term effect on non-target organisms, problems of pest resistance, resurgence, pesticides residues, destruction of beneficial fauna and environmental pollution, which raises needs to introduce effective but safe substitutes. However, asides chemical control of insect pest, the parts of some plants (seed, root, bark leaf) as botanical extracts have been discovered to be effective in pest management considering their environmental safety.

**KEYWORDS**

Botanical extracts, pesticides, insect pests, okra

## 1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable having better dietary value with medicinal and industrial importance. It is also known as lady's finger, it's a flowering plant in the mallow family. Even though, the plant is cultivated in tropical and warm temperate region around the world but the species is still poorly studied (Maganha et al.,2010). It is one of the most widely known and utilized species of the family Malvaceae (Naveed et al., 2009) and an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Saifullah et al., 2009). Okra originated in Ethiopia (Sathish et al., 2013 ) and was then propagated in North Africa, in the Mediterranean, in Arabia and India by the 12th century BC (Nzikou et al., 2006). Latin botanical names for Okra are *Abelmoschus esculentus* and *Hibiscus esculentus* (Kumar et al., 2010). The plant is rich in minerals, carbohydrate ,fibre, protein, fat and phenols (Huang et al., 2008). Okra plants have small erect stems that can be easily bristly or hairless with heart shaped leaves. The leaves are 10 -20 cm long with 5 -7 lobes. The plant produces flowers with five white to yellow petals which are 4 - 8 cm in diameter. The seed pod is a capsule up to 25 cm long, containing numerous seeds. The crop is widely cultivated in Turkish, West Africa, India, Burma, Japan, Afghanistan, Yugoslavia, Bangladesh , Pakistan, Malaysia, Brazil , Ghana , Ethiopia , Cyprus and the Southern United States (Tripathi et al., 2011). Okra has considerable area under cultivation in Africa and Asia with huge socio economic potential. In Nigeria, okra is called Ila (yoruba), Kubewa (Hausa), Layre (Fulfude), Epehu (Egbira), Pomi (Nupe). In West and Central Africa (WCA), it is called Gan (Bambara), Kandia (Manding), Nkruma (Akan), Fetri (Ewe), Gombo (French) and is among the most frequently and popularly consumed traditional vegetables.

The term okra was in the use of English by the late 18th century (Arapitsas et al., 2008). Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds (Mihretu et al., 2014). In the African context, okra has been called as —a perfect villager's vegetable because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) it provides to diet (NAP, 2006). The crop is widely cultivated throughout the year in the tropics. Okra production is estimated at 6 million tonnes per year in the world. The share of India being 67.1%, followed by Nigeria at 15.4% and Sudan at 9.3 %. Next to onion, okra has highest export potential as fresh vegetable which accounts for 30% to 70 % exchange earnings. Okra contains proteins, carbohydrates and vitamin C, and plays a vital role in human diet. It is one of the most important vegetable crops, has its own importance, taste, flavour and nutritional values as human food. It has good nutritional value particularly high content of calcium and vitamin C (Anita and Nandihalli, 2008). In India, okra is cultivated in an area of 0.37 million hectare with an annual production of 3.53 million tons. In Odisha (an eastern Indian state of the Bay of Bengal) okra is grown in an area of 531 ha having production of 6350 yielding 11958.6 kg/ha (Dept. of Agriculture and Co-operation,Govt.of Odisha).

In 2009-2010, the total world area under cultivation was 0.43 million hectares and the production stood at 4.54 million tons and India production of okra 5784 thousand tones and productivity 11.1 tones /hectares (Indian Horticulture database, 2011). The yield is very low as compared to the yield 9.7 -10 tonnes per hectare of other developing countries of the world. Okra is a heat loving plant, growing best in southern climates in a well draining light sandy to medium loams. Soils should be high in organic matter with a pH between 5.8 to 6.8. If planted in clay soil, transplants are recommended due to the difficulty encountered in seedling emerging from the heavy soil . The plant should be grown in an area of high sunlight and grows best in hot temperatures. Soil temperatures should be at least 18.3°C with optimal growth of the plants occurring at soil temperature between 23.9 - 32.3 °C . Okra is noted to be seriously responsive to soils compaction and also with hard pan soil which can harshly alter the growth of plant. Okra is temperate crop. The plant grows earlier and faster due to its great level which may not be required to follow up with a delay in time due to higher temperatures. It takes about 90-100 days before okra starts flowering. Okra fruits are harvested when they are mature or not fully formed and it can be consumed as a vegetable. Okra can be cooked in several means (Tripathi et al., 2011).

