MANAGEMENT OF LEAF ROLLER *Sylepta derogata* Fab. (Lepidoptera: Pyralidae) ON SOME OKRA VARIETIES IN SAMARU AND KADAWA, NIGERIA

BY

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ZARIA, NIGERIA

APRIL, 2021

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B. AGRIC. (KSU) 2015
P16AGCP8004

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSc.) DEGREE IN CROP PROTECTION

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ZARIA, NIGERIA

APRIL, 2021

DECLARATION

I declare that this dissertation entitled "**Management of Leaf roller *Sylepta derogata* Fab. (Lepidoptera: Pyralidae) on Some Okra Varieties in Samaru and Kadawa, Nigeria"**, was written by me and it is a record of my research work. It has not been presented before in any previous application for a higher degree in any institution and all cited reference of published and unpublished literatures were duly acknowledged.

Sunday Idenyi ATULUKWU	_____	_____
Name of student	Signature	Date

CERTIFICATION

This dissertation entitled "**MANAGEMENT OF LEAF ROLLER *Sylepta derogata* Fab. (Lepidoptera: Pyralidae) ON SOME OKRA VARIETIES IN SAMARU AND KADAWA, NIGERIA"** by Sunday Idenyi ATULUKWU meets the regulations governing the award of the degree of Master of Science in Crop Protection of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

_____ _____

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DEDICATION

This work is dedicated to Engr. and Mrs A.A. Idenyi and to my siblings Ukwubile Abel, Achetu Helen, Ukwo Grace and Uredo Peace.

ACKNOWLEDGEMENT

All honour to God Almighty for the strength, wisdom and understanding he bestowed upon me during this research work. My unalloyed gratitude goes to Prof. L.J. Bamayi, Chairman of my supervisory team and Dr. I.M. Utono, member of my supervisory team for their advice, guidance, creative insights, encouragement, valuable suggestions and understanding which were crucial to the success of this work. I appreciate you both and thank you for your mentorship and guidance. My sincere gratitude goes to the Head, Department of Crop Protection, Prof. L.J. Bamaiyi and all my lecturers, who taught me during this programme and who were a great source of encouragement, as well as some colleagues and the entire staff of the Department who in one way or the other encouraged and motivated me towards the successful completion of this work, may the good Lord bless you all. The fatherly love of Pa Ishaku Musa of the Insect Museum is also deeply appreciated and not forgetting Aminu Gadina Ahmadu for his friendly role and support. I will like to thank also my mates, Gambari Lukman, Peace Ehilegbu, Isah Adamu, Zuliyat Abdulsemiu, Chiagozie, Amos Gbenga, Mufeedat for their support, May God see you all through your various endeavours. My unalloyed appreciation goes to my friends, Monica Ilani, Habib Muhammed, Frank Osas, Abdulrahman, Ifeanyi Oluka, for constantly being there for me during every critical period of my life, I say thank you all.

ABSTRACT

Field trials were conducted at two locations namely Samaru in Zaria, Kaduna State and Kadawa, Kano State during the 2019 wet season to determine the effects of five (5) okra varieties (Clemson spineless, Ex-Basawa, Jokoso, Ex-Samaru and NHAE-47), three (3) insecticides (Lambda-cyhalothrin, Cypermethrin + Dimethoate and Chlorantraniliprole + Lambda-Cyhalothrin) with an Untreated control and time of sowing (July and August). Treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated three (3) times. A total of four spray applications at two weeks' interval beginning from 7 WAS were carried out. Observations were recorded on the larval count, percentage incidence, damage on leaves and okra fruit yield. Variety Ex-Samaru recorded the least larval incidence of okra leaf roller at Samaru (1.67 %) and Kadawa (1.67 %) while Variety Jokoso recorded the highest incidence of leaf roller at Samaru (6.57 %) and Kadawa (7.33%). Plots sprayed with Ampligo (Chlorantraniliprole + Lambda-Cyhalothrin) and Cyperplus (Cypermethrin + Dimethoate) were found to have the least incidence at Samaru (1.67 %) while plots sprayed with Ampligo alone recorded the least incidence at Kadawa (1.67 %). Lambda (Lambda-cyhalothrin) recorded the highest incidence at Samaru (3.67 %) and Kadawa (3.06 %). Ex-Samaru recorded the least leaf damage at Samaru (70.71 %) and Kadawa (70.71 %), while Jokoso recorded the highest leaf damage at Samaru (82.21 %) and Kadawa (80.50 %). Also, plots sprayed with Ampligo recorded the least leaf damage at Samaru (70.71 %) and Kadawa (70.71 %) over plots sprayed with Cyperplus, Lambda and Untreated control in that order at both locations. At Samaru, varieties sprayed with Ampligo was found to reduce the population of leaf roller over other insecticides while at Kadawa, varieties sprayed with Ampligo and Cyperplus reduced the population of the okra leaf roller. At both locations, plots sprayed with Lambda was the least effective over the untreated control in reducing the leaf roller population. Larval population occurred first at 7 WAS for crops sown in July and 8 WAS for crops sown in August. The peak population period was September and October (9WAS) for crops sown in July and August; respectively. Jokoso variety recorded the highest larval population, while Ex-Samaru recorded the least larval population. Ex-Samaru recorded the highest yield at Samaru and Kadawa while NHAE-47 recorded the least yield at Samaru and Kadawa. Crops sprayed with Ampligo produced the highest yield at Samaru (3362.86 kg/ha) and Kadawa (4012.85 kg/ha) and crops sown in July had more yield (3933.85 kg/ha) than crops sown in August (2822.31 kg/ha.)

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CHAPTER ONE

1.0 INTRODUCTION

Okra, *Abelmoschus esculentus* L. (Moench) is one of the mostimportant vegetable crops cultivated in the tropics, subtropics and warmer parts of the temperateregion and belongs to the family Malvaceae.Okra plant or lady's finger was previously included in the genus *Hibiscus*but was later designated to *Abelmoschus.* It originated probably from East Africaand now widely distributed around the world (Sathish *et al*., 2013).There are two distinct seasons for okra production in Nigeria, the peak and the lean seasons. The lean season is characterized by low production, scarcity and consequently expensive okra fruit. However, in the peak season, okra is produced in large quantities (Bamire and Oke, 2003).In 2019, the total world area under okra cultivation was 2.2 million hectares and the production stood at 9.9 million tons; with India being the largest producer (61.9%), followed by Nigeria (22.2%) and Sudan (3.2 %) (FAOSTAT, 2019). Okra is widely cultivated and consumed throughout Nigeria(Christo and Onuh, 2005; Katung and Kashina, 2005).

In Africa, most of the stable meal consists of bulky starchy products and as such the mucilaginous content of okra helps in the consumption of these meals. The crop has its economic importance on the account of its taste, flavor andnutritional value as human food. It is a commercial vegetable crop that plays an important role in the human diet (Kahlon *et al*., 2007, Saifullah and Rabbani 2009).It supplies fats, proteins, carbohydrates, phosphorus, calcium, iron, sulphur, fibre, minerals and vitamins (Lamont, 1999; Owolarafe and Shotonde, 2004; Gopalan *et al*., 2007, Arapitsas, 2008; Dabire-Binso*et al*., 2009). About 4550Kcal/kg of calories is obtainable when okra is consumed (Babatunde *et al*., 2007).

The nutritional value of okra is higher than that of tomato, eggplant and most of the cucurbits, except bitter gourd (Nonnecke, 1989). Its exceptional nutritional value includes high content of vitamin C(13.10 mg/100g), calcium (66mg/100g), iron (35mg/100g), magnesium(53g/100g), potassium (103g/100g) and carbohydrates (6.4g/100g) (Gopalan *et al*., 2007).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). Dried okra seeds are a nutritious material that can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute (Schippers, 2000;Moekchantuk and Kumar, 2004).

Carbohydrates are mainly present in the form of mucilage (Kumar *et al*., 2010).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%. Okra seeds contain about 20% protein and 20% oil (Tindall, 1983). Industrially, okra mucilage is usually used for glace paper production and also has a confectionery use. Okra has found medical application as a plasma replacement or blood volume expander (Savello *et al*., 1980, Markose and Peter, 1990, Lengsfeld *et al*., 2004, Adetuyi *et al*., 2008, Kumar *et al*., 2010).The bark fibre is easy to extract. It is white to yellow, strong but rather coarse. Tests conducted in China suggest that an alcohol extract of

okra leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, reduce proteinuria, and improve renal function (Liu *et al*., 2005, Kumar *et al*., 2010).

In Nigeria and Thailand, okra is usually boiled in water resulting in slimy soups and sauces, which are relished. The fruits also serve as soup thickeners. Okra seed can be dried, and the dried seeds are a nutritious material that can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute (Moekchantuk and Kumar, 2004). Okra leaves are considered good cattle feed, but this is seldom compatible with the primary use of the plant. The leaf buds and flowers are also edible (Doijode, 2001).

1.1 Justification of the Study

Okra production in Nigeria is hampered by many biotic and abiotic factors, notable among the biotic factors are insect pests. Okra is attacked by a number of insect pests and many ofthe pests occurring on cotton are found to ravage the okra crop. As highas 72 species of insects have been recorded on okra,of which, leafhopper (*Amrasca biguttula biguttula* Ishida), leaf roller (*Sylepta derogata* Fabricius), whitefly (*Bemisia tabaci* Gennadius), fruit borers are known to cause severe damage to thecrop (Rao andRajendran, 2003; Mandal *et al*., 2006;Kedar *et al*, 2014;Ogbalu *et al*., 2015;Sheeba and Sundar, 2017). Dhandapani *et al*. (2003) documented that, in India, losses in okra due to insect pests was between49-74 per cent. Ogbalu *et al*. (2015) reported that the foliagefeeder leaf rollerculminates a huge economic loss in okra by hampering photosyntheticactivities of the plant. Punctures caused as a result of leaf roller are subjected to wear and tear under heavy winds which as a result cause reduction in photosynthetic activities in okra. Leaf rollercaused up to 28.4 % abscission of okra leaves in screened plots (Ogbalu *et al*., 2015). In a study by Obeng-Ofori and Sackey (2003), they found out that damage caused by insects to the leaves of okra was, however, the most significant cause of yield loss and stunted

growth.Control of this pest and other field insect pests of okra remains a major production constraint of farmers.

In Nigeria, Leaf roller has been reported to be a major pest of okra, attacking the leaves, causing rolling of the leaves, abscission of the leaves and in severe cases defoliation of the leaves which leads to yield loss (Anioke, 1989;Ogbalu *et al*., 2015). The oviposition patterns of female leaf rolleron okra leaves reduced photosynthetic activities as the deposited eggs cover a reasonable area of the leaf. On the effect of the larval feeding activities on seeds; 64.5% of the seeds produced loss their viability and could not germinate (Ogbalu *et al*., 2015). Under heavy infestation, larvae resort to feeding on tender fresh pods in the absence of leaves which had been defoliated by early instars. Furthermore, leaf eating bugs and pests also serve a inoculant or carrier/vectors off other pathogens (bacteria, virus, nematodes or fungi) that could plague okra production.

The use of synthetic insecticides, though now becoming unpopular cannot be undetermined in the control of insect pests control, hence researching on pyrethriods which are less toxic to mammals, less pesistent and effective, becomes pertinent. It is therefore against this background that this research becomes imperative.

1.2 Aim and Objectives of the Study

The main aim of this research is to identify less susceptible okra varieties, appropriate time of planting and insecticides for better management of Leaf roller on okra.

The objectives are:

i. To evaluate the reaction of okra variety on the damage caused by leaf rollerlarvae on okra leaves.

ii. To evaluate the effect of time of planting on the population of leaf roller larvae.

iii. To evaluate the effect of some insecticides on the management of leaf rollerlarvae and okra yield.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Botany of Okra

Okra (*Abelmoschus esculentus*L. Moench), is a vegetable crop belonging to the family Malvaceae. It is widely cultivated for its young fresh leaves and fruits (Nwangburuka *et al*., 2011). Okra is mainly propagated by seeds. Okra plants are characterized by indeterminate growth and are generally an annual plant. The stem is robust, erect, varying in branching and varying from 0.5 to 4.0 m in height. The woody stem bear leaves that are lobed and are generally hairy, some reaching up to 12 inches inlength. Leaves are cordate (heart-shaped), simple, usually palmately 3-7 lobed and veined. Leaves aresubtended by a pair of narrow stipules. The okra leaf is dark green in color and resembles a maple leaf.Flowering is continuous but highly dependent upon biotic and abiotic factors. The plant usually bears its first flower one to two months after sowing (Tripathi *et al*., 2011).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. 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 on 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 lowermost 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).

Flower bud initiation, flowering, anthesis and stigma receptivity are influenced by genotype and climatic factors like temperature and humidity (Venkatramini, 1952). Flower buds are initiated at 22-26 days and the first flower opened 41-48 days after sowing. Once initiated, flowering continues for 40-60 days (Sulikeri and Swamy Rao, 1972). Anthers dehisce before flower opening and hence self-pollination may occur at anthesis. The dehiscence of anthers is transverse and complete dehiscence occurs in 5-10minutes (Purewal and Randhawa, 1947). Pollen fertility is maximum in the period between an hour before and an hour after opening of the flower (Srivastava, 1964). Flowers open only once in the morning and close after pollination on the same day. The following morning the corolla withers. Okra has perfect flowers (male and female reproductive parts in the same flower) and is self-pollinating. 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 upto the extent of 4 - 42.2 % (Mitidieri and Vencovsky, 1974; Purewal and Randhawa, 1947; Choudhury and Choomsai, 1970; Shalaby, 1972).

The fruit is a capsule and grows quickly after flowering. The greatest increase in fruit length and diameter occurs from4 to 6 day after pollination. It is at this stage that fruit is most often plucked for consumption. The okra pods are harvested for consumption when immature and high in mucilage, before becoming highly fibrous. The fruits are a green capsule containing numerous white seeds when immature and the flowers and upright plants give okra an ornamental value

(Duzyaman, 1997; Jesus *et al*., 2008). The okra fruit can be classified based on the shape as angular or circular (Mota *et al*., 2005).

Generally, the fibre production in the fruit starts from 6 days after fruit formation and a sudden increase in fibre content is observed from 9 days (Nath, 1976). Okra plants continue to flower and to fruit for 10 to 12 weeks, depending upon the variety, the season and soil moisture and fertility. Regular harvesting stimulates continued fruiting, so much that it may be necessary to harvest every day in climates where growth is especially vigorous (Tripathi *et al*., 2011).

2.2 Origin and Geographic Distribution

Okra plant or lady's finger was previously included in the genus *Hibiscus.* Later, it was designated to *Abelmoschus*, which is distinguished from the genus *Hibiscus* (Aladele *et al*., 2008). *Abelmoschus* was subsequently proposed to be raised to the rank of the distinct genus by Medikus in 1787. Okra originated somewhere around Ethiopia and was cultivated by the ancient Egyptians by the 12th century BC (Simmone *et al.*, 2004; Sathish and Eswar, 2013). Its cultivation spread throughout Middle East and North Africa (Nzikou *et al*., 2006; Arapitsas, 2008; Saifullah and Rabbani, 2009).

This crop can be grown on a large commercial farm or as a garden. Okra plants are grown commercially in many countries such as India, Nigeria, Sudan, Japan, etc. (Purseglove, 1987; Benjawan *et al*., 2007; Qhureshi, 2007).