Okra has huge potential for enhancing livelihoods in urban and rural areas and to several stakeholders (NAP, 2006). It offers a possible route to prosperity for small- scale and large-scale producers alike and all those in the okra value chain ,including women, producers and traders. One of the major constraints associated with okra production is heavy infestations caused by insect's pest of the crop ,which not only exert quantitative loss

but also qualitative loss to the crop. The occurrence and intensity of damage caused by them varies from different crop growth stages , regions and seasons, Also ,infestations by sucking insect's pest would not only affect the crop but also hamper the crop health by transmitting pathogenic diseases. The incidence and dynamics of insect pests on okra are essential to develop a sustainable management practice.

### 1.1 Origin and Distribution of Okra

Okra originated in Ethiopia (Sathish and Eswar, 2013) and it was then cultivated within Mediterranean in North Africa ,in Indian and Arabian by the 12th century BC (Nzikou et al., 2006). The process through which okra was carried from Ethiopia to North Africa , the Eastern Mediterranean ,India and Arabia and which are of without means of certainty .Although it has been commonly cultivated in Egypt for many hundreds of years, no sign of it has ever been found in any of the ancient monuments or relics of old Egypt. Because the Spanish Moors and the Egyptians of the 12th and 13th centuries used an Arab word for okra, it probably was taken into Egypt by the Moslems from the East who conquered Egypt in the 7th century. It requires

no stretch of the imagination to suppose that the plant earlier was taken from Ethiopia to Arabia across the narrow Red Sea or the narrower strait at its southern end. From Arabia, okra was spread over North Africa, completely around the Mediterranean, and eastward. The absence of any ancient Indian names for it suggests that it reached India after the beginning of the Christian era. Okra (*Hibiscus esculentus*) is also called "gumbo" in this country, although the latter term is more often applied to soups or other dishes which contain okra. Both of these names are of African origin "Gumbo" is believed to be a corruption of a Portuguese corruption, quingombo, of the word quillobo, native name for the plant in the Congo and Angola areas of Africa.

### 1.2 Botany of Okra

Okra is a short annual crop which is grown in the lowland tropics and it has several cultivars that vary in maturity, shape of fruit, stem length, colour of leaves and other characteristics. Okra is mainly propagated by seeds and has duration of 90-100 days. It is generally an annual plant. Its stem is robust, erect, variable in branching and varying from 0.5 to 4.0 metres in height. Leaves are alternate and usually palmately five lobed, whereas the flower is axillary and solitary. Okra plants are characterized by indeterminate growth. Flowering is continuous but highly dependent upon biotic and abiotic stress. The plant usually bears its first flower one to two months after sowing. The fruit is a capsule and grows quickly after flowering. The greatest increase in fruit length, height and diameter occurs during 4th to 6th day after pollination. It is at this stage that fruit is most often plucked for consumption. The okra pods are harvested when immature and high in mucilage, but before becoming highly fibrous. Generally the fibre production in the fruit starts from 6th day onwards of fruit formation and a sudden increase in fibre content from 9th day is observed (Nath, 2006). Okra plants continue to flower and to fruit for an indefinite time, depending upon the variety, the season and soil moisture and fertility. Infact the regular harvesting stimulates continued fruiting, so much that it may be necessary to harvest every day in climates where growth is especially vigorous. The okra flowers are 4-8 cm in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal and the flower withers within one day. The flower structure combines hermaphroditism and self-compatibility. Flower bud appears in the axil of each leaf, above 6th to 8th leaf depending upon the cultivar. The crown of the stem at this time bears 3-4 underdeveloped flowers but later during the period of profuse flowering of the plant there may be as many as 10 undeveloped flowers on a single crown. As the stem elongates, the lower most flower buds open into flowers. There may be a period of 2, 3 or more days between the time of development of each flower but never does more than one flower appear on a single stem. A flower bud takes about 22-26 days from initiation to full bloom. The style is surrounded by a staminal column which may bear more than 100 anthers. The pollen may come in contact with the stigmas through a lengthening of the staminal column or through insect foraging (Thakur and Arora, 1986). Thus the flowers of okra are self-fertile. The pollen grain is large with many pores, and every pore is a potential tube source; therefore, many tubes can develop from one pollen grain (Purewal and Randhawa, 1947).