Okra is found all around the world from equatorial areas to the Mediterranean Sea as may be seen from the geographical distribution of cultivated and wild species. Cultivated and wild species of okra clearly showed overlapping in Southeast Asia, which is considered as the centre of diversity. The spread of the other species is the result of their introduction to Africa and

America (Qhureshi, 2007; Aladele *et al*., 2008). There are two hypotheses concerning the geographical origin of *A. esculentus*. Based on ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), others suggest that the area of domestication is Ethiopia or North Egypt, but no definitive proof is available today (Department of Biotechnology, 2009). *Abelmoschus* species occur in the world including *A. moschatus, A. manihot, A. esculentus, A. tuberculatus, A. ficulneus, A. crinitus* and *A. angulosus* (Charrier, 1984). The three cultivated species which are sometimes found in a semi-wild state in clearings, along roads and near villages, occur at low altitudes in all tropical, subtropical and warm temperate regions of the world. The species *A. moschatus* has a wide geographical distribution in India, Southern China, Indonesia, Papua New Guinea, Australia, Central and West Africa. The species *A. manihot subsp. manihot* is cultivated mainly in the East Asia, but also in the Indian sub-continent and Northern Australia. It is less frequently found in America and tropical Africa.

The species *A. manihot subsp. tetraphyllus* comprises two wild forms differentiated based on their ecological adaptation. First, *var. tetraphyllus*, grows at low altitudes between 0 and 400 m in the regions with a marked dry season of Indonesia, Philippines, Papua New Guinea and New Ireland. Second, *var. punens*, grows at altitudes between 400 and 1600 m in Philippine and Indonesia (Department of Biotechnology, 2009).

The species *A. esculentus* is cultivated as a vegetable in most tropical and subtropical regions of Africa such as Ghana, Guinea, Ivory Coast, Liberia and Nigeria. The wild species *A. tuberculatus*, related to *A. esculentus*, is endemic to the medium altitude hilly areas in India (IBPGR, 1991). The wild species *A. ficulneus* is found in a vast geographic area stretching from Africa to Asia and Australia. It flourishes in tropical areas of low altitude with a long dry season, i.e. desert regions of Sahelian Africa (Niger), Madagascar, East Africa, India, Indonesia,

Malaysia and Northern Australia (Lamont, 1999). The two wild species *A. crinitus* and *A. angulosus* are exclusive of Asian origin. They are differentiated by their ecology. *A. crinitus* grows at low altitudes in regions with a marked dry season, being (China, India, Pakistan and Philippines). *A. angulosus* grows at altitudes between 750 and 2000 m in Pakistan, India, Sri Lanka and Indonesia (Charrier, 1984; IBPGR, 1991).

2.3 Pests of Okra

The yield of okra has been reported to be very low in Nigeria, hardly up to 7t/ha (Schippers, 2000). Many of the pests occurring on cotton are found to ravage okra: with up to 72 species of insects recorded on okra (Ghanem, 2003; Rao and Rajendran, 2003). Various growth stages of the crops are susceptible to different insect pests (Ek-amnuay, 2010; Fasunwon and Banjo, 2010).

Okra is attacked by quite an array of insects prominent among them are *Sylepta derogata*, *Dysdercus superstitiosus*, *Podagrica uniforma* and *P. sjostedti*, others include *Anomis flava*, *Earias biplaga*, *Aphis gossypii*, *A. craccivora*, *Bemisia tabaci*, *Zenocerus variegatus* and others (Ogbalu *et al*., 2015).

2.4 Biology of *Sylepta derogata*

Leaf-roller S*ylepta derogata* Fabis a major pest of okra and belong to the family Pyralidae. The pest occurs in Nigeria, India, Pakistan, Bangladesh, Burma, Australia, China, Japan, Sri Lanka and other parts of the world. The pest is active from September to November (Mariselvi and Manimegalai, 2016).

As described by Anioke (1989), the eggs are minute, scale-like and brown or pale white. Eggs are laid both singly and in batches on both sides of the leaf, but more on the abaxial surface.

Newly laid eggs are colourless but later changes to dirty white towards the time of eclosion. The eggs hatch into larvae (First instar) in about 4-6 days, after hatching, they begin to roll the leaves and live inside the rolls, feeding on the leaf tissue. After emergence, newly hatched larvae starts feeding on the lower surface of the leaves and as the larvae grew older, larvae roll the leaves from the edges inward up to the midrib and feed on the leaf tissue inside. The young larva is glistering green in color and semi-translucent with a dark brown head. The larvae moults 4 or 5 times. The general characters of all the instars are similar and a fair description of the 1^{st} and 5^{th} instars are given.

1st Instar. A day old larva is light green and the body is slender and slimy. It has a small head and enlarged prothorax. Each thoracic segment bears a pair of legs. Four abdominal prolegs are located on the 3^{rd} to the 6^{th} segments. The last abdominal segment bears the 5^{th} abdominal prolegs or claspers. The body is covered with numerous setae. *2nd Instar.* A day old larva is green. Two small brown spots are located on the dorsal aspect of the prothorax on the position of the D1 setae.*3rd Instar.* The epicranial and frontal sutures become distinct and the head capsule is slightly bilobed. The posterior portion is brownish while the anterior portion is light brown. The two brown spots on the prothorax start to develop into thoracic shields.*4th Instar.* A day old larva is deep green. The bilobed head capsule and thoracic shields are black. The prothoracic segment becomes slightly flattened on the ventral surface. The thoracic legs are black with white claws. The abdominal prolegs are dirty white. The stematae become visible by the sides of the head near the antennae.*5th Instar.* The larva is green but towards pupation turns light green. The black thoracic shields start to degenerate from the posterior portion. The mandibles are stout with 5 teeth, 3 of which are more prominent.*6th Instar.* This is similar to the proceeding instar but for the prothoracic shields which continued to degenerate, thereby exposing the greater part of the prothoracic segment.

The total larval period lasts 15-20 days. A full grown caterpillar is about one and a quarter inch long, greenish with a dark brown head. At the end of the larval period, as indicated by cessation of feeding, they undergo pupation. The pupation takes place either in rolled leaves or amongst the fallen plant debris in the soil. The larva shortens and loses its characteristic green colour and becomes pinkish. It becomes inactive.The pupa is obtect in shape with more or less convex head. The thoracic segments are not visible on the ventral aspect having been concealed by the appendages. A dorsomedial ridge runs from the mesothorax and extends to the last abdominal segment. The thoracic spiracles consist of a single pair located between the pro and metathoracic segments, towards the dorsal aspect. The abdominal spiracles are only visible on the 3rd to the 8th segments, the one on the 4th segment being the most prominent. All the spiracles have thick round to oval and dark-brown peritremes. The abdomen is conical in shape. The 9th and 10th segments are not distinctly separated. Pairs of proleg scars are conspicuous on the ventral surface of the 5th and 6th segments. On the last segment is attached a black cremaster which is conical in shape. It bears six curved hooks. The pupa is dark-brown towards the time of adult emergence.

The period of pupation is about 6-12 days. The adult moth is white with yellowish wings bearing many fine lines. Sex could be distinguished at the adult stage. The adult is a small and delicate moth which is silvery white to gold in colour with a network of brown markings on the wings. Both the wings and the body are covered with scales. The abdomen of the male is slender and tapers gently towards the tip. In the female the abdomen is stouter and more blunt at the tip. Female moths are darker in colour than males.After copulation, the female lays eggs and the male dies. There are 3-4 generations in a year and the life cycle completed within 25-30 days (Mariselvi and Manimegalai, 2016).

2.5 Nature of Damage

The pest is a polyphagous insect and attacks crops like *Gossypium hirsutum, Abelmoschus esculentus, Hibiscus rosasinensis, Urena lobata, Althaca rosea, Sida cordifolia, Malvastrum tricuspidatum* and other Malvaceous plants. The damage is caused by the caterpillars which feed on the leaves and young buds. The larva rolls the leaf and feeds on the green tissue in the early stage and eats up a large portion of the leaf as it grows. Flowering and fruiting are poor and yield declines considerably due to this pest. The webbing and withering of leaves could be the symptoms of this pest infection (Mariselvi and Manimegalai, 2016). As a result of its attack, the whole leaf has been eaten up or big holes are made into it and finally, the infected leaves drops. Severe infection indicates the presence of a large number of leaf rolls and ultimately the plants become stunted probably as a result of impeded photosynthetic activities.

The caterpillars roll up the leaves from sides and bind the roll with silk spun by the spinnerets located near the mouth and the leaf tissues from inside. There may be 5 or 6 but sometimes 32 young caterpillars are seen in each infected leaf (Fadare and Amusa, 2003). During March – October the moth *Sylepta derogata* lays 200 eggs under the surface of the leaves.

2.6 Management of*Sylepta derogata*

The chemical groups, conventionally in use today are synthetic pyrethroids, organophosphates and carbamates. Pyrethroid insecticides are generally the most effective and less persistent than organophosphates (Fishel, 2005). They are characterised by high knockdown and lethal activity, a wide spectrum, good residual activity, together with repellent and anti-feeding activity. With these characteristics, pyrethroid insecticides have become widely used for plant protection. Their major use has been for the control of bollworms and leafworms in cotton but they have also achieved widespread use for controlling various species of lepidopterous pests in fruits and vegetables, aphids in cereals, and many other minor outlets.

Although the early synthetic pyrethroids suffered from a lack of activity against mites and soil pests, later additions, such as fenpropathrin, have combined high acaricidal activity with insecticidal activity and further pyrethroids are being introduced for use in soil. The extent of pyrethroid use has increased progressively since the first of the 'photostable' pyrethroids was registered in 1974. In 1986, the market share of pyrethroids reached 25% of the total insecticide market for plant protection; this figure can be increased in the future.At a rate of 49.5 ml/15L of water, Lambda cyhalothrin was found to reduce *Sylepta derogata* population and increase the yield of okra (Obeng-Oforiand Sackey2003).

2.6.1 Mode of Action of Pyrethroids

Pyrethroids in general are less acutely toxic than the organochlorine, organophosphate and carbamate pesticides with the exception of esfenvalerate, deltamethrin, bifenthrin, tefluthrin, flucythrinate, cyhalothrin and fenpropathrin which show the highest acute oral toxicities (Fishel, 2005; WHO, 2015). Acute and sub-acute studies have shown the main effects of pyrethroids as neurotoxicity at high doses and liver hypertrophy which are reversible if death does not occur. Many pyrethroids are mildly to severely irritating to the skin and eyes and some cause facial skin. Cypermethrin a systemic, class II synthetic pyrethroid pesticide, crosses the blood brain barrier and exerts neurotoxicity in the central nervous system and also induces motor deficits. Pyrethroids, including, cypermethrin extend the opening of sodium channels in the central nervous system leading to hypo-polarization and hyper-excitation of the neurons. Short-term neurotoxicity caused by cypermethrin is primarily mediated through hyper-excitation of the central nervous system (Eells and Dubocovich, 1988; Narahashi *et al*., 1992; Kirby *et al*., 1999). Chlorantraniliprole, a ryanoid is xylem-mobile, allowing the insecticide tomove upwards throughout the plant (Lahm *et al*., 2007). It is oftenapplied to the soil as seed treatments, soil

drenches, or throughchemigation in multiple crops such as brassicas and other vegetables(Lahm *et al*., 2007; Kuhar *et al*., 2008; Palumbo, 2008; Ghidiu *et al*.,2009; Schuster *et al*., 2009; Cameron *et al*., 2015). With those applications,the insecticide is taken up by the roots and provides effectivecontrol of lepidopterans and other insect pests on the foliage.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Field trials were conducted during the rainy season of 2019 in the Research Farm of the Institute for Agricultural Research, Samaru (11º 11' N, 07º 38' E which is 688.12 m above sea level) the Northern Guinea Savannah agro-ecological zone of Nigeria and Kadawa stations (11º 39' N, 8° 27' E which is 695 m above sea level) in the Sudan Savannah agro-ecological zone of Nigeria.

3.2 Experimental Materials

Five (5) varieties of okra consisting of three (3) improved varieties namely: Jokoso, Clemson Spineless and NHAE – 47 and two (2) local varieties namely: Ex-Basawa and Ex-Samaru, which are all medium to early maturing varieties were used.The five varieties of okra were obtained from the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria. Three (3) synthetic insecticides, namely: Lambda (Lambda-Cyhalothrin 2.5% EC), Cyperplus (Cypermethrin 30 g/L + Dimethoate 250 g/L) and Ampligo (Chlorantraniliprole 100g/L + Lambda-Cyhalothrin 50g/L) with an Untreated control were evaluated. The insecticides were purchased from a certified local vendor at Samaru main market.

3.2.1 Description of okra varieties used

Jokoso: The root system is extensive and the stem consists of an erect axis and primary laterals which becomes woody with age. The plant is indeterminate in growth. The leaves are ovate and not very lobed. The flowers are axillary, large and contain both stamens and pistils. The plants grow to a height of about 43cm. The fruits are elongated with medium sized pods. The fruits are

mildly spined and are consumed in the immature state. It is an improved variety and higher yielding compared to the local variety.

NHAE 47-4: The root system is extensive. The variety is indeterminate in growth habit. The plant consists of an erect axis and primary laterals which becomes woody with age. The leaves are lobed. The flowers are axillary, large and contain both stamens and pistils. The plant grows to a height of about 45 cm. The fruit is ribbed with spines. Fruit diameter is large. When mature, the pods are hard and woody. It is an improved and high yielding variety. Fruits are consumed both in the mature and immature stages.

Clemson spineless: It is a variety with pale green colour, angular pods. The fruits are slightly longer than other varieties, with small diameter. The plant is also a short variety (4-5 ft), with broad leaves, but narrower at the edge. It possesses fewer numbers of branches per plant than most of the other varieties evaluated. It has a fresh fruit yield potential of about 3 to 7 t/ha.

Ex-Samaru: It is a short local variety with broad leaves and few branches. It fruits well, but the fruits are small in size and possess spines. It is highly mucilaginous and produces few flowers compared to some improved varieties. The variety possesses fewer numbers of leaves (6-7 per plant) and matures in 52-54 days. The variety has yield potential of 4 to 6 t ha^{-1} of fresh fruit.

Ex-Basawa: The leaves are spherical, thin, and glabrous, with serrated margins. The stems are glabrous and about 110 cm in height. The fruits are glabrous and cylindrical. The flowers which are bright yellow are carried singly in the leaf axis on peduncles rarely more than 3 cm in length. The total green pod yield is about 3 t ha^{-1}.

3.3 Field Experiment

3.3.1 Treatments and Experimental design

The treatments consists of five (5) okra varieties (Clemson spineless, Ex-Basawa, Jokoso, Ex-Samaru and NHAE-47), three (3) insecticides (Lambda-cyhalothrin, Cypermethrin + Dimethoate and Chlorantraniliprole + Lambda-Cyhalothrin) with control and two planting periods (July and August) of three (3) weeks interval starting from July 2019, were laid out in 2 x 4 x 5 factorial experiment in a Randomized Complete Block Design (RCBD), replicated three (3) times. The field was cleared, harrowed, ridged and sprayed with a pre-emergence herbicide. The area of the land used was 90 m x 9 m length and width respectively (for both experiments).Two (2) okra seeds of each variety were sown at a plant spacing of 60 cm x 30 cm inter and intra-rows spacing respectively, on a plot of four (4) rows (1.8 m) by 4 m length, the spacing of 0.5 m between each plot and spacing of one row (1.2 m) between each replication.Seeds which after sowing did not germinate were re-sown one (1) week after sowing.