Okra has perfect flowers (male and female reproductive parts in the same flower) and is self-pollinating . If okra flowers are bagged to exclude pollinators, 100% of the flowers will set seed. It has been found experimentally that there is no significant difference in fruit set under open-pollinated, self-pollinated (by bagging alone) and self-pollinated (hand pollination of bagged flowers), indicating that it is potentially a self-pollinated crop (Purewal and Randhawa, 1947).

Although insects are unnecessary for pollination and fertilization in case of okra, the flowers are

very attractive to bees and the plants are cross-pollinated. The cross pollination up to the extent of 4-19 % (Purewal and Randhawa, 1947; Choudhury et al., 1970; Shalaby, 1972) with maximum of 42.2 % (Mitidieri and Vencovsky, 1974) has been reported. The extent of cross-pollination in a particular place will depend upon the cultivar, competitive flora, insect population and season.

### 1.3 Nutritional Composition of Okra

Okra is more a diet food than staple (NRC.,2006). Okra seeds have been used on a small scale for oil production. Lipid components greatly contribute to the nutritional and sensory value of almost all types of foods.Four classes of lipids are habitually found in vegetable oils: triacylglycerols, diacylglycerols, polar lipids, and free fatty acids. The fatty acid composition determines the physical properties, stability, and nutritional value of lipids. The most naturally occurring storage lipids are triacylglycerols . Triacylglycerols are natural compounds that consist of saturated and unsaturated fatty acids that differ in the length of their acyl chains and the number and positions of double bonds: saturated, monoenoic, and polyunsaturated fatty acids that differ with respect to detailed fatty acid composition. Monoenoic fatty acids and polyunsaturated fatty acids are structurally distinguished by the presence of repeating methylene units. These units produce an extremely flexible chain that rapidly reorients through conformational states and constitutes an influential group of molecules that promote health (Vermeris et al., 2006). Okra seeds from Greece are a potential source of oil, with concentrations varying from 20% to 40%, depending on the extraction method. The oil mainly consists of linoleic acid (up to 47.4%). Okra seed oil is a rich source of linoleic acid, a polyunsaturated fatty acid essential for human nutrition. Proteins play a particularly important role in human nutrition. The amino acid contents, proportions, and their digestibility by humans characterize a protein's biological value.

Okra has been called "a perfect villager's vegetable" because of its robust nature, dietary fiber, and distinct seed protein balance of both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses). The amino acid composition of okra seed protein is comparable to that of soybean and the PER is higher than that of soybean (Adetuyi et al., 2012) and the amino acid pattern of the protein renders it an adequate supplement to legume or cereal based diets (Ndanqui et al., 2010). Okra seed is known to be rich in high quality protein especially with regards to its content of essential aminoacids relative to other plant protein sources. Hence, it plays a vital role in the human diet. Okra also contains carbohydrates and vitamins, and plays a vital role in human diet. Consumption of young immature okra pods is important as fresh fruits, and it can be consumed in different forms. Fruits can be boiled, fried or cooked (Akintoye et al., 2011).

The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin

0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. The composition of okra leaves per 100 g edible portion is: water 81.50 g, energy 235.00 kJ (56.00 kcal), protein 4.40 g, fat 0.60 g, carbohydrate 11.30 g, fiber 2.10 g, Ca 532.00 mg, P 70.00 mg, Fe 0.70 mg, ascorbic acid 59.00 mg, β-carotene 385.00 µg, thiamin 0.25 mg, riboflavin 2.80 mg, niacin 0.20 mg (Varmudy., 2011). Carbohydrates are mainly present in the form of mucilage . That of young fruits consists of long chain molecules with a molecular weight of about 170,000 made up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%).