Thinning was carried out one (1) week after germination to establish only one plant per stand making up to thirteen (13) plants per row and fifty-two (52) plants per plot. Each plot was fertilized with 0.2 kg of N P K [20:10:10] compound fertilizer at the recommended rate of 250kg/ha of N P K [20:10:10] (Aluko *et al*., 2017). The fertilizer was applied to each plant as a side dressing two weeks after germination. Spraying with the recommended rate: 800 ml/ha of Lambda-cyhalothrin 2.5% EC, 300 ml/ha of Chlorantraniliprole 100 g/L + Lambda-Cyhalothrin 50 g/L and 1 L/ha of Cypermethin 30 g/L + Dimethoate 250 g/L commenced when the insect was first noticed (7 WAS) and continued on a fortnightly (14 days interval) basis and was terminated before pod initiation, using a knapsack CP15 sprayer. The field was weeded at one week interval to keep it free of weed.

3.4 Data Collection

Data collection commenced three (3) Weeks After Sowing (WAS) and continued at 6, 9, 12 and 14 WAS. Fifteen (15) plants were selected and tagged from each plot per replication for data recording. All readings were taken from the tagged plants and averaged. Successive harvesting of immature fruits was done regularly.The experiment was terminated at 14 WAS. The data was recorded and analyzed as presented below:

i. **Larval count:** Number of larvae from rolled leaves on fifteen (15) tagged plants per plot were counted before and after spray. The data recorded from this was transformed using the Square root transformation $x = \sqrt{(n + 0.05)}$ before being subjected to Analysis of Variance (ANOVA). This was later used to calculate the Reduction Over Control (%) using the formula:

Reduction over control (%) =

$$\frac{\text{Population in control plots} - \text{Population in treated plots}}{\text{Population in treated plots}} \times 100$$

(Maji *et al*., 2015).

ii. **Larval incidence:**The numbers of larvae from rolled leaves on fifteen (15) tagged plants were recorded for each plot. The ratio was therefore transformed using the Arcsine transformation [Y'=arcsin√(Y)]and converted to percentage before being subjected to Analysis of Variance.

iii. **Damage on leaves:** The number of rolledleaves from the fifteen (15) tagged plants per plot was recorded. The ratio was transformed using the Arcsine transformation and was therefore converted to percentage before being subjected to Analysis of Variance.

iv. **Yield**Pods harvested from each plot were placed in separate polythene bags, labeled and taken to the laboratory where pod weight was taken using an electric balance (Camry). The figures were then extrapolated to Kg/ha and subsequently subjected to Analysis of Variance.

3.5 Data Analysis

All data collected from the experiments were subjected to Analysis of Variance (ANOVA) using SAS program 8.1 (SAS, 2000). Where significant difference was observed, means were separated using The Student Newman Keul's test (SNK) at 5% level of probability.

CHAPTER FOUR

4.0 RESULTS

4.1 Effect of Variety, Insecticide and Time of sowing on the Incidence (%) of leaf roller larvae on Okra leaves at Samaru and Kadawa during the 2019 wet season

The effect of variety, insecticide and time of sowing on the percentage incidence of leaf roller larvae on okra leaves at Samaru and Kadawa is presented in Table 1. Ex-Samaru (1.67 %) recorded the least incidence at Samaru which was significantly ($P<0.05$) higher than NHEA-47 (2.92 %), Clemson spineless (3.82%), Ex-Basawa (3.96 %) and Jokoso (6.57 %). Jokoso recorded the highest incidence at Samaru which was significantly ($P<0.05$) higher than other varieties. However, Clemson spineless, NHAE-47 andEx-Basawa (3.96 %) were not significantly different ($P>0.05$).At Kadawa, Ex-Samaru (1.67 %) recorded the least incidence but was not significant ($P>0.05$) different from NHEA-47 (2.50 %), but was significantly ($P<0.05$) higher than other varieties. NHAE-47 was not significantly different ($P>0.05$) from Clemson spineless (3.69 %) and Ex-Basawa (3.48 %). Jokoso similarly recorded the highest incidence (7.33 %) which was significantly ($P<0.05$) higher than all other varieties. At the combined analysis, Ex-Samaru (1.67 %) and NHEA-47 (2.50 %) which were not significantly ($P>0.05$) different but were significantly ($P<0.05$) higher than other varieties. Jokoso (6.95 %) recorded the highest incidence which was significantly ($P<0.05$) higher than all other varieties. Clemson spineless (3.75 %) and Ex-Basawa (3.72 %) were not significantly different ($P>0.05$)

At Samaru, crops sprayed withCyperplus (1.67 %) and Ampligo (1.67 %) were not significantly different ($P>0.05$) but were significantly ($P<0.05$) higher than crops sprayed with Lambda (3.67 %). Untreated control plots recorded the highest incidence (8.15 %).At Kadawa, crops sprayed with Cyperplus (2.17 %), Ampligo (1.67 %) and Lambda (3.06 %) were not significantly different ($P>0.05$). At the combined analysis, crops sprayed with Cyperplus (1.92 %) and

Ampligo (1.67 %) were not significantly different (P>0.05) but were significantly (P<0.05) higher than Lambda (3.36 %).

It was equally recorded that, plots sown in July (4.68 %) had significantly (P<0.05) higher incidence of leaf roller than those sown in August (2.89 %) at Samaru. At Kadawa, crops sown in July (3.29 %) were not significantly (P>0.05) different from those sown in August (4.01 %). At Kadawa and combined analysis, the time of sowing was not significant.

From the trial, the interactions between variety and insecticides for Samaru, Kadawa and the combined analysis were highly significant. The interaction between time of sowing and variety was significant at Samaru but was found not to be significant at Kadawa and the combined analysis. Also the interaction between time of sowing and insecticide was found to be significant at Samaru and the combined analysis but not significant at Kadawa. The interaction between time of sowing, variety and insecticide was found to be significant at Samaru but not significant at Kadawa and the combined analysis.

Table 1: Effect of Variety, Insecticide and Time of sowing on the Incidence (%) of leaf roller larvae on Okra Leaves at Samaru and Kadawa during 2019 wet season

	Means of larval Incidence (%)		
Treatment	**Samaru**	**Kadawa**	**Combined**
Variety			
Clemson spineless	3.82[b]	3.69[b]	3.75[b]
Ex-Samaru	1.67[c]	1.67[c]	1.67[c]
NHAE-47	2.92[b]	2.08[bc]	2.50[c]
Ex-Basawa	3.96[b]	3.48[b]	3.72[b]
Jokoso	6.57[a]	7.33[a]	6.95[a]
SE±	0.350	0.504	0.307
Insecticide			
Cyperplus	1.67[c]	2.17[b]	1.92[c]
Ampligo	1.67[c]	1.67[b]	1.67[c]
Lambda	3.67[b]	3.06[b]	3.36[b]
Untreated	8.15[a]	7.70[a]	7.93[a]
SE±	0.313	0.451	0.274
Time of sowing			
June	4.68[a]	3.29	3.99
July	2.89[b]	4.01	3.45
SE±	0.222	0.319	0.194
Interaction			
Variety X Insecticide	**	**	**
Time of sowing X Variety	**	NS	NS
Time of Sowing X Insecticide	**	NS	*
Time of Sowing X Variety X Insecticide	**	NS	NS

Means followed by the same letter(s) within a column and category are not statistically different at (P>0.05) using SNK NS: not significant. **: Highly significant (P<0.01) *: Significant (P<0.05)

4.1.1 Effect of interaction between variety and insecticide on the incidence (%) ofLeaf rollerlarvae on Okra leaves at Samaru, Kadawa and the combined analysis during 2019 wet season

The effect of interaction between variety and insecticide on the incidence (%) of leaf roller larvae on Okra leaves at Samaru, Kadawa and the combined analysisduring 2019 wet seasonis shown in Table 2. At Samaru, it was recorded that all plots sprayed with Cyperplus (1.67 %) and Ampligo (1.67 %) were not significantly different (P>0.05). For crops sprayed with Lambda, Jokoso (5.00 %) and Clemson spineless (5.00 %) were not significantly different (P>0.05) from NHAE-47 (3.33 %) and Ex-Basawa (3.33 %) but were significantly (P<0.05) higher than Ex-Samaru (1.67 %). Ex-Samaru, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For the untreated control plots, Jokoso (17.92 %) recorded the highest incidence which was significantly (P<0.05) higher than all others. Ex-Basawa (9.18 %) was not significantly (P>0.05) different than Clemson spineless (6.95 %) but was significantly (P<0.05) higher than Ex-Samaru (1.67 %) and NHAE-47 (5.00 %) while Clemson spineless and NHAE-47 were not significantly different (P>0.05).

At Kadawa, all varieties sprayed with Cyperplus, Ampligo or Lambda were not significantly different (P>0.05). For the Untreated control plots, Jokoso (19.04 %) recorded the highest larval incidence which was significantly (P<0.05) higher than all other varieties. Clemson spineless (8.91 %) and Ex-Basawa (7.24 %) were not significantly different (P>0.05) but were significantly (P<0.05) higher than Ex-Samaru (1.67 %) and NHAE-47 (1.67 %), which were statistically similar.

At the combined analysis, all plots sprayed with Cyperplus or Ampligo were not significantly different (P>0.05). For varieties sprayed with Lambda, Clemson spineless (3.75 %) and Jokoso (4.73 %) were not significantly different (P>0.05) from Ex-Basawa (3.34 %) and NHAE-47

(3.34 %) but were significantly (P<0.05) higher than Ex-Samaru (1.67 %). Ex-Samaru, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For the untreated control plots, Jokoso (18.48 %) was significantly (P<0.05) higher than all other varieties. Ex-Basawa (8.21 %) and Clemson spineless (7.93 %) were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 (3.34 %) and Ex-Samaru (1.67 %). NHAE-47 and Ex-Basawa were not significantly different (P>0.05).

Table 2: Effect of interaction between variety and insecticide treatment on the incidence (%) of Leaf rollerlarvae at Samaru, Kadawa and the combined analysisduring 2019 wet season

	Means of larval Incidence (%) Insecticide			
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
Variety		**Samaru**		
Clemson spineless	1.67	1.67	5.00[a]	6.95[bc]
Ex-Samaru	1.67	1.67	1.67[c]	1.67[e]
NHAE-47	1.67	1.67	3.33[b]	5.00[cd]
Ex-Basawa	1.67	1.67	3.33[b]	9.18[b]
Jokoso	1.67	1.67	5.00[a]	17.92[a]
SE±		0.701		
		Kadawa		
Variety				
Clemson spineless	1.67	1.67	2.50	8.91[b]
Ex-Samaru	1.67	1.67	1.67	1.67[d]
NHAE-47	1.67	1.67	3.34	1.67[d]
Ex-Basawa	1.67	1.67	3.34	7.24[bc]
Jokoso	4.17	1.67	4.45	19.04[a]
SE±		1.008		
		Combined		
Variety				
Clemson spineless	1.67	1.67	3.75[b]	7.93[bc]
Ex-Samaru	1.67	1.67	1.67[d]	1.67[e]
NHAE-47	1.67	1.67	3.34[bc]	3.34[d]
Ex-Basawa	1.67	1.67	3.34[bc]	8.21[b]
Jokoso	2.92	1.67	4.73[a]	18.48[a]
SE±		0.614		

Means followed by the same letter(s) within the same column and row in the same category are not different statistically at 5 % level of Probability using SNK

4.1.2 Effect of the interaction between variety and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru during the 2019 wet season

Table 3 shows the interaction between variety and time of sowing on the percentage incidence of leaf roller larvae on okra leaves at Samaru. For varieties sown in July, Ex-Samaru (1.67 %) recorded the least incidence which was significantly ($P<0.05$) higher than NHAE-47 (3.75 %), Clemson spineless (4.73 %), Ex-Basawa (5.01 %) and Jokoso (8.26 %). Ex-Basawa, Clemson spineless and NHAE-47 were not significantly different ($P>0.05$) but were significantly ($P<0.05$) higher than Jokoso. For the varieties sown in August, Ex-Samaru (1.67 %) recorded the least incidence which was not significantly ($P>0.05$) different from NHAE-47 (2.08 %) and Ex-Basawa (2.92 %) and Clemson spineless (2.92 %). Jokoso (4.87 %) recorded the highest incidence which was significantly ($P<0.05$) higher than other varieties.

Table 3: Effect of the interaction between variety and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru during the 2019 wet season

	Means of larval Incidence (%) Time of Sowing	
Treatment	**July**	**August**
Variety		
Clemson spineless	4.73^{bc}	2.92^{b}
Ex-Samaru	1.67^{e}	1.67^{bc}
NHAE-47	3.75^{bcd}	2.08^{bc}
Ex-Basawa	5.01^{b}	2.92^{b}
Jokoso	8.26^{a}	4.87^{a}
SE±	0.496	

Means followed by the same letter(s) within the same column and row are not different statistically at 5 % level of Probability using SNK

4.1.3 Effect of the interaction between insecticide and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru, Kadawa and the combined analysis during the 2019 wet season

Table 4 shows the effect of the interaction between insecticide and time of sowing on the percentage incidence of leaf roller larvae on okra leaves at Samaru, Kadawaand the combined analysisduring the 2019 wet season. At Samaru, for July sowing date, Cyperplus (1.67 %), Ampligo (1.67 %) and Lambda (4.34 %) were statistically similar but were significantly ($P<0.05$) higher than the Untreated control (11.07 %) plots. At Samaru, for the August sowing date, Ampligo (1.67 %) and Cyperplus (1.67 %) were not significantly ($P>0.05$) different but were significantly ($P>0.05$) higher than Lambda (3.00 %). Untreated control (5.23 %) plotswere significantly ($P<0.05$) higher than other insecticides in terms of the incidence of leaf roller larvae. The interaction at Kadawa was not significant.

At the combined analysis, for July sowing date, crops sprayed with Cyperplus (1.88 %) and Ampligo (1.67 %) were statistically similar ($P>0.05$) but were significantly higher than crops sprayed with Lambda (3.34 %) and Untreated control (9.10 %) plots. Crops sprayed with Lambda was significantly ($P<0.05$) higher than the Untreated control plots. For the August sowing date, Ampligo (1.67 %) recorded the least incidence which was statistically similar ($P>0.05$) to crops sprayed with Cyperplus (2.00 %), Ampligo and Cyperplus were significantly ($P<0.05$) higher than Lambda (3.39 %) and Untreated control (6.75 %) plots. Crops sprayed with Lambda was significantly ($P<0.05$) higher than the Untreated control plots.

Table 4: Effect of the interaction between insecticide and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru, Kadawaand Combined analysis during the 2019 wet season

	Means of larval Incidence (%) Time of Sowing	
Treatment	**July**	**August**
Insecticide	**Samaru**	
Cyperplus	1.67[c]	1.67[c]
Ampligo	1.67[c]	1.67[c]
Lambda	4.34[b]	3.00[b]
Untreated	11.07[a]	5.23[a]
SE±	0.443	
Insecticide	**Kadawa**	
Cyperplus	2.00	2.33
Ampligo	1.67	1.67
Lambda	7.14	8.26
Untreated	2.33	3.78
SE±	0.638	
Insecticide	**Combined**	
Cyperplus	1.88[c]	2.00[c]
Ampligo	1.67[c]	1.67[c]
Lambda	3.34[b]	3.39[b]
Untreated	9.10[a]	6.75[a]
SE±	0.388	

Means followed by the same letter(s) within the same column and row in the same category are not different statistically at 5 % level of Probability using SNK

4.1.4 Effect of the interaction between variety, insecticide and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru during the 2019 wet season

Table 5 shows the interaction between variety, insecticide and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru during the 2019 wet season. It was recorded that all plots sprayed with Cyperplus or Ampligo for both July and August were not significantly different ($P>0.05$). In June, for varieties sprayed with Lambda, Clemson spineless (6.67 %) was not significantly different ($P>0.05$) from NHAE-47 (5.00 %), Jokoso (5.00 %) but was significantly ($P<0.05$) higher than Ex-Basawa (3.34 %) and Ex-Samaru (1.67 %). NHAE-47 and Jokoso were not significantly different ($P>0.05$) from Ex-Basawa but were significantly higher ($P<0.05$) than Ex-Samaru. However, Ex-Basawa was not significantly different ($P>0.05$) from Ex-Samaru. For the untreated control plots, Jokoso (24.71 %) was significantly ($P<0.05$) higher than other varieties. Ex-Basawa (13.37 %) was significantly ($P<0.05$) higher than Clemson spineless (8.91 %). Clemson spineless was significantly ($P<0.05$) higher than NHAE-47 (6.67 %). NHAE-47 was also significantly ($P<0.05$) higher than Ex-Samaru (1.67 %). In July for varieties sprayed with Lambda, Jokoso (5.00 %) was not significantly different ($P>0.05$) from Clemson spineless (3.34%) and Ex-Basawa (3.34%) but was significantly ($P<0.05$) higher than Ex-Samaru (1.67 %) and NHAE-47 (1.67%). Clemson spineless and Ex-Basawa were not significantly different from Ex-Samaru and NHAE-47. For the untreated control plots in July, Jokoso (11.14 %) was significantly ($P<0.05$) higher than other varieties. While Clemson spineless (5.00 %) and Ex-Basawa (5.00 %) were not significantly different ($P>0.05$) from NHAE-47 (3.34 %) but were significantly ($P<0.05$) higher than Ex-Samaru (1.67 %). NHAE-47 was not significantly different ($P>0.05$) from Ex-Samaru.

Table 5: Effect of the interaction between variety, insecticide and time of sowing on the incidence (%) of leaf roller larvae on okra leaves at Samaru during the 2019 wet season

	Means of larval Incidence (%) Insecticides			
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
Variety		**June**		
Clemson spineless	1.67	1.67	6.67[a]	8.91[c]
Ex-Samaru	1.67	1.67	1.67[d]	1.67[e]
NHAE-47	1.67	1.67	5.00[bc]	6.67[d]
Ex-Basawa	1.67	1.67	3.34[bc]	13.37[b]
Jokoso	1.67	1.67	5.00[b]	24.71[a]
		July		
Clemson spineless	1.67	1.67	3.34[ab]	5.00[b]
Ex-Samaru	1.67	1.67	1.67[bc]	1.67[c]
NHAE-47	1.67	1.67	1.67[bc]	3.34[bc]
Ex-Basawa	1.67	1.67	3.34[ab]	5.00[b]
Jokoso	1.67	1.67	5.00[a]	11.14[a]
SE±		0.991		

Means followed by the same letter(s) within the same column and row are not different statistically at 5 % level of Probability using SNK.

4.2 Effect of Variety, Insecticide and Time of Sowing on Damage (%) Caused by leaf roller Larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

Table 6 shows the effect of variety, insecticide and time of sowing on damage (%) caused by leafroller larvae on okra leaves at Samaru and Kadawa during the 2019 wet season. At Samaru, Ex-Samaru gave the least (70.71 %) damage which was significantly ($P<0.05$) different from other varieties. NHAE-47 (73.31 %) was significantly ($P<0.05$) higher than Clemson spineless (75.88 %), Ex-Basawa (76.42 %) and Jokoso (82.21 %). However, Clemson spineless and Ex-Basawa were statistically similar ($P>0.05$) but were significantly ($P<0.05$) higher than Jokoso.At Kadawa, While Ex-Samaru and NHAE-47 had the least (70.71 %) damage caused by the leaf roller larvae, Jokoso recorded the highest (80.50 %) damage.Ex-Samaru and NHAE-47 were statistically ($P>0.05$) similar but were significantly ($P<0.05$) higher than other varieties. Ex-Basawa (73.99 %) and Clemson spineless (74.93 %) were not significantly different ($P<0.05$). At the combined analysis, Jokoso (81.36 %) recorded the highest damage which was significantly ($P<0.05$) higher than other varieties. Ex-Basawa (75.20 %) and Clemson spineless (75.40 %) were not significantly different ($P>0.05$) but were significantly ($P<0.05$) higher than Ex-Samaru (70.71 %) and NHAE-47 (72.01 %). NHAE-47 and Ex-Samaru were not significantly different ($P>0.05$).

At Samaru, plots sprayed with Cyperplus (70.71 %) and Ampligo (70.71 %) recorded the least leaf damage caused by the leaf roller larvae which were statistically similar but were significantly ($P<0.05$) higher than other insecticides.Plots sprayed with Lambda (74.24 %) was significantly ($P<0.05$) higher thanUntreated control (87.16 %) plots. At Kadawa, plots sprayed with Ampligo (70.71 %) recorded the least damage which was statistically ($P>0.05$) similar to .Plots sprayed with Cyperplus (71.59 %) and Lambda (72.49 %). Untreated control (81.88 %) plots had the most damage caused by the leaf roller larvae. At the combined analysis, Untreated

control (84.52 %) plots recorded the highest damage which was significantly ($P<0.05$) higher than plots sprayed with Cyperplus (71.15 %), Ampligo (70.71 %) and Lambda (73.36 %). Lambda was significantly ($P<0.05$) higher than Cyperplus and Ampligo but Ampligo and Cyperplus were not significantly different.

Plots sown in July at Samaru and combined analysis recorded the highest (78.28 % and 76.14 % respectively) damage which were significantly ($P<0.05$) higher than crops sown in August (73.13 % and73.73 %), however, there was no significant difference between crops sown in July and August at Kadawa in foliar damage due to leaf roller larvae activities.

The interaction between Variety and Insecticide was significant at Samaru, Kadawa and Combined analysis, while the interaction between sowing date and Variety was significantly high at Samaru and the Combined analysis but not at Kadawa. Similarly, the interaction between sowing date and insecticide was statistically significant at Samaru and the Combined analysis but not at Kadawa. The interaction between sowing date, variety and insecticide was statistically high at Samaru and Combined analysis but not at Kadawa.

Table 6: Effect of Variety, Insecticide and Time of sowing on the Damage (%) caused byleaf roller larvae on Okra Leaves at Samaru and Kadawa during 2019 wet season.

Means of the Damage (%) caused by leaf roller larvae on Okra leaves			
Treatment	**Samaru**	**Kadawa**	**Combined**
Variety			
Clemson spineless	75.88[b]	74.93[b]	75.40[b]
Ex-Samaru	70.71[d]	70.71[c]	70.71[c]
NHAE-47	73.31[c]	70.71[c]	72.01[c]
Ex-Basawa	76.42[b]	73.99[b]	75.20[b]
Jokoso	82.21[a]	80.50[a]	81.36[a]
SE±	0.726	0.773	0.533
Insecticide			
Cyperplus	70.71[c]	71.59[b]	71.15[c]
Ampligo	70.71[c]	70.71[b]	70.71[c]
Lambda	74.24[b]	72.49[b]	73.36[b]
Untreated control	87.16[a]	81.88[a]	84.52[a]
SE±	0.649	0.691	0.477
Time of Sowing			
July	78.28[a]	74.33	76.14[a]
August	73.13[b]	74.01	73.73[b]
SE±	0.459	0.489	0.34
Interaction			
Variety X Insecticide	**	**	**
Sowing date X Variety	**	NS	*
Sowing date X Insecticide	**	NS	**
Sowing date X Variety X Insecticide	**	NS	**

Means followed by the same letter(s) within a column and category are not statistically different at (P>0.05) using SNK NS: not significant. **: Highly significant (P<0.01) *: Significant (P<0.05)

4.2.1 Effect of interaction between variety and insecticide on the Damage (%) caused by Leaf rollerlarvae on Okra leaves at Samaru, Kadawa and the combined analysis during 2019 wet season

Table 7 shows the effect of interaction between variety and insecticide on the Damage (%) caused by Leaf roller larvae on okra leaves at Samaru, Kadawa and the combined analysis during 2019 wet season. At Samaru, all varieties sprayed with either Cyperplus or Ampligo were not significantly different (P>0.05). For varieties sprayed with Lambda, Jokoso (76.93 %) recorded the highest leaf damage which was not significantly different (P>0.05) from Clemson spineless (75.26 %) Ex-Basawa (74.36 %), NHAE-47 (73.92 %) but was significantly higher than Ex-Samaru (70.71 %). Ex-Basawa, NHAE-47 and Ex-Samaru were not significantly different. For the untreated control plots, Jokoso (99.44 %) was significantly (P<0.05) higher than all other varieties. Ex-Basawa (89.88 %) and Clemson spineless (86.82 %) were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 (77.91 %) and Ex-Samaru (70.71%). NHAE-47 was significantly (P<0.05) higher than Ex-Samaru.

At Kadawa, all varieties sprayed with Cyperplus or Ampligo were not significantly different (P>0.05). For varieties sprayed with Lambda, Jokoso (75.11 %) was not significantly different (P>0.05) from Clemson spineless (72.53 %) and Ex-Basawa (72.53 %) but was significantly (P<0.05) higher than Ex-Samaru (70.71 %) and NHAE-47 (70.71 %). Clemson spineless, Ex-Samaru, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For the untreated control plots, Jokoso (90.20 %) was significantly higher (P<0.05) than all other varieties. Clemson spineless (85.78 %) was not significantly different (P>0.05) from Ex-Basawa (82.00 %) but was significantly (P<0.05) higher than Ex-Samaru (70.71 %) and NHAE-47 (70.71 %). Ex-Basawa was significantly (P<0.05) higher than Ex-Samaru and NHAE-47. Ex-Samaru and NHAE-47 were not significantly different (P>0.05).

At the combined, all varieties sprayed with Cyperplus and Ampligo were not significantly different (P>0.05). For varieties sprayed with Lambda, Jokoso (76.45 %) was not significantly different (P>0.05) from Clemson spineless (73.90 %) and Ex-Basawa (73.45 %) but was significantly (P<0.05) higher than NHAE-47 (72.32 %) and Ex-Samaru (70.71%). Clemson spineless, Ex-Samaru, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For the untreated control plots, Jokoso (94.82 %) was significantly (P<0.05) higher than Ex-Basawa (85.94 %), Clemson spineless (85.30 %), NHAE-47 (74.31 %) and Ex-Samaru (70.71 %). Clemson spineless and Ex-Samaru were not significantly different (P>0.05) but were significantly (P<0.05) higher than Ex-Samaru and NHAE-47. NHAE-47 was significantly (P<0.05) higher than Ex-Samaru.

Table 7: Effect of interaction between variety and insecticide treatment on the damage (%) caused byLeaf rollerlarvae at Samaru, Kadawa and the Combined analysisduring 2019 wet season

Means of the Damage (%) caused by leaf roller larvae on Okra leaves				
	Insecticide			
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
Variety			**Samaru**	
Clemson spineless	70.71	70.71	75.26^{ab}	86.82^{bc}
Ex-Samaru	70.71	70.71	70.71^{c}	70.71^{e}
NHAE-47	70.71	70.71	73.92^{bc}	77.91^{d}
Ex-Basawa	70.71	70.71	74.36^{bc}	89.88^{b}
Jokoso	70.71	70.71	76.93^{a}	99.44^{a}
SE±			1.451	
			Kadawa	
Variety				
Clemson spineless	70.71	70.71	72.53^{ab}	85.78^{b}
Ex-Samaru	70.71	70.71	70.71^{c}	70.71^{d}
NHAE-47	70.71	70.71	70.71^{c}	70.71^{d}
Ex-Basawa	70.71	70.71	72.53^{ab}	82.00^{bc}
Jokoso	75.11	70.71	75.11^{a}	90.20^{a}
SE±			1.545	
			Combined	
Variety				
Clemson spineless	70.71	70.71	73.90^{ab}	85.30^{b}
Ex-Samaru	70.71	70.71	70.71^{c}	70.71^{e}
NHAE-47	70.71	70.71	72.32^{bc}	74.31^{d}
Ex-Basawa	70.71	70.71	73.45^{ab}	85.94^{bc}
Jokoso	72.91	70.71	76.45^{a}	94.82^{a}
SE±			1.066	

Means followed by the same letter(s) within the same column and row in the same category are not different statistically at 5 % level of Probability using SNK

4.2.2 Effect of the interaction between variety and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru, Kadawaand combined analysisduring the 2019 wet season

Table 8 shows the effect of the interaction between variety and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru during the 2019 wet season.At Samaru in July, Ex-Samaru (70.71 %) recorded the least damage which was significantly ($P<0.05$) different from other varieties. NHAE-47 (75.13 %) was significantly ($P<0.05$) higher than Clemson spineless (78.55 %), Ex-Basawa (79.34 %) and Jokoso (87.76 %). Clemson spineless and Ex-Basawa were statistically ($P>0.05$) similar but were significantly ($P<0.05$) higher than Jokoso.In August, Ex-Samaru gave the least (70.71 %) damage which was statistically ($P>0.05$) similar to NHAE-47 (71.50 %), Clemson spineless (73.20 %) and Ex-Basawa (73.49 %) but was significantly ($P<0.05$) higher than Jokoso (76.75 %).The interaction between the variety and time of sowing on the damage caused by leaf roller larvae at Kadawa was not significant.

At the combined analysis in July, Ex-Samaru recorded the least (70.71 %) damage which was not significantly ($P>0.05$) different from NHAE-47 (72.92 %). Ex-Basawa (76.26 %) and Clemson spineless (76.92 %) were not significantly different ($P>0.05$) but were significantly higher than Jokoso (83.90 %). In August, Jokoso (78.82 %) was significantly ($P<0.05$) higher than Clemson spineless (73.89 %), Ex-Basawa (74.13 %), NHAE-47 (71.71 %) and Ex-Samaru (71.71 %). Clemson spineless and Ex-Basawa were not significantly different ($P>0.05$), but were significantly ($P<0.05$) higher than NHAE-47 and Ex-Samaru. NHAE-47 and Ex-Samaruwhich were statistically ($P<0.05$) comparable.