The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of about 30%. Potassium, Sodium, Magnesium and Calcium are the principal elements in pods, which contain about 17% seeds. Presence of Iron, Zink, Manganese and Nickel also has been reported. Fresh pods are low in calories (20 per 100 g), practically no fat, high in fiber, and have several valuable nutrients, including about 30% of the recommended levels of vitamin C (16 to 29 mg), 10 to 20% of folate (46 to 88 mg) and about 5% of vitamin A (14 to 20 RAE). Both pod skin (mesocarp) and seeds are excellent source of zinc (80 mg/g. Okra seed is mainly composed of oligomericcatechins (2.5 mg/g of seeds) and flavonol derivatives (3.4 mg/g of seeds), while the mesocarp is mainly composed of hydroxycinnamic and quercetin derivatives (0.2 and 0.3 mg/g of skins). Pods and seeds are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and

hydroxycinnamic derivatives. These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in the human diet. Dried okra sauce (pods mixed with other ingredients and regularly consumed in West Africa) does not provide any beta carotene (vitamin A) or retinol (Avallone et al., 2008). However, fresh okra pods are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol. Seven-days-old fresh okra pods have the highest concentration of nutrients (Agbo et al., 2008).

### 1.4 Chemical Composition of Okra

Okra contains proteins, carbohydrates and vitamin C (Owolarafe and Shotonde, 2004; Gopalan et al., 2007; Arapitsas, 2008; Dilruba et al., 2009). Then plays a vital role in human diet (Kahlon et al., 2007; Saifullah and Rabbani, 2009). Consumption of young immature okra pods is important as fresh fruits, and it can be consumed in different forms (Ndunguru and Rajabu, 2004).Fruits can be boiled, fried or cooked (Akintoye et al., 2011). The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g, energy 144.00 Kj (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. The composition of okra leaves per 100 g edible portion is: water 81.50 g, energy 235.00 kJ (56.00 kcal), protein 4.40 g, fat 0.60 g, carbohydrate 11.30 g, fibre 2.10 g, Ca 532.00 mg, P 70.00 mg, Fe 0.70 mg, ascorbic acid 59.00 mg, β-carotene 385.00 µg, thiamin 0.25 mg, riboflavin 2.80 mg, niacin 0.20 mg (Gopalan et al., 2007; Varmudy 2011). Carbohydrates are mainly present in the form of mucilage (Liu et al., 2005; Kumar et al., 2009). That of young fruits consists of long chain molecules.

### 1.5 Varieties of Okra

- Clemson spineless

A typical okra plant at 4 feet or slightly more in mature height , Clemson Spineless accounts for the lion's share of commercial and home planting in California, where it is grown commercially in kings and Tulare counties and elsewhere. Slightly ridged pods appear in 56 days. Seeds are open pollinated and the plants are self-pollinating, meaning that resulting seeds can be saved and planted, and should grow true to the parent .

˝Spineless˝ refer to the relative lack of spines on the pods and branches.

- Other Heirloom

Star of David open pollinated okra, an Eastern Mediterranean heirloom, grows 7 feet tall or higher, with purplish leaves and chubby pods ready for harvest in 60 to 75 days.

- Emerald

Okra type with a smooth round dark green pod.

- Lee

Is a spineless type known by its deep bright green , very stagnant angular pods?

- Annie Oakley

Is a hybrid, spineless kind of okra with bright green , angular pods. It takes less than two months from seedling to maturity.

- Chinese Okra

Is a dark green type grown in California and reaches 10 to 13 inches in length. These extra-long okra pods are sometimes called 'ladyfingers'

### 1.6 Soil and Climatic Requirement

Okra requires warm and humid conditions for good growth. It is susceptible to low temperature. It can be grown successfully under the temperature ranging between 25– 30$^0$C. The okra plants grow taller in the rainy season than in the warm summer. For seed germination optimum soil temperature and a temperature range between 25$^0$ C and 35$^0$C is required, with fast germination observed at 35 $^0$C. Seeds fail to germinate below 17$^0$C. At temperature above 42$^0$C flower buds in most of the cultivars may desiccate and crop causing yield losses. The soil requirement of okra is Sandy to clay soils, so long as those are well mannered supplied with enough organic matter and with good drainage are fit for okra cultivation. For best yield, soil pH should range between 6.0 and 6.8, because maximum nutrient uptake through roots, in most of the cultivars.