Table 8: Effect of the interaction between variety and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru, Kadawa and combined analysis during the 2019 wet season

Means of the Damage (%) caused by leaf roller larvae on Okra leaves		
Time of Sowing		
Treatment		
	July	**August**
Variety	**Samaru**	
Clemson spineless	78.55^{bc}	73.20^{b}
Ex-Samaru	70.71^{e}	70.71^{bc}
NHAE-47	75.13^{d}	71.50^{bc}
Ex-Basawa	79.34^{b}	73.49^{b}
Jokoso	87.67^{a}	76.75^{a}
SE±	1.026	
Variety	**Kadawa**	
Clemson spineless	75.30	74.57
Ex-Samaru	70.71	70.71
NHAE-47	70.71	70.71
Ex-Basawa	73.20	74.78
Jokoso	80.12	80.88
SE±	1.093	
Variety	**Combined**	
Clemson spineless	76.92^{b}	73.89^{bc}
Ex-Samaru	70.71^{de}	71.71^{d}
NHAE-47	72.92^{d}	71.71^{d}
Ex-Basawa	76.27^{bc}	74.13^{b}
Jokoso	83.90^{a}	78.82^{a}
SE±	0.754	

Means followed by the same letter(s) within the same column and row in the same category are not different statistically at 5 % level of Probability using SNK.

4.2.3 Effect of the interaction between insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru, Kadawaand combined analysisduring the 2019 wet season

Table 9 show the interaction between insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru, Kadawa and combined analysis during the 2019 wet season. At Samaru for both July and August sowing dates, plots sprayed withAmpligo and Cyperplus recorded the least (70.71 % and 70.71 % respectively) damage which was statistically ($P>0.05$) similar to plots sprayed with Lambda (75.04 % and 73.43 % respectively) but were significantly ($P<0.05$) higher than Untreated control (96.65 % and 77.67 % respectively) plots. The interaction between the insecticide and time of sowing on the damage caused by leaf roller larvae at Kadawa was not significant.

At the combined analysis, in July, plots sprayed with Ampligo recorded the least damage (70.71 %) which was not significantly ($P>0.05$) different from Cyperplus (71.03 %) but was significantly ($P<0.05$) higher than Lambda (73.61 %). Cyperplus was significantly ($P<0.05$) higher than Lambda.

In August, There was no significant ($P>0.05$) difference between plots sprayed with Ampligo (70.71 %) andCyperplus (71.28 %). Similarly, plots sprayed with Cyperplus was not significantly ($P>0.05$) different from plots sprayed with Lambda (73.12 %).

Table 9: Effect of the interaction between insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru, Kadawa and combined analysis during the 2019 Wet season

Means of the Damage (%) caused by leaf roller larvae on Okra leaves		
Time of Sowing		
Treatment		
	July	**August**
Insecticide	**Samaru**	
Cyperplus	70.71[c]	70.71[c]
Ampligo	70.71[c]	70.71[c]
Lambda	75.04[b]	73.43[b]
Untreated	96.65[a]	77.67[a]
SE±	0.918	
	Kadawa	
Insecticide		
Cyperplus	72.17	72.81
Ampligo	70.71	70.71
Lambda	81.81	81.96
Untreated	71.34	71.84
SE±	0.977	
	Combined	
Insecticide		
Cyperplus	71.03[c]	71.28[bc]
Ampligo	70.71[c]	70.71[c]
Lambda	73.61[b]	73.12[b]
Untreated	89.23[a]	79.81[a]
SE±	0.674	

Means followed by the same letter(s) within the same column and row in the same category are not different statistically at 5 % level of Probability using SNK

4.2.4 Effect of the interaction between variety, insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaruduring the 2019 wet season

Table 10 shows the interaction between variety, insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at Samaru during the 2019 wet season. It was recorded that all varieties sprayed with Cyperplus, Ampligo and Lambda in both July and August sowing dates were not significantly different ($P>0.05$). However, in July for the Untreated control plots, Ex-Samaru (70.71 %) recorded the least damage caused by leaf roller larvae which was significantly ($P<0.05$) higher than other varieties. NHAE-47 (81.95 % was significantly higher than Clemson spineless (86.51 %), Ex-Basawa (91.42 %) and Jokoso (99.68 %). In August for the Untreated control plots, Jokoso (88.07%) was not significantly different ($P>0.05$) from Ex-Basawa (78.19%) but was significantly higher ($P<0.05$) than Clemson spineless (77.51%), Ex-Samaru (70.71%) and NHAE-47 (73.87%). Ex-Basawa, Clemson spineless, Ex-Samaru and NHAE-47 were not significantly different.

Table 10: Interaction between Time of sowing, Variety and Insecticide on the Damage (%) caused byLeaf roller larvae on Okra leaves at Samaru during the 2019 Wet Season

Means of the Damage (%) caused by leaf roller larvae on Okra leaves				
Insecticide				
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
Variety		**July**		
Clemson spineless	70.71	70.71	76.65	86.51^{bc}
Ex-Samaru	70.71	70.71	70.71	70.71^{e}
NHAE-47	70.71	70.71	77.14	81.95^{d}
Ex-Basawa	70.71	70.71	74.36	91.42^{b}
Jokoso	70.71	70.71	76.35	99.68^{a}
		August		
Variety				
Clemson spineless	70.71	70.71	73.87	77.51^{bc}
Ex-Samaru	70.71	70.71	70.71	70.71^{c}
NHAE-47	70.71	70.71	70.71	73.87^{bc}
Ex-Basawa	70.71	70.71	74.36	78.19^{abc}
Jokoso	70.71	70.71	77.51	88.07^{a}
SE+		**2.513**		

Means followed by the same letter(s) within the same column and row are not different statistically at 5 % level of Probability using SNK

4.2.5 Effect of the interaction between variety, insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at combined analysisduring the 2019 wet season

Table 11 shows the effect of the interaction between variety, insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at the combined analysis during the 2019 wet season. It was recorded that varieties sown in July and August, sprayed with Cyperplus and Ampligo were not statistically different from all varieties sown in July sprayed with Lambda. However, in August for varieties sprayed with Lambda, Jokoso (77.54 %) was not significantly ($P>0.05$) different from Clemson spineless (74.11 %) but was significantly ($P<0.05$) higher than Ex-Samaru (70.71 %), NHAE-47 (70.71 %) and Ex-Basawa (72.53 %). Clemson spineless, Ex-Samaru, NHAE-47 and Ex-Basawa were not significantly different ($P>0.05$). In July, Untreated control plots with Jokoso (99.65 %) was significantly ($P<0.05$) higher than Clemson spineless (92.59 %), Ex-Samaru (70.71 %), NHAE-47 (76.33 %) and Ex-Basawa (89.30 %). Clemson spineless and Ex-Basawa were not significantly ($P>0.05$) different but was significantly ($P<0.05$) higher than Ex-Samaru and NHAE-47. NHAE-47 was significantly ($P<0.05$) higher than Ex-Samaru. In August, Untreated control plots with Jokoso (93.48 %) was significantly ($P<0.05$) higher than Clemson spineless (80.01 %), Ex-Samaru (70.71 %), NHAE-47 (72.29 %) and Ex-Basawa (82.58 %). Clemson spineless and Ex-Basawa were not significantly ($P>0.05$) different but were significantly ($P<0.05$) higher than NHAE-47 and Ex-Samaru. Ex-Samaru and NHAE-47 were not different.

Table 11: Effect of the interaction between variety, insecticide and time of sowing on the damage (%) caused by leaf roller larvae on okra leaves at combined analysis during the 2019 wet season

Means of the Damage (%) caused by leaf roller larvae on Okra leaves				
	Insecticide			
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
			July	
Variety				
Clemson spineless	70.71	70.71	73.68	92.59^{b}
Ex-Samaru	70.71	70.71	70.71	70.71^{e}
NHAE-47	70.71	70.71	73.92	76.33^{d}
Ex-Basawa	70.71	70.71	74.36	89.30^{bc}
Jokoso	72.29	70.71	75.36	99.65^{a}
			August	
Variety				
Clemson spineless	70.71	70.71	74.11^{ab}	80.01^{b}
Ex-Samaru	70.71	70.71	70.71^{c}	70.71^{c}
NHAE-47	70.71	70.71	70.71^{c}	72.29^{c}
Ex-Basawa	70.71	70.71	72.53^{bc}	82.58^{b}
Jokoso	73.53	70.71	77.54^{a}	93.48^{a}
SE+			**1.508**	

Means followed by the same letter(s) within the same column and row are not different statistically at 5 % level of Probability using SNK

4.3 Effect of insecticide on the population reduction over control (%) of Leaf roller larvae on Okra leaves at Samaru and Kadawa during the 2019 wet season

The effect of Variety and Insecticide on the Population Reduction (%) over control of leaf rollerlarvae on Okra leaves at Samaru and Kadawa is presented in Table 12. At Samaru, varieties sprayed with Ampligo gave the highest (84.86 %) percentage reduction over Untreated control which was significantly ($P<0.05$) higher than varieties sprayed with Cyperplus (53.58 %) and Lambda (51.27 %). However, varieties sprayed with Cyperplus and Lambda were not significantly ($P>0.05$) different. At Kadawa, varieties sprayed with Ampligo (45.76 %) and Cyperplus (45.76 %) were not significantly ($P>0.05$) different from varieties sprayed with Lambda (20.58 %) but were significantly ($P<0.05$) higher over the Untreated control. At the Combined analysis, varieties sprayed with Ampligo (65.29 %) was not significantly ($P>0.05$) higher than varieties sprayed with Cyperplus (49.67 %) but was significantly higher ($P<0.05$) than varieties sprayed with Lambda (35.93 %). Varieties sprayed with Cyperplus and Lambda were however not significantly ($P>0.05$) different but were significantly ($P<0.05$) higher than the Untreated control.

Table 12:Effect of insecticide on the population reduction over control (%) of Leaf roller larvae on Okra leaves at Samaru and Kadawa during the 2019 wet season

	Reduction over control (%)		
Insecticides	Samaru	Kadawa	Combined
Cyperplus	53.58[b]	45.76[a]	49.67[ab]
Ampligo	84.86[a]	45.76[a]	65.29[a]
Lambda	51.27[b]	20.58[ab]	35.93[b]
Control	0.00[c]	0.00[b]	0.00[c]
SE±	9.133	7.941	6.394

Means followed by the same letter(s) within the same column are not different statistically at 5 % level of Probability using SNK.

4.4 Effect of variety and insecticide on the population of Leaf roller larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

The recorded data for the effect of variety and insecticideon the population of Leaf roller larvae on okra leaves at Samaru and Kadawa is shown in Table 13a and 13b.In July, at Samaru, at 7 WAS,Clemson spineless, Ex-Samaru, NHAE-47 and Ex-Basawa had the least (0.71) larval population which were significantly ($P<0.05$) higher than Jokoso (0.79). On the insecticides, plots sprayed with Cyperplus, Ampligo and Lambda were statistically ($P>0.05$) similar (0.71) but were significantly ($P<0.05$) higher than the Untreated control. At Kadawa, the reading indicated that all varieties sown were not significant ($P>0.05$). All insecticides sprayed were statistically similar.

At 8 WASfor crops sown at Samaru in July, larval population on all varieties and insecticides sprayed was not significantly ($P>0.05$) different. At Kadawa, the reading indicated that all varieties sown were not significantly different ($P>0.05$). Also, all insecticides sprayed were not significantly different ($P>0.05$).

At 9 WASfor crops sown at Samaru in July, Ex-Samaru recorded the least (0.71) larval population which was not significantly ($P>0.05$) different from NHAE-47 (0.79) but was significantly ($P<0.05$) higher than other varieties. NHAE-47 was however, statistically similar to Clemson spineless and Ex-Basawa (0.96), which were all significantly ($P<0.05$) higher than Jokoso (1.19). Also, all insecticides sprayed were not significantly different ($P>0.05$). At Kadawa, Jokoso (0.95) recorded the highest population which was significantly ($P<0.05$) higher than all other varieties. Also, all insecticides sprayed were not significantly different ($P>0.05$).

There was no significant ($P>0.05$) difference for all varieties and insecticides at 10 WAS to 14 WAS at both Samaru and Kadawa.

The result for the August sowing date indicated that, there was no significant (P>0.05) difference for the population of larvae on all varieties sown and insecticides sprayed at 7 WAS, 8 WAS, 10 WAS, 11 WAS, 12 WAS, 13 WAS and 14 WAS.

At 9 WAS, in Samaru, there was no significant (P>0.05) difference among all varieties sown and insecticides sprayed. Untreated control (0.95) recorded the highest population which was not significantly (P>0.05) different from Lambda (0.84) but was significantly higher (P<0.05) than other insecticides. Ex-Samaru and NHAE-47 had the least (0.71) larval population which were statistically (P>0.05) similar to Clemson spineless and Ex- Basawa (0.86) but was significantly (P<0.05) higher than Jokoso (0.50). However, Clemson spineless, Ex-Basawa and Jokoso are statistically (P>0.05) similar on the larval population. All insecticides sprayed were not significantly (P>0.05) different.

Table 13a: Effect of variety and insecticide on the Population of Leaf roller Larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

Treatment	Mean Larval Population							
	JULY							
	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS
Variety				**Samaru**				
Clemson spineless	0^{b} (0.71)	0.17 (0.79)	0.42^{b} (0.96)	0.08 (0.75)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Samaru	0^{b} (0.71)	0 (0.71)	0^{c} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
NHAE-47	0^{b} (0.71)	0.17 (0.79)	0.17^{bc} (0.79)	0.08 (0.75)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Basawa	0^{b} (0.71)	0.08 (0.75)	0.42^{b} (0.96)	0.17 (0.79)	0.08 (0.75)	0.08 (0.75)	0.08 (0.75)	0 (0.71)
Jokoso	0.17^{a} (0.79)	0.33 (0.91)	0.92^{a} (1.19)	0.33 (0.91)	0.17 (0.79)	0.17 (0.79)	0.08 (0.75)	0 (0.71)
SE±	0.037	0.090	0.107	0.096	0.099	0.082	0.051	0.000
Insecticide								
Cyperplus	0^{b} (0.71)	0^{b} (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ampligo	0^{b} (0.71)^{b}	0^{b} (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Lambda	0^{b} (0.71)^{b}	0.20^{ab} (0.84)	0.27^{b} (0.88)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Untreated	0.13^{a} (0.78)	0.40^{a} (0.95)	1.27^{a} (1.33)	0.53 (1.01)	0.33 (0.91)	0.20 (0.84)	0.13 (0.78)	0 (0.71)
SE±	0.033	0.081	0.096	0.086	0.089	0.073	0.046	0.000
Interaction								
Variety X Insecticide	NS	NS	NS	NS	NS	NS	NS	NS
Variety				**Kadawa**				
Clemson spineless	0 (0.71)	0.08 (0.75)	0.08^{b} (0.75)	0.17 (0.82)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Samaru	0 (0.71)	0.00 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
NHAE-47	0 (0.71)	0.00 (0.71)	0.08^{b} (0.75)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Basawa	0 (0.71)	0.08 (0.75)	0.17^{b} (0.79)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Jokoso	0.08 (0.75)	0.08 (0.75)	0.50^{a} (0.95)	0.17 (0.82)	0.08 (0.75)	0.08 (0.75)	0 (0.71)	0 (0.71)
SE±	0.037	0.061	0.095	0.082	0.053	0.037	0.000	0.000
Insecticide								
Cyperplus	0 (0.71)	0 (0.71)	0.08^{b} (0.75)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ampligo	0 (0.71)	0 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Lambda	0 (0.71)	0 (0.71)	0.13^{b} (0.79)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Untreated	0.07 (0.74)	0.20 (0.84)	0.47^{a} (0.98)	0.27 (0.88)	0.13 (0.79)	0.08 (0.75)	0 (0.71)	0 (0.71)
SE±	0.033	0.055	0.085	0.074	0.048	0.033	0.000	0.000
Interaction								
Variety X Insecticide	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column are not different statistically at 5 % level of Probability using SNK.NS= Not significant. Values in parenthesis are square root transformed.