## 2. Cultural and Management Practices

### 2.1 Planting time

In the spring, plant okra seeds after all danger of frost, when the soil has warmed to 62 degrees F and about 10 days after tomatoes are transplanted. This is April 1015 in southern Arkansas, April 1521 in central Arkansas and April 21 May 5 in northern Arkansas and at the higher elevations. Short day length, less than 11 hours, promotes flowering in most cultivars. Okra planted too late in the spring may remain vegetative until late summer or early fall. The cultivar 'Clemson Spineless' is less sensitive to day length. Transplants of okra can be started four to six weeks prior to direct seeding in the garden. This will allow early and continued production .

### 2.2 Spacing and Depth of Planting

Okra has a thick seed coat and does not germinate easily. Soak seeds in water at room temperature overnight to improve germination. Discard nonviable seeds that float after soaking. Sow seeds 1 inch deep in rows that are 3 to 4 feet apart. When the seedlings are 3 inches high, thin to 10 to 18 inches apart.

### 2.3 Soil Preparation

Soil should be turned after harvest in autumn and early spring. This practice will expose overwintering insects to killing frosts and bring weed seeds to the surface where they will germinate. The weed seedlings will be destroyed when disking the soil before planting, therefore reducing chemical use and saving on labour input for weeding. Recommended row spacing is 71 to 96 cm with 20 to 30 cm between plants. Seeds should be chemically treated to reduce damping off (seedling rot) and planted about 2 to 5 cm deep. When okra is 8 cm tall, plants should be thinned 20 to 30 cm between plants. Okra has 3629 seeds per kg, and 5 to 6 kg of seeds are required to plant 1 ha. If a precision planter is used, 3 kg/ha is re commended .Okra has a thick seed coat and does not germinate easily. The seed must be surface-dried for mechanical planting.

### 2.4 Fertilisation

Before planting, soil fertility should be tested and recommendations followed. High rates of nitrogen cause excessive vegetal growth, which can reduce yields. If soil tests indicate a high pH, lime is recommended and should be applied 3 to 4 months before the crop is seeded. The following are general recommendations. Before planting apply:

- Nitrogen – 13 to 22 kg/ha at planting. Side-dress with an additional 16 to 23 kg N/ha when plants are 20 to 25 cm tall, or use 11 kg N/ha after first fruit set and again after 4 to 6 weeks at the same rate. Adequate nitrogen is necessary to ensure a long harvest period; however, excessive rate are to be avoided as they can cause okra to become excessively vegetative.

- Phosphoric fertilizer – 23 to 45 kg/ha, all applied at, or before planting.

### 2.5 Irrigation

Adequate soil moisture is necessary for optimum growth and yield. A regular irrigation schedule of water every 10 days is recommended for maximum yields. Conversely, overwatering may drown plants or cause excessive growth. When using furrow irrigation during harvest, watering alternate rows is recommended. The dry furrow is used to walk in during harvest. Subsequent irrigation should be applied to the dry furrow.

### 2.6 Weed Control

Weed species infesting okra include annual grasses such as crab grass and goose grass; perennial grasses such as Bermuda grass; broadleaf weeds such as sickle pod, annual morning glory, and nutsedge. When the okra and weeds are small, tilling with a rolling cultivator will kill off most small weeds. Later, use sweep cultivators or rolling cultivators set to cover small weeds within the row. Avoid throwing too much soil directly against the okra stems, because doing so can increase the incidence of stem rot. Few herbicides are registered for weed control in okra fields. Using them improperly can damage your crop.

Okra is harvested over a long period of time, so full-season weed control

is usually required. A preplant application of Treflan is recommended for control of grasses. There are no herbicides labelled for broadleaf weed control in okra. Mechanical cultivation should be used as often as necessary to control broadleaf weed species. Care should be taken to cultivate as shallowly as possible to avoid root damage to the okra. Producers may want to avoid fields with known heavy infestations of broadleaf weeds.