Table 13b: Effect of Variety, Insecticide on the Population of Leaf roller Larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

Treatment	Mean Larval Population							
	AUGUST							
	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS
Variety				**Samaru**				
Clemson spineless	0 (0.71)	0.08 (0.75)	0.17 (0.82)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Samaru	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
NHAE-47	0 (0.71)	0 (0.71)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Basawa	0 (0.71)	0.08 (0.75)	0.17 (0.82)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Jokoso	0 (0.71)	0.08 (0.75)	0.33 (0.91)	0 (0.79)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
SE±	0.000	0.066	0.111	0.053	0.000	0.000	0.000	0.000
Insecticide								
Cyperplus	0 (0.71)	0 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ampligo	0 (0.71)	0 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Lambda	0 (0.71)	0 (0.71)	0.20^{ab} (0.84)	0.07 (0.74)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Untreated	0 (0.71)	0.20 (0.84)	0.40^{a} (0.95)	0.07 (0.74)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
SE±	0.000	0.059	0.099	0.048	0.000	0.000	0.000	0.000
Interaction								
Variety X Insecticide	NS	NS	NS	NS	NS	NS	NS	NS
Vareity				**Kadawa**				
Clemson spineless	0 (0.71)	0 (0.71)	0.25^{ab} (0.86)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Samaru	0 (0.71)	0 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
NHAE-47	0 (0.71)	0 (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ex-Basawa	0 (0.71)	0 (0.71)	0.25^{ab} (0.86)	0.08 (0.75)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)
Jokoso	0 (0.71)	0.08 (0.75)	0.50^{a} (1.00)	0.33 (0.91)	0.08 (0.75)	0 (0.71)	0 (0.71)	0 (0.71)
SE±	0.000	0.037	0.120	0.111	0.053	0.000	0.000	0.000
Insecticide								
Cyperplus	0 (0.71)	0 (0.71)	0^{b} (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Ampligo	0 (0.71)	0 (0.71)	0^{b} (0.71)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Lambda	0 (0.71)	0 (0.71)	0.2^{b} (0.81)	0^{b} (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
Untreated	0 (0.71)	0.07 (0.74)	0.53^{a} (1.01)	0.40^{a} (0.95)	0.13 (0.79)	0 (0.71)	0 (0.71)	0 (0.71)
SE±	0.000	0.033	0.107	0.099	0.048	0.000	0.000	0.000
Interaction								
Variety X Insecticide	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column are not different statistically at 5 % level of Probability using SNK.NS= Not significant.Values in parenthesis are square root transformed.

4.5 Effect of Variety, Insecticide and Time of Sowing on the Yield (Kg/ha) of Okra at Samaru and Kadawa during the 2019 Wet season

Table 14 shows the effect of Variety, Insecticide and Time of Sowing on the Yield (Kg/ha) of Okra at Samaru and Kadawa during the 2019 Wet season. At Samaru, Ex-Samaru recorded the highest yield (3853.73 kg/ha) which was significantly ($P<0.05$) higher than other varieties. However, Clemson spineless (3424.91 kg/ha) and Jokoso (3182.29 kg/ha) were not significantly different ($P>0.05$) but were significantly ($P<0.05$) higher than Ex-Basawa (2701.69 kg/ha) and NHAE-47 (2008.68 kg/ha). Ex-Basawa was significantly ($P<0.05$) higher than NHAE-47. At Kadawa, Ex-Samaru (4550.00 kg/ha) recorded the highest yield which was significantly higher ($P<0.05$) than all other varieties. However, Clemson spineless (4121.18 kg/ha) and Jokoso (3850.35 kg/ha) were not significantly different ($P>0.05$) but were significantly ($P<0.05$) higher than Ex-Basawa (3353.82 kg//ha) and NHAE-47 (2733.16 kg/ha). Ex-Basawa was significantly ($P<0.05$) higher than NHAE-47. At the combined, Ex-Samaru (4201.90 Kg/ha) recorded the highest yield which was significantly ($P<0.05$) higher than Clemson spineless (3773.00 kg/ha), Jokoso (3516.30 kg/ha), Ex-Basawa (3028.30 kg/ha) and NHAE-47 (2370.90 kg/ha).

At Samaru, plots sprayed with Ampligo gave the highest yield (3362.85 kg/ha) which was not significantly ($P>0.05$) higher than plots sprayed with Cyperplus (3128.13 kg/ha). Plots sprayed with Cyperplus, Lambda (2843.75 kg/ha) and Untreated control (2803.13 kg/ha) were found not to be significantly different ($P>0.05$) At Kadawa, plots sprayed with Ampligo had the highest yield (4012.85 kg/ha) which was not significantly ($P>0.05$) higher than plots sprayed with Cyperplus (3877.43 kg/ha) but were higher than other plots. Plots sprayed with Lambda (3534.38 kg/ha) and Untreated control (3462.15 kg/ha) were found not to be significantly different. At the combined analysis, there was no significant ($P>0.05$) difference between plots sprayed with

Ampligo (3687.80 kg/ha) and Cyperplus (3502.80 kg/ha). Plots sprayed with Lambda (3189.10 Kg/ha) and Untreated control (3132.60 kg/ha) were not significantly different.

It was recorded that there was a significant ($P<0.05$) difference between plots sown in July (3527.60 kg/ha) and August (2541.30 kg/ha) at Samaru. Similarly, at Kadawa, plots sown in July (4340.10 kg/ha) were significantly ($P<0.05$) higher than crops sown in August (3103.30 kg/ha). At the combined analysis, July (3933.85 kg/ha) was significant ($P<0.05$) higher than August (2822.31 kg/ha).

The interaction between Variety and Insecticide for Samaru, Kadawa and combined analysis were significant ($P<0.05$). The interactions between variety and sowing date, sowing date and insecticide, and variety, insecticide and sowing date were not significant ($P>0.05$) at Samaru, Kadawa and combined analysis.

Table 14: Effect of Variety, Insecticide and Time of Sowing on the Yield (Kg/ha) of Okra at Samaru, Kadawa and Combined analysis during the 2019 Wet season

Means Yield of Okra (Kg/ha)			
Treatment	**Samaru**	**Kadawa**	**Combined**
Variety			
Clemson spineless	3424.91[b]	4121.18[b]	3773.00[b]
Ex-Samaru	3853.73[a]	4550.00[a]	4201.90[a]
NHAE-47	2008.68[d]	2733.16[d]	2370.90[e]
Ex-Basawa	2702.69[c]	3353.82[c]	3028.30[d]
Jokoso	3182.29[b]	3850.35[b]	3516.30[c]
SE±	130.533	128.346	91.206
Insecticide			
Cyperplus	3128.13[ab]	3877.43[a]	3502.80[a]
Ampligo	3362.85[a]	4012.85[a]	3687.80[a]
Lambda	2843.75[b]	3534.38[b]	3189.10[b]
Untreated	2803.13[b]	3462.15[b]	3132.60[b]
SE±	116.752	114.796	81.577
Time of sowing			
June	3527.60[a]	4340.10[a]	3933.85[a]
July	2541.30[b]	3103.30[b]	2822.31[b]
SE±	82.556	81.173	57.683
Interaction			
Variety X Insecticide	*	*	**
Sowing date X Variety	NS	NS	NS
Sowing date X Insecticide	NS	NS	NS
Sowing date X Variety X Insecticide	NS	NS	NS

Means followed by the same letter within a column and category are not statistically different at (P>0.05) using SNKNS: not significant. **: Highly significant. *: Significant.

4.5.1 Effect of Interaction between variety and insecticide on the yield of okra at Samaru, Kadawa and Combined analysis during 2019 wet Season

Table 15 shows the effect of interaction between variety and insecticide on the yield of Okra at Samaru, Kadawa and Combinedanalysis. At Samarufor crops sprayed with Cyperplus, Clemson spineless (3836.81 kg/ha), Ex-Samaru (3972.22 kg/ha) and Jokoso (3430.56 kg/ha) were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 (1940.97 kg/ha) and Ex-Basawa (2460.07 kg/ha), while Ex-Basawa was significantly (P<0.05) higher than NHAE-47. For varieties sprayed with Ampligo, Ex-Samaru (4175.35 kg/ha) and Jokoso (4107.64 kg/ha) were not significantly different (P>0.05) but were significantly (P<0.05) higher than Clemson spineless (3204.86 kg/ha), NHAE-47 (2527.78 kg/ha) and Ex-Basawa (2798.61 kg/ha), while Clemson spineless, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For varieties sprayed with Lambda, Ex-Samaru (3565.97 kg/ha) was not significantly (P>0.05) different from Clemson spineless (3611.11 kg/ha) but was significantly (P<0.05) higher than NHAE-47 (1850.69 kg/ha), Ex-Basawa (2392.36 kg/ha) and Jokoso (2798.61 kg/ha), while Clemson spineless and Jokoso were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 and Ex-Basawa. Ex-Basawa and NHAE-47 were not significantly different (P>0.05). For the Untreated control plots, X- Samaru (3701.39 kg/ha) was not significantly different (P>0.05) from Clemson spineless (3046.88 kg/ha) but was significantly (P<0.05) higher than NHAE-47 (1715.28 kg/ha), Ex-Basawa (3159.72 kg/ha) and Jokoso (2392.36 kg/ha), while Clemson spineless, NHAE-47, Ex-Basawa and Jokoso were not significantly different (P>0.05).

At Kadawa, for varieties sprayed with Cyperplus, Clemson spineless (4572.57 kg/ha), Ex-Samaru (4707.99 kg/ha) and Jokoso (4211.46 kg/ha) were not significantly different (P>0.05) but were significantly (P<0.05) higher than Ex-Basawa (3173.26 kg/ha) and NHAE-47 (2721.87

kg/ha), while Ex-Basawa was significantly (P<0.05) higher than NHAE-47. For Varieties sprayed with Ampligo, Ex-Samaru (4888.54 kg/ha) was not significantly (P>0.05) different from Jokoso (4662.85 kg/ha) but was significantly higher (P<0.05) than Clemson spineless (3895.49 kg/ha), NHAE-47 (3263.54 kg/ha) and Ex-Basawa (3353.82 kg/ha), while Jokoso was not significantly different (P>0.05) from Clemson spineless but was significantly (P<0.05) higher than NHAE-47 and Ex-Basawa. Clemson spineless, NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For varieties sprayed with Lambda, Ex-Samaru (4166.32 kg/ha) and Clemson spineless (4346.87 kg/ha) were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 (2586.46 kg/ha), Ex-Basawa (3082.99 kg/ha) and Jokoso (3489.24 kg/ha), while NHAE-47, Ex-Basawa and Jokoso were not significantly different (P>0.05). For Untreated control plots, Ex-Samaru (4437.15 kg/ha) and Clemson spineless (3669.79 kg/ha) were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 (2360.76 kg/ha), Ex-Basawa (3805.21 kg/ha) and Jokoso (3037.85 kg/ha), while NHAE-47, Ex-Basawa and Jokoso were not significantly different (P>0.05).

At the combined, for varieties sprayed with Cyperplus, Clemson spineless (4204.69 kg/ha), Ex-Samaru (4340.10 kg/ha) and Jokoso (3821.01 kg/ha) were not significantly (P>0.05) different but were significantly (P<0.05) higher than NHAE-47 (2331.42 kg/ha) and Ex-Basawa (2816.67 kg/ha), while NHAE-47 and Ex-Basawa were not significantly different (P>0.05). For varieties sprayed with Ampligo, Ex-Samaru (4531.94 kg/ha) was not significantly different (P>0.05) from Jokoso (4385.24 kg/ha) but was significantly (P<0.05) higher than Clemson spineless (3550.17 kg/ha), NHAE-47 (2895.66 kg/ha) and Ex-Basawa (3076.21 kg/ha), while Jokoso was not significantly (P>0.05) different from Clemson spineless but was significantly (P<0.05) higher than NHAE-47 and Ex-Basawa. Clemson spineless, NHAE-47 and Ex-Basawa were not different significantly. For varieties sprayed with Lambda, Ex-Samaru (3866.15 kg/ha) was not

significantly different (P>0.05) from Clemson spineless (3978.99 kg/ha) and Jokoso (3143.92 kg/ha) but was significantly (P<0.05) higher than NHAE-47 (2218.58 kg/ha) and Ex-Basawa (2737.67 kg/ha). Clemson spineless and Jokoso were not significantly different (P>0.05) but were significantly (P<0.05) higher than NHAE-47 and Ex-Basawa. Ex-Basawa and NHAE-47 were not different significantly (P>0.05). For Untreated control plots, Ex-Samaru (4069.27 kg/ha) was not significantly different (P>0.05) from Clemson spineless (3358.33 kg/ha) but was significantly (P<0.05) higher than Jokoso (2715.10 kg/ha), NHAE-47 (2038.02 kg/ha) and Ex-Basawa (3482.47 kg/ha). Clemson spineless, NHAE-47, Ex-Basawa and Jokoso were not significantly different.

Table 15: Effect of Interaction between variety and insecticide on the yield of okra at Samaru, Kadawa and combined during 2019 wet Season

Means of the Yield (Kg/ha) of Okra				
Treatment	**Cyperplus**	**Ampligo**	**Lambda**	**Untreated**
Variety		**Samaru**		
Clemson spineless	3836.81^{ab}	3204.86^{c}	3611.11^{a}	3046.88^{bc}
Ex-Samaru	3972.22^{a}	4175.35^{a}	3565.97^{ab}	3701.39^{a}
NHAE-47	1940.97^{d}	2527.78^{e}	1850.69^{d}	1715.28^{e}
Ex-Basawa	2460.07^{c}	2798.61^{d}	2392.36^{cd}	3159.72^{b}
Jokoso	3430.56^{ab}	4107.64^{ab}	2798.61^{bc}	2392.36^{cd}
SE±		261.065		
		Kadawa		
Variety				
Clemson spineless	4572.57^{ab}	3895.49^{bc}	4346.87^{a}	3669.79^{ab}
Ex-Samaru	4707.99^{a}	4888.54^{a}	4166.32^{ab}	4437.15^{a}
NHAE-47	2721.87^{cd}	3263.54^{de}	2586.46^{de}	2360.76^{d}
Ex-Basawa	3173.26^{c}	3353.82^{cd}	3082.99^{cd}	3805.21^{ab}
Jokoso	4211.46^{ab}	4662.85^{ab}	3489.24^{bc}	3037.85^{bc}
SE±		256.691		
		Combined		
Variety				
Clemson spineless	4204.69^{ab}	3550.17^{bcd}	3978.99^{a}	3358.33^{ab}
Ex-Samaru	4340.10^{a}	4531.94^{a}	3866.15^{a}	4069.27^{a}
NHAE-47	2331.42^{cd}	2895.66^{cde}	2218.58^{cd}	2038.02^{d}
Ex-Basawa	2816.67^{c}	3076.21^{cde}	2737.67^{c}	3482.47^{ab}
Jokoso	3821.01^{ab}	4385.24^{ab}	3143.92^{ab}	2715.10^{bc}
SE±		257.968		

Means followed by the same letter(s) within the same column are not different statistically at 5 % level of Probability using SNK.