## 3. Constraints of Okra Production

### 3.1 Diseases of Okra

Among the constraints of okra production is the infestation of disease .Okra (*Abelmoschus esculentus* ) is affected by disease which include :

i. Powdery mildew (*Erysiphe cichoracearum)* : Greenish powdery growth occurs on the under as well as on the upper surface of the leaf causing severe reduction in fruit yield

ii. Fusarium wilt (*Fusarium oxysporum* ) which begins with a yellowing and stunting of the plant. Older plants shows symptoms of wilting and rolling of the leaves as if the roots were unable to supply sufficient water ,wilting is usually pronounced after heavy summer rain .

iii. Cerscospora Leaf Spots (*Cercospora malayensis)* which causes brown and irregular spots on the leaves. The affected leaves roll,wilt and fall. The leaf spots cause severe defoliation and are common during humid seasons . (Moekchantuk et al., 2004).

iv. Enation Leaf Curl : The important symptoms of this disease are curlingof leaves in an adaxial direction ,and mild or bold enations on the under surface of the leaves. Fruits from infected plants are small and deformed and unfit for marketing. (Ghanem, 2003).

### 3.2 Insect Pests of Okra

Severity of insect damage varies from year to year and is different at each stage of plant development. Aphids usually attack okra early in the season. Later, plants and pods may be attacked by stinkbugs, cabbage loopers, corn earworms, European corn borers and the leaf-footed plant bugs. Chemical control of insect pests of okra can be a problem because few insecticides are registered for use on this crop. Frequent pest scouting and use of cultural controls are advised to find pest problems early and make the crop less susceptible to insect infestations. Insect pests of okra fall into two categories—foliage feeders and pod feeders. Foliage feeders only cause economic damage (loss of yield) when pest numbers are high or when plants are young (or stressed). Foliage feeding on well-established plants does not normally cause loss of yield because healthy plants can tolerate considerable loss of foliage before yield loss occurs. Tolerance of foliar damage increases with age of the plant and favourable growing conditions (that is, plentiful soil moisture, proper fertility).

Young plants are more susceptible to foliar feeding damage, so these plants should be scouted frequently to check for insects and feeding. Control may be necessary if moderate feeding damage is observed on young plants. Insects' pest of okra include:

#### *3.2.1 Melon thrips (Thrips palmi)*

This is polyphagous but mostly found on Cucurbitaceae and Solenaceae crops. Eggs are colourless; bean shaped; turns yellow towards maturation; laid singly inside the plant tissues.

Larvae resembles adult in general body form but lacked wings. They usually feed on older leaves. Full fed larvae descend to the soils of leaf litter where it pupates making an earthen

chamber. Adults are pale yellow with numerous dark setae. A black line from the juncture of wings runs along the back of the body. Slender fringed wings are pale. Fringe is shorter on the anterior edge than posterior. Body length is 0.8 -1.0 mm. Thrips antenna is seven segmented, Ocelli red pigmented.

#### *3.2.2 Leafhopper (Amarasca biguttula)*

Adults are greenish yellow, small, wedge shaped 3 mm long having black spot on each forewing and vertex. Lays yellowish eggs in clusters on underside, embedded in the leaf veins.

Nymphs and adults feed underside by sucking sap.

#### *3.2.3 Whitefly (Bemisia tabaci)*

Adults are yellowish dusted with white waxy powder, 1.0- 1.5 mm in length. Female lays stalked eggs singly on underside of leaves. Nymphs and adults suck the sap of leaves.

#### *3.2.4 Aphids (Aphis gossypii)*

Adults are small soft bodied found in colonies in tender parts. Damage is caused by both nymphs and adults by sucking cell sap. Black shooty molds develop on honey dew secreted by aphids on leaves. Dry condition favours population flair up.

#### *3.2.5 Shoot and fruit borer (Earias vittela and E. insulana)*

Adult of *Earias vittela*is 2.5 cm across the wings and have narrow light green band in the middle of forewings. Whereas *E. insulana* does not have such conspicuous band on forewings.

Full grown larvae are dull green, 2 cm long having tiny stout bristles and a series of black spots on the body. Eggs are laid singly and are of sky blue. Both bores in to shoots resulting in to drooping down of growing points and later on bore in to fruits.

#### *3.2.6 Okra fruit borer (Helicoverpa armigera)*

Polyphagous, lays spherical yellow eggs singly on tender parts. Eggs are flat at the bottom. Larvae are of varying colour with darker broken lines along side of the body. Body covered with

radiating hairs. Pupates inside the soil. Adult is medium sized brownish forewings with dark cross band near outer margin and dark spots near coastal margins. Bore fruits with circular irregular holes comparatively bigger in size. Half portions of larva remain inside the fruit while feeding.

#### *3.2.7 Red spider mite (Tetranychus spp.)*

Mites are minute in size and vary in colour with two dark spots on the body. Infestation usually observed during warm and dry periods. Damage is done by sucking cell sap ,giving grey patches on leaves and leaves become brown and fall .In several infestation webbing is observed.

### 3.3 Flea beetle

Many flea beetles are attractively coloured; dark, shiny and often metallic colors predominate. Adult flea beetle feed externally on plants ,eating the surface of the leaves ,stems and petals. Major agricultural crops are attacked by flea beetles ,including various cruciferous plants .Flea beetle execute their most severe attacks during dry weather and are more active on sunny days.

## 4. Management of Insect Pest of Okra

### 4.1 Cultural control

Cultural method is used to reduce the use of chemical insecticides .Crop rotation as a cultural method with improved efficiency in the use of soil nutrients by different plants, thereby maintaining soil fertility , reduction in soil erosion and better control of weeds (Linker et al., 2009). The rotation of crop on the same piece of land is an alternate way of reducing pest infestation . Crop rotation is the successive cultivations of different crops in an orderly manner on the same field, it involves the changing of crops over time (Wszelaki and Broughton, 2012) .

### 4.2 Biological control

Biological control assumes that natural predators are able to suppress insect pest. Initaially therefore natural enemies were imported to control insect pests .There are two groups of beneficial microbial organism ;predators and parasites. Parasites are organism that live depending on another organism such as larvae of parasitic wasps ,which live in the larvae of whitefly and eat them from inside .Predators are simply prey on other organism for food such as lady birds which eat aphids .Some commonly use macrobials are; *Phytoseiulus persimilis* against red spider mite, *Encarsia formosa* against whitefly *and Neioseiulus cucumeris* against thrips.

### 4.3 Physical control

This refers to mechanical, manual or hand control where the pest is actually attacked and destroyed. This is a method of getting rid of insects and small rodents by killing, removing ,or setting up barriers that will prevent further destruction of ones plant. Row covers are used in horticultural crops for keeping insects out of the plant area, they are made thin and light to permit sunshine and water from the air. Fire has also been

a powerful techniques used by farmers to destroy insect breeding floors which burn the top of the soil to kill the insects that lie there, though it do make soil less effective and burn beneficial insects in the soil .

### 4.4 Chemical Control

The use of synthetic insecticide has been in the control of insect pest of okra which include; the jassids, *Amrasca biguttula* ;the aphid ,*Aphis gosssypii* ;the fruit borers, *Earias insulana* and others. Insecticides are Permethrin 25EC, Emamectin benzoate 5 SG, Fenpropathrin 30 EC, Pyriprofen 5EC, which control allows for higher gain in Okra. Indiscriminate use of chemical insecticides has led to many problems like adverse effects on parasites, predators and pollinators; toxic residues cause health hazards, development of resistance in insects and environmental pollution.

### 4.5 Bio Pesticidal Control

This involves the use of plant parts as botanical extracts, it is cheap, readily available and environmentally friendly. Some plants which have kept promising as biopesticides for the management of insect pests of okra include but not limited to.

### 4.6 Moringa and Its Uses

*Moringa oleifera* leaves have been found to possess antibacterial and antifungal characteristics (Rao et al., 2007). Moringa is an all-purpose plant. It is a native of India but is widely cultivated in some sub-Sahara African countries like Zimbabawe ,Madagascar , Zanzibar, South Africa, Tanzania , Malawi, Benin, Burkina Faso, Cameroon, Mauritania, Nigeria, Niger, Sierra Leone, Sudan, Ethiopia, Somalia, Zaire, Togo, Uganda and Senegal (Amaglo, 2010; Fugile and Sreeja, 2011). Every part of the plant can be used for one thing or the other. The leaves have very high nutritional value. They are good sources of protein, minerals, vitamins ,beta carotene, amino acids and various phenolic compounds. They provide a rich and rare combination of zeatin, quercetin, beta-sitosterol, caffeoylquinic acid and kaempferol (Moyo et al., 2011). The seed is eaten like a peanut in Malaysia. The thickened root is used as substitute for horseradish.