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Effect of Variety, Insecticides and Time of sowing on the Percentage Incidence of *S. derogata* larvae on Okra leaves at Samaru and Kadawa during 2019 wet season

From the result, it was evident that, there was a variation in the incidence of Leaf roller larvae on the different varieties of okra. While Jokoso recorded the highest larval incidence, Ex-Samaru recorded the least larval incidence at both locations. This could be attributed to some physical morphological features (hairs) on the leaves of Ex-Samaru. These findings were in tune with the observations of Gonde *et al*. (2012), Muazzma*et al*. (2014) and Nagar*et al*.(2017) who reported that, insect population on the leaves of okra differs between varieties. However, Ojiako *et al*.(2018) opined that there were no clear cut differences in the performance of three okra varieties as variety alone had no significant effect on insect pest infestation.

The result revealed that all the insecticides provedeffective in controlling the okra leaf roller (*S. derogata*) infestation over untreated plot as evident from the datacollected on its incidence on the leaves, which could be as a result of the effectiveness of the insecticide in ameliorating the incidence of the larvae on the leaves.Evaluation of infestationof Leaf roller by their incidence on okra leaves depicted that the highest percentage incidence on average was noted in the Untreated plots followed by Lambda at both Samaru and Kadawa. At Samaru, Ampligo and Cyperplus recorded the least incidence. At Kadawa, plots sprayed with Ampligo alone recorded the least incidence followed by Cyperplus. These findings conforms with earlier works by Eijaz *et al*. (2014) and Bhatt *et al*. (2018)who opined respectively that Dimethoate and Cypermethrin were some of the best insecticides for providing a maximum reduction of insect pests of okra. Similar results were defined by Biswas *et al*. (2009) that, Dimethoate was effective for controlling the insect pests of okra. Misra *et al*. (2002) also reported that Profenofos was found effective in

combination with Cypermethrin for controlling the leaf rollerand fruit borer, *Earias* spp infesting the okra crop.Ahmed *et al.*(2007) similarly reported a high reduction of fleabeetles with different insecticides molecules.Prasad and Prasad(2004)found that Cypermethrin, Indoxacarb and Spinosad were effective against *Earias vittella* while Imidaclorpid and malathion were least effective in reducing per cent shoot and fruit infestation by number and weight. A similar result was found by Misra *et al.* (2002), Nachane *et al.* (2003) and Bajad *et al.* (2014) who showed the effectiveness of Cypermethrin and Indoxacarb respectively.

It was evident from the results that, larval incidence in crops sown in July were higher than that in August. For the crops sown in July, the insect was noticed from 7 WAS (August) to 13 WAS (October), while for crops sown in August, the insect was noticed from 8 WAS (October) to 11 WAS (October). This could be due to the climatic conditions prevalent during this period which supports the growth of leaf roller (See Appendix XXV and XXVI). This was similar to findings by Mariselvi and Manimegalai(2016) who found that leaf roller is active from September to November.

5.2 Effect of Variety and Insecticides on the Percentage Damage caused by Leaf roller larvae on Okra leaves at Samaru and Kadawa during 2019 wet season

All varieties except Ex-Samaru at both locations and NHAE-47 at Kadawa showed a variable level of leaf damage by leaf roller, which could be as a result of non-preference of the varieties by the insect. Also, the presence of leaf hairs on Ex-Samaru could have been a reason for the unsuitability of the variety for the insect growth, hence less damage. Ex-Samaru was also an indigenous variety which could have been more adapted to the region and evolved probably via a process of natural selection. Similar findings were reported by Yahaya *et al*. (2012), that all cotton varieties studied were significantly different in their responses to leaf roller damage and complete absence of leaf roller larva on a variety of cotton (CL07), could be as a result of non-

preference for CL07 leaf morphology. This finding also corroborates with earlier works by Raut and Sonone (1979), Prabu *et al*.(2009) and Konsam *et al*. (2015) who recorded that the local varieties of okra were resistant to infestation by okra fruit borer (*Earias* spp.).

It was evident from the results from Samaru and Kadawa that all the insecticides significantly reduced the leaf rollerleaf damage when compared to the untreated plot, which is a function of pyrethroids which have been found to be effective in the control of insect pests of okra including the leaf roller. Chlorantraniliprole+Lambda-cyhalothrin (Ampligo) and Cypermethrin + Dimethoate (Cyperplus) were found to be more effective than Lambda-cyhalothrin (Lambda), which could be as a result of their mode of action. While Ampligo and Cyperplus are contact and systemic insecticides, Lambda is a contact insecticide and the leaf roller though a moth, the larvae lives in rolled leaves for feeding and protection. This is in corroboration with works by Prasad and Prasad(2004) and Nachne, *et al.*(2003) who opined that synthetic pesticides reduce shoot damage caused by *Earias* spp on okra. Fadare and Amusa (2003) reported that, chemical pesticides reduced the percentage of bollworm damage on okra.

The damage caused by Leaf roller larvae on the leaves of okra was higher in July than in August sown crops. This could be as a result of the temperature and RH combinations during this period which encourages high population of larvae during the growing periods (August to November) of the July and August sown crops (See Appendix XXV and XXVI). These findings agree with the work by Ahmad *et al*. (2000) who found peak larval population of *Earias vitella* on okrawith temperature and RH combination of 29.9 ±2.9 °C and 84.0 ±5.1%.

5.3 Effect of Time of sowing on the Population of Leaf roller Larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

This result shows that Jokoso recorded the highest larval population at Samaru and Kadawa for crops sown in July, while Ex-Samaru recorded the least larval population. This finding clearly

shows that the latter was not preferred by the larvae. The peak population period was 9 WAS (September) at Samaru and Kadawa for crops sown in July and 9 WAS (October) at Samaru and Kadawa for crops sown in August, which indicates that the temperature and relative humidity conditions within this period promotes the growth of the insect. This finding was in corroboration with earlier work by Ch.Sammaiah*et al*. (2014) who found thatthe infestations of Leaf rollerwasrecorded at the 8th week of the Bt-cotton and Non Bt-cotton crop and the maximum percentage of infestation was recorded in September. The work in the foregoing can be compared with the work of Gogoi and Dutta (2000), who recorded the maximum leaf hopper population during last week of May whenthe temperature was 30-36 °C followed by < 80% RH and low rainfall coupled with bright sunshine. Kumawat *et al*. (2000) also observed that the whitefly infestation on okra attained peak during the period of maximum temperature regime which varied significantly with the pest population.

From the findings, the population growth on the crop was first observed between 49 to 53 days old crops, while the peak population was seen on 63 days old crop, this shows that the insect prefers older leafs to the younger ones. This finding agrees with earlier work by Hassan *et al*. (2008) who recorded that peak population of whitefly on okra was seen on 60 days old crop.

5.4 Effect of Insecticide on the Population Reduction (%) of Leaf roller Larvae on Okra leaves at Samaru and Kadawa during the 2019 Wet season

It was evident from the result that Ampligo recorded the highest reduction over control at Samaru, while at Kadawa, Ampligo and Cyperplus recorded the highest reduction over control. Lambda, however, recorded the least percentage of reduction over control at both locations. This finding can be attributed to the mode of action of the insecticides, while Ampligo and Cyperplus exhibit contact and systemic actions, Lambda exhibits contact action.The present findings are in collaboration with works by Anand *et al*., 2013 and Bhatt *et al*. (2018) who found the variation

in the mean population of leafhopper when sprayed with different synthetic insecticides. Saha *et al*., 2014 also recordeda percent reduction in the leafhopper population on okra when sprayed with different insecticides.

5.5 Effect of Leaf roller activitieson the Yield of Okra (Kgha^{-1}) at Samaru and Kadawa during 2019 Wet season

Yield from all varieties sown at both Samaru and Kadawa differs significantly from each other except Clemson spineless and Jokoso. Ex-Samaru gave the highest fresh pod weight at both Samaru and Kadawa, which shows that the indigenous variety was less susceptible to the infestation than the exotic varieties, hence giving a higher yield. This finding was in corroboration with earlier work by Salau and Makinde (2015) who reported that the number of pods per plant was affected by different okra cultivar. The higher yield recorded by Ex-Samaru could be attributed to its non-preference traits to leaf roller infestation. NHAE-47 recorded the least fresh pod weight which differs from the work by Salau and Makinde (2015) who recorded higher yield from NHAE-47 than LD88 and Jokoso.

The yield data clearly revealed that all the insecticidal treatmentsgave significantly higher yield than untreated control except Lambda at Samaru and Kadawa which shows that the insecticides used were effective in controlling the leaf roller, hence giving a higher yield compared to the untreated control. This finding was similar to the reports by Singh*et al*.(2006), Pardeshi*et al*.(2011) and Bajad*et al*. (2014) who opined that the application of synthetic pesticides for themanagement of okra shoot and fruit borer, *E. vittella*recorded higher yield in okra. Biswas *et al.* (2009)stated that the best quality of marketable okra fruits is related to the efficacy of synthetic chemical pesticides used for managing the infesting insect pests.

It was evident from the results that plants sown in July gave the highest yield than plants sown in August at both Samaru and Kadawa, this could be due to the abundance of rainfall during the growing period. Salau and Makinde (2015) reported also that, lower rains reduced the growing period of okra and hence shorter harvest period which reduces yield.Similarly, Chattopadhyay *et al*. (2011) reported that rainfall was a major contributor tovarying okra yields. Early sowing had the full advantage of rains for developmentand had better growth (Salau and Makinde (2015).Early planting had a longer harvest period because fruitingstarted at a time when there was still some rainfall. Low okra pod yield, asa result of late planting, is similar to the report on amaranthus (De Troiani*et al*., 2004). Low okra yield due to late planting indicates that potential fordevelopment was limited due to rainfall.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

This study was carried out to assess the "management of leaf roller *Sylepta derogata* Fab. (Lepidoptera: Pyralidae) on some okra varieties in Samaru and Kadawa, Nigeria". Field trials were conducted at two locations namely Samaru in Zaria, Kaduna State and Kadawa, Kano State during the 2019 wet season to determine the effects of five (5) okra varieties (Clemson spineless, Ex-Basawa, Jokoso, Ex-Samaru and NHAE-47), three (3) insecticides (Lambda-cyhalothrin, Cypermethrin + Dimethoate and Chlorantraniliprole + Lambda-Cyhalothrin) with an Untreated control and time of sowing (July and August). Treatments were arranged in a Randomized Complete Block Design and replicated three (3) times. A total of four spray applications at two weeks' interval beginning from 7 WAS were carried out. Observations were recorded on the larval count, percentage incidence, damage on leaves and okra fruit yield.

From the results obtained from this study, it was evident that there was a significant difference ($P<0.05$) on the incidence of leaf roller larvae found on Jokoso from all other varieties in July and August at Samaru and in July and August at Kadawa. Ex-Samaru recorded the least larval incidence at both locations and time of sowing. Untreated control had a significant difference ($P<0.05$) from all other insecticides sprayed at Samaru in July and August and at Kadawa in July and August. The interaction of the incidence between the variety and insecticide was also significant at both locations in July and August sowing dates.

Also, there was a significant difference on the damage caused by leaf roller larvae on Jokoso from other varieties at Samaru in July and August and at Kadawa in July and August.Ex-Samaru recorded the least leaf damage at both locations and time of sowing. The Untreated control

recorded the highest leaf damage at Samaru in July and August while at Kadawa, Untreated control similarly, recorded the highest leaf damage in July and August. The interaction of variety and insecticides on leaf damage was significant at both locations and sowing periods.

There was a significant difference between Ampligo and other insecticides sprayed at Samaru in their reduction over control. However, at Kadawa, there was no significant difference between Ampligo and Cyperplus from other insecticides sprayed in their percentage reduction over control.

At Samaru and Kadawa, the leaf roller was first recorded 7 WAS and the peak population period was 9 WAS on Jokoso, Ex-Basawa, Clemson spineless and NHAE-47 for crops sown in July at Samaru. For crops sown at Kadawa in July, the peak population period was 9 WAS on Jokoso, Ex-Basawa, Clemson spineless and NHAE-47. While for crops sown in August, it was first recorded 8 WAS and the population period was observed 9 WAS on Jokoso, Clemson spineless and Ex-Basawaand NHAE-47 for crops sown at Samaru, while that at Kadawa recorded the peak population period at 9 WAS on Jokoso, Clemson spineless and Ex-Basawa. There was no larval population on Ex-Samaru variety at both locations

Ex-Samaru recorded the highest yield at Samaru in July and Augustand Kadawa in July and August. Similarly, crops sprayed with Ampligo recorded the highest yield at Samaru in July and August and at Kadawa in July and August. The interaction between the variety and insecticide was not significantly at both locations and time of sowing.

6.2 Conclusions

It can be concluded from this study that:

- Okra leaf roller Larval population occurred first at 7WASfor crops sown in Julywith peak population period in September and 8 WAS for crops sown in Augustwith peak population period in October (9WAS).
- Jokoso variety recorded the highest larval population at Samaru (6.57 %) and Kadawa (7.33%) while Ex-Samaru recorded the least larval population at Samaru (1.67 %) and Kadawa (1.67 %)
- The least leaf damage wasrecorded by Ex-Samaru at both locations (70.71 %), while Jokoso recorded the maximum leaf damage at Samaru (82.21 %) and Kadawa (80.50 %).
- The use of 300 ml/ha of Ampligo (Chlorantraniliprole 100 g/L + Lambda-Cyhalothrin 50 g/L) resulted in the least larval incidence (1.67 %) at Samaru and Kadawa while 1 L/ha of Cyperplus (Cypermethin 30 g/L + Dimethoate 250 g/L) resulted in the least incidence at only Samaru (1.67 %). Lambda (Lambda-Cyhalothrin 2.5%) recorded the highest incidence after untreated control at Samaru (3.67 %) and Kadawa (3.06 %).
- Plots on which Ampligo (300 m/ha of Chlorantraniliprole 100 g/L + Lambda-Cyhalothrin 50 g/L) was used had the least leaf damage (70.71 %) over Cyperplus (71.15 %), Lambda (73.36 %) and untreated control (84.52 %) in that order at both locations.
- Overall, the treatment with 300 m/ha of Ampligo (Chlorantraniliprole 100 g/L + Lambda-Cyhalothrin 50 g/L) reduced the population of leaf roller by 84.86 % over other insecticides while Lambda was the least effective over the Untreated.

- Ex-Samaru recorded the highest yield at Samaru (3853.73 kg/ha) and Kadawa (4550.00 kg/ha) while NHAE-47 recorded the least yield at Samaru (2008.68 kg/ha) and Kadawa (2733.16 kg/ha). Crops sprayed with Ampligo produce the highest yield at Samaru (3362.86 kg/ha) and Kadawa (4012.85 kg/ha).

6.3 Recommendations

Based on the findings from this research, it is recommended that 300 ml/ha of Ampligo (Chlorantraniliprole 100 g/L + Lambda-Cyhalothrin 50 g/L) and 1 L/ha of Cyperplus (Cypermethin 30 g/L + Dimethoate 250 g/L) should be used to control leaf roller in okra. Farmers at Samaru and Kadawa should practice early (July) sowing of Okra. Also recommended is the use of variety Ex-Samaru by farmers. Further studies may be conducted to locate thereason responsible for the non-preference of variety Ex-Samaruby the leaf roller with the aim of crossing with a higher yielding exotic variety with a view to inducing resistance to phytophagus pests.