Moringa is very important for its many impressive ranges of medicinal uses. Various parts of this plant such as the leaves, roots, seeds, fruits ,roots, flowers, and immature pods act as cardiac and circulatory stimulants. They possess antitumor, antipyretic, antiepileptic, anti-inflammatory and anti-fungal, cholesterol lowering properties and some antioxidants (Fuglie and Sreeja, 2011; Moyo et al., 2011). The leaves are ground and used for scrubbing utensils and for cleaning walls.

### 4.7 Red Jatropha and Its Uses

*Jatropha gossypifolia* belongs to the family *eurphorbiaceae* and the order, "Geraniale". Other members of the family include *Jatropha curcas*, *Jatropha multifida*, *Jatropha podagrica* and *Bridelia ferriginea*. The common name for *J. gossypifolia* is pignut or fignut, and in Yoruba land it is commonly known as "Lapalapa" (Odebiyi and Sofowora, 1998). The fruits are three-celled with one seed per cell. *J. gossypifolia* is the common red species planted around houses and is used as a therapeutic agent in different ways. In Southern Nigeria, the extract from fresh leaf applied with crushed leaf is routinely used by herbalists and local people to stop bleeding from the skin and nose. The anticoagulant activity of the leaf extract of *J.gossypifolia* was detected while trying to examine its coagulant properties . The leaf decoction of *J. gossypifolia* is used for bathing wounds (Omoregbe et al., 2006) reported that the leaf bath is used for sores, sprains, rash and bewitchment in Latin America and the Caribbean; the poultices are used for sores and pain in Trinidad (Morton, 1981).

### 4.8 Neem and Its Uses

Neem, *Azadirachta indica* is a tree in the mahogany family *Meliaceae.* It is one of the two species in the genus *Azadirachta*, and is native to the Indian subcontinent, i.e India, Nepal, Pakistan, Bangladesh and Maldives. It is typically grown in tropical and semi tropical regions. The fruit is a smooth ,olive –like drupe which varies in shape from elongate oval to nearly roundish , and when ripe is 1.4 -2.8 centimetres. The neem tree is often confused with a similar looking tree called bakain. Bakain also has toothed leaflets and similar looking fruit. One difference is that neem leaves are twice and thrice pinnate. It is considered a major component in siddha medicine and Ayurvedic and Unani medicine and is particularly prescribed for skin diseases.

The Neem tree grows very quickly and tolerates harsh environments. It can grow in just about any kind of soil and requires very little water or any quality. It can thrive in conditions of up to $50^0$C down to $5^0$C . It will live 150-200 years and usually reaches 20 metres in height. (Discover Neem, 2010).

Neem is a key ingredient in Non-Pesticidal Management NPM, providing a natural alternative to synthetic pesticides. Neem does not directly kill insects on the crop. It acts as an anti feedant, repellent, and egg-laying deterrent, protecting the crop from damage. The insects starve and die within a few days. Neem leaf boiled in water can be used as a very cost-effective bird repellant, especially for sparrows .Many researchers have shown that the spray solution of neem oil helps to control common pests like whiteflies, aphids, scales, mealybug, spider, mites, locusts, thrips and Japanese beetles etc. (www.organeem.com).

### 4.9 Intergrated Pest Management

Integrated pest management strategies that can be used in the control of insect pests of okra includes;

i. Setting up yellow sticky and delta traps for white fly.

ii. Erection of bird perches at 10/acre in the field for facilitating bird predation .

iii. Install pheromone traps at 2/acre for monitoring of *Earias vitella* moth emergence. Replace the lures after every 15 -20 days interval

iv. Periodically remove and destroy the borer affected shoots and fruits.

v. Release egg parasitoid Trichogramma chilonis at 1-1.5 lakh /ha starting from 30-35 days after sowing ,4-5 times at weekly interval for shoot & fruit borer ,if crosses ETL (5.3 % infestation ), spray cypermethrin 25 EC at 200 g a.i/ha.

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