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Appendices

Appendix I: Randomized Complete Block Design ANOVA for the incidence of leafroller in July and August at Samaru

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	11.5811286	5.7905643	1.96^{NS}	0.1471
Variety	4	312.0138361	78.0034590	26.46	<.0001
Insecticide	3	840.4743216	280.1581072	95.04	<.0001
Time of sowing	1	96.3881025	96.3881025	32.70	<.0001
Variety X insecticide	12	634.4682364	52.8723530	17.94	<.0001
Variety X Time of Sowing	4	35.2624115	8.8156029	2.99^{NS}	0.0237
Insecticide X Time of Sowing	3	172.3436036	57.4478679	19.49	<.0001
Variety X Insecticide X Time of Sowing	12	150.1488851	12.5124071	4.24	<.0001
Error	78	229.935855	2.947896		
Total	119	2482.616381			

Appendix II: Randomized Complete Block Design ANOVA for the incidence of leafroller in July and August at Kadawa

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	25.6428899	12.8214449	2.10	0.1290
Variety	4	479.3837188	119.8459297	19.65	<.0001
Insecticide	3	687.3192162	229.1064054	37.57	<.0001
Time of sowing	1	15.7644003	15.7644003	2.59	0.1119
Variety X Insecticide	12	795.0982956	66.2581913	10.87	<.0001
Variety X Time of Sowing	4	28.3995753	7.0998938	1.16	0.3330
Insecticide X Time of Sowing	3	10.1678734	3.3892911	0.56	0.6458
Variety X Insecticide X Time of Sowing	12	107.1143290	8.9261941	1.46	0.1562
Error	78	475.605341	6.097504		
Total	119	2624.495640			

Appendix III: Randomized Complete Block Design ANOVA for the incidence of leafroller at Combined analysis

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	28.803806	14.401903	2.25	0.1083
Variety	4	774.057974	193.514493	30.21	<.0001
Insecticide	3	1516.635332	505.545111	78.93	<.0001
Time of sowing	1	17.095479	17.095479	2.67	0.1039
Location	1	1.152043	1.152043	0.18	0.6720
Variety X Insecticide	12	1360.748479	113.395707	17.70	<.0001
Variety X Time of Sowing	4	14.243365	3.560841	0.56	0.6949
Insecticide X Time of Sowing	3	66.807796	22.269265	3.48	0.0170
Variety X Insecticide X Time of Sowing	12	66.893620	5.574468	0.87	0.5781
Error	197	1261.826171	6.405209		
Total	239	5108.264064			

Appendix IV: Randomized Complete Block Design ANOVA for the larval damage in July and August at Samaru

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	73.732200	36.866100	2.92	0.0600
Variety	4	1764.428520	441.107130	34.92	<.0001
Insecticide	3	5499.081743	1833.027248	145.09	<.0001
Time of sowing	1	795.230257	795.230257	62.95	<.0001
Variety X Insecticide	12	3807.969488	317.330791	25.12	<.0001
Variety X Time of Sowing	4	375.728449	93.932112	7.44	<.0001
Insecticide X Time of Sowing	3	1927.126812	642.375604	50.85	<.0001
Variety X Insecticide X Time of Sowing	12	1430.363898	119.196991	9.44	<.0001
Error	78	985.41203	12.63349		
Total	119	16659.07339			

Appendix V: Randomized Complete Block Design ANOVA for the larval damage in July and August at Kadawa

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	P r> F
Replication	2	100.974400	50.487200	3.52	0.0342
Variety	4	1551.159087	387.789772	27.07	<.0001
Insecticide	3	2428.800494	809.600165	56.52	<.0001
Time of sowing	1	3.105113	3.105113	0.22	0.6428
Variety X Insecticide	12	2258.645631	188.220469	13.14	<.0001
Variety X Time of Sowing	4	18.456378	4.614095	0.32	0.8623
Insecticide X Time of Sowing	3	2.009147	0.669716	0.05	0.9865
Variety X Insecticide X Time of Sowing	12	265.025997	22.085500	1.54	0.1273
Error	78	1117.198478	14.323057		
Total	119	7745.374725			

Appendix VI: Randomized Complete Block Design ANOVA for the larval damage both locations

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	P r> F
Replication	2	121.752400	60.876200	2.30	0.1025
Variety	4	3259.507675	814.876919	30.84	<.0001
Insecticide	3	7594.347392	2531.449131	95.82	<.0001
Time of sowing	1	349.475838	349.475838	13.23	0.0004
Location	1	141.529453	141.529453	5.36	0.0217
Variety X Insecticide	12	5812.451513	484.370959	18.33	<.0001
Variety X Time of Sowing	4	165.120447	41.280112	1.56	0.1858
Insecticide X Time of Sowing	3	985.590628	328.530209	12.44	<.0001
Variety X Insecticide X Time of Sowing	12	911.738118	75.978177	2.88	0.0011
Error	197	5204.46411	26.41860		
Total	239	24545.97757			

Appendix VII: Randomized Complete Block Design ANOVA for the reduction over control in July and August at Samaru

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	1827.15908	913.57954	0.74	0.4781
Variety	4	57734.97752	14433.74438	11.77	<.0001
Insecticide	3	69867.49305	23289.16435	18.99	<.0001
Time of sowing	1	11279.05667	11279.05667	9.20	0.0033
Variety X Insecticide	12	27599.83185	2299.98599	1.88	0.0504
Variety X Time of Sowing	4	6834.78669	1708.69667	1.39	0.2441
Insecticide X Time of Sowing	3	7681.85345	2560.61782	2.09	0.1086
Variety X Insecticide X Time of Sowing	12	5421.23804	451.76984	0.37	0.9708
Error	78	95660.8603	1226.4213		
Total	119	283907.2566			

Appendix VIII: Randomized Complete Block Design ANOVA for the reduction over control in July and August at Kadawa

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	18129.4930	9064.7465	5.70	0.0049
Variety	4	364658.3665	91164.5916	57.29	<.0001
Insecticide	3	168910.3206	56303.4402	35.38	<.0001
Time of sowing	1	137.2018	137.2018	0.09	0.7698
Variety X Insecticide	12	126966.6772	10580.5564	6.65	<.0001
Variety X Time of Sowing	4	6892.2512	1723.0628	1.08	0.3709
Insecticide X Time of Sowing	3	50.7155	16.9052	0.01	0.9985
Variety X Insecticide X Time of Sowing	12	2317.3433	193.1119	0.12	0.9999
Error	78	124120.7256	1591.2914		
Total	119	812183.0946			

Appendix IX: Randomized Complete Block Design ANOVA for the reduction over control at both locations

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	12755. 6497	6377.8249	3.27	0.0402
Variety	4	334063.3727	83515.8432	42.79	<.0001
Insecticide	3	222012.0515	74004.0172	37.92	<.0001
Time of sowing	1	6952.1174	6952.1174	3.56	0.0606
Location	1	42528.9782	42528.9782	21.79	<.0001
Variety X Insecticide	12	121607.3640	10133.9470	5.19	<.0001
Variety X Time of Sowing	4	6130.3029	1532.5757	0.79	0.5360
Insecticide X Time of Sowing	3	4317.1560	1439.0520	0.74	0.5309
Variety X Insecticide X Time of Sowing	12	3760.3007	313.3584	0.16	0.9995
Error	197	384492.036	1951.736		
Total	239	1138619.329			

Appendix X: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 7 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.00893164	0.00446582	1.00	0.3774
Variety	4	0.07145312	0.01786328	4.00	0.0084
Insecticide	3	0.05358984	0.01786328	4.00	0.0144
Variety X Insecticide	12	0.21435936	0.01786328	4.00	0.0605
Error	38	0.16970116	0.00446582		
Total	59	0.51803512			

Appendix XI: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 8 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.23609680	0.11804840	3.39	0.0440
Variety	4	0.54484403	0.13621101	3.92	0.0093
Insecticide	3	1.21400591	0.40466864	11.64	<.0001
Variety X Insecticide	12	0.75268675	0.06272390	1.80	0.0830
Error	38	1.32164913	0.03478024		
Total	59	4.06928262			

Appendix XII: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 9 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.04406261	0.02203130	0.79	0.4613
Variety	4	0.86627198	0.21656800	7.76	0.0001
Insecticide	3	2.91946709	0.97315570	34.88	<.0001
Variety X Insecticide	12	2.04129146	0.17010762	6.10	0.0811
Error	38	1.06028713	0.02790229		
Total	59	6.93138027			

Appendix XIII: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 10 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.08062708	0.04031354	1.76	0.1858
Variety	4	0.16907680	0.04226920	1.84	0.1403
Insecticide	3	0.72909141	0.24303047	10.61	<.0001
Variety X Insecticide	12	0.50723039	0.04226920	1.84	0.0752
Error	38	0.87060413	0.02291063		
Total	59	2.35662980			

Appendix XIV: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 11 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.02546440	0.01273220	0.47	0.6259
Variety	4	0.03248049	0.00812012	0.30	0.8744
Insecticide	3	0.29450334	0.09816778	3.66	0.0207
Variety X Insecticide	12	0.09744146	0.00812012	0.30	0.9850
Error	38	1.01972176	0.02683478		
Total	59	1.46961145			

Appendix XV: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 12 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.06455818	0.03227909	1.97	0.1538
Variety	4	0.05371100	0.01342775	0.82	0.5214
Insecticide	3	0.09683727	0.03227909	1.97	0.1352
Variety X Insecticide	12	0.16113299	0.01342775	0.82	0.6306
Error	38	0.62336251	0.01640428		
Total	59	0.99960195			

Appendix XVI: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Samaru 13 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.03572655	0.01786327	2.11	0.1351
Variety	4	0.02679491	0.00669873	0.79	0.5379
Insecticide	3	0.05358982	0.01786327	2.11	0.1149
Variety X Insecticide	12	0.08038473	0.00669873	0.79	0.6559
Error	38	0.32153892	0.00846155		
Total	59	0.51803492			

Appendix XVII: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Kadawa 7 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.00893164	0.00446582	1.00	0.3774
Variety	4	0.01786328	0.00446582	1.00	0.4196
Insecticide	3	0.01339746	0.00446582	1.00	0.4034
Variety X Insecticide	12	0.05358984	0.00446582	1.00	0.6674
Error	38	0.16970116	0.00446582		
Total	59	0.26348338			

Appendix XVIII: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Kadawa 8 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.21698104	0.10849052	3.88	0.0293
Variety	4	0.28768865	0.07192216	2.57	0.0532
Insecticide	3	0.49773382	0.16591127	5.93	0.0020
Variety X Insecticide	12	0.23756545	0.01979712	0.71	0.7339
Error	38	1.06248187	0.02796005		
Total	59	2.30245083			

Appendix XIX: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Kadawa 9 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.12151523	0.06075762	2.23	0.1213
Variety	4	0.43732931	0.10933233	4.01	0.0082
Insecticide	3	0.46925529	0.15641843	5.74	0.0024
Variety X Insecticide	12	0.42527279	0.03543940	1.30	0.2579
Error	38	1.03495895	0.02723576		
Total	59	2.48833158			

Appendix XX: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Kadawa 10 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.04947711	0.02473855	1.47	0.2422
Variety	4	0.09221974	0.02305494	1.37	0.2618
Insecticide	3	0.18227285	0.06075762	3.62	0.0216
Variety X Insecticide	12	0.27665923	0.02305494	1.37	0.2215
Error	38	0.63844358	0.01680115		
Total	59	1.23907252			

Appendix XXI: Randomized Complete Block Design ANOVA for the population of leaf roller larvae at Kadawa 11 WAS

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	0.00893164	0.00446582	1.00	0.3774
Variety	4	0.01786327	0.00446582	1.00	0.4196
Insecticide	3	0.01339745	0.00446582	1.00	0.4034
Variety X Insecticide	12	0.05358982	0.00446582	1.00	0.4674
Error	38	0.16970110	0.00446582		
Total	59	0.26348328			

Appendix XXII : Randomized Complete Block Design ANOVA for Yield in July and August at Samaru

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	1160160.38	580080.19	1.42	0.2482
Variety	4	48187442.24	12046860.56	29.46	<.0001
Insecticide	3	6194914.77	2064971.59	5.05	0.0030
Time of sowing	1	29182664.13	29182664.13	71.36	<.0001
Variety X Insecticide	12	12204663.50	1017055.29	2.49	0.0082
Variety X Time of Sowing	4	77323.24	19330.81	0.05	0.9957
Insecticide X Time of Sowing	3	181389.24	60463.08	0.15	0.9308
Variety X Insecticide X Time of Sowing	12	250311.10	20859.26	0.05	1.0000
Error	78	31896557.7	408930.2		
Total	119	129335426.3			

Appendix XXIII: Randomized Complete Block Design ANOVA for Yield in July and August at Kadawa

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	3085619.49	1542809.74	3.90	0.0242
Variety	4	47394327.56	11848581.89	29.97	<.0001
Insecticide	3	6344221.36	2114740.45	5.35	0.0021
Time of sowing	1	45890642.77	45890642.77	116.08	<.0001
Variety X Insecticide	12	12503849.11	1041987.43	2.64	0.0052
Variety X Time of Sowing	4	0.00	0.00	0.00	1.0000
Insecticide X Time of Sowing	3	0.00	0.00	0.00	1.0000
Variety X Insecticide X Time of Sowing	12	0.00	0.00	0.00	1.0000
Error	78	30836630.2	395341.4		
Total	119	146055290.5			

Appendix XXIV: Randomized Complete Block Design ANOVA for Yield at both locations

Source of Variation	Degree of Freedom	Sums of Squares	Mean Sums of Square	F-Value	Pr > F
Replication	2	3891862.34	1945931.17	5.94	0.0031
Variety	4	95543107.71	23885776.93	72.91	<.0001
Insecticide	3	12448440.88	4149480.29	12.67	<.0001
Time of sowing	1	74131888.31	74131888.31	226.29	<.0001
Location	1	28337894.69	28337894.69	86.50	<.0001
Variety X Insecticide	12	24583356.80	2048613.07	6.25	<.0001
Variety X Time of Sowing	4	38661.63	9665.41	0.03	0.9983
Insecticide X Time of Sowing	3	90694.70	30231.57	0.09	0.9642
Variety X Insecticide X Time of Sowing	12	125155.60	10429.63	0.03	1.0000
Error	197	64537548.8	327601.8		
Total	239	303728611.4			

Appendix XXV: Rainfall, Temperature and Relative Humidity at Samaru during the 2019 Wet season

Months	Rainfall (mm)	Temperature (°c)	Relative humidity (%)
July	525.10	26	78
August	485.90	25	83
September	169.80	26	74
October	179.40	27	68
November	0	29	27
December	0	25	18

Source: Institute for Agricultural Research Samaru, 2020.

Appendix XXVI: Rainfall, Temperature and Relative Humidity at Kadawa during the 2019 Wet season

Months	Rainfall (mm)	Temperature (°c)	Relative humidity (%)
July	165.80	30	57
August	293.80	27	71
September	47.2	29	57
October	45.4	30	50
November	0	30	19
December	0	25	15

Source: Institute for Agricultural Research Kadawa, 2020.