EFFECTS OF PLANTING DATES AND CULTIVAR ON PEST INFESTATION, YIELD AND DAMAGE OF SESAME (*Sesamum indicum* L.) IN OWERRI, RAIN-FOREST ZONE OF NIGERIA

WRIITTEN

BY

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CERTIFICATION

This is to certify that the research, " Effects of planting dates and cultivar on pest infestation, yield and damage of some Sesame (*Sesamum indicum* L) in Owerri, rainforest zone was carried out by Umelo Chidinma Queen with registration number 20164025838 of the Department of Crop Science and Technology, Federal University of Technology, Owerri ,Imo State, Nigeria.

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DEDICATION

This research is dedicated to my Father and Spiritual Hero," His Grace, the Most Rev. Prof. Daddy Hezekiah, the Anointed Prophet of the Most High God, Founder and Leader Living Christ Mission Inc. Proprietor/ Chancellor Hezekiah University Umudi, Imo State. He is my greatest achievement.

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ABSTRACT

The field study was carried out in the Post Graduate Teaching and Research Farm, Department of Crop Science and Technology, Federal University of Technology Owerri, Imo State in 2018 to determine the level of pest infestation, yield and damage parameters of Sesame cultivars under different planting seasons in Owerri humid environment. The field design was a 3 x 6 factorial experiment laid out in a Randomized Complete Block Design with 3 replications. Each replication consists of six plots of size 2.4 x 2.4 m^2. Treatments comprised of: Factor A -Three planting dates (14th of April- early planting;14th of June- mid planting and14th of August- late planting) and Factor B- Six sesame cultivars (MAJIGIDA, NCRIBEN 01M, NCRIBEN 02M, NCRIBEN 04E, NCRIBEN 05E, NCRIBEN E-8). Treatments were allocated in an area of land measuring 23.9m x 13.2m (315.48m^2). Planting was carried out at a spacing of 30cm within rows and 60cm between rows at a rate of three (3) seeds per stand which was later thinned to one(1). Morphological parameters (days to emergence, germination percentage, days to flower bud initiation and opening, days to capsule initiation and capsule formation, days to maturity and plant height at maturity) were recorded. Counts of insect visually seen on the plants were also recorded. Data on sesame yield and damage include- capsule, seed, and thrash yields kg/ha, per plot, and per plant. The results show that Majigida cultivar had the highest growth performance at days to emergence (5.22), percentage emergence (66.3%) and days to maturity (108 days) with appreciable plant height (164.9), significant seed yield/ plant (6.44g) and thrash yield (274kg/ha; 147.8g/plot) and low damage percentage(2.9%) irrespective of pest population at vegetative and flowering stages. Sesame planted on 14th of April had better growth performance from emergence to maturity with high capsule yield (465kg/ha), seed yield (182.5kg/ha) and thrash yield (296kg/ha) and low percentage damage (2.6%) irrespective of pest population at vegetative and flowering phases. Therefore, for increased yield of Sesame that may ensure food security, availability and sesame productivity, planting of Maijigida cultivar during second week of April planting should be adopted in Owerri, Rain forest Zone, Nigeria.

Keywords: Sesame; Cultivar; Pest; Planting date; Yield; Damage

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND INFORMATION

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated crops in the world. It was one of the highly priced crops of Babylon and Assyria at least 4000 years ago (Oplinger *et al*, 1990). It is known under different countries of the world as Simsim, Bennised, Till, Gingelly, Joinjolly (Anwar, 2010). The majority of the world species of the genus *Sesamum* are native to the sub Saharan African. The crop is mainly grown in the tropics and sub tropics and major producing countries are India, China, Turkey etc. (Anon, 2004). In Nigeria, the cultivation has been limited to the Northern states: Adamawa, Jigawa, Kogi, Benue etc. (Ingawa *et al*., 2004). Recently due to its awareness importance, mandate and quest for production of oil seed crops by West African oil seeds mission, the crop has spread beyond the local growing areas in Nigeria.

Sesame is one of the cash crops of the Sudan beside its value as a source of high nutritive seed value (Lazim, 1973) .The cash crop is one of the foreign currency earners (Omran, 1985). Sesame is rich in source of 50-52% oil, 17-19% protein, phosphorus, calcium and 16-18% carbohydrate (Ustimenko-Bakumovsky, (1983). Sesame seed is used in baking, candy making and other food industries, till cake used for poultry, goat sheep, fish and cattle feed (Khan *et al*., 2009). Flowers are used in curing alopecia, frostbite constipation, paints, pharmaceuticals, cosmetics and perfume industries (Plunger *et al*, 1990. Sesame oil is considered superior because of its high quality and stability due to the presence of balance properties of saturated and unsaturated fatty acids which has a reducing effect of the plasma cholesterol, antibacterial agent, reliever of anxiety and Insomnia etc. Because of the high yield and quality of sesame oil and meal, it is often described as the queen of the oil seeds (Weiss, 1971).

Production and yield performances of Sesame is low in some countries of the world like Pakistan (Nadeem *et al*., 2015). The causes behind the set–back are varied which may include use of marginal land, improved seed, low yielding varieties, imported sowing time, irrigation frequency, fertilizer and other cultural practices (Saleem,2012). Low yielding of Sesame in Pakistan may be attributed to the lesser availability of good quality seeds, sowing method (broadcast, sowing time (early or late sowing) and less or over plant population (Ashri, 1989). Environmental and other management practices also influence sesame production (Adebisi, 2004).

The timing of crop development may have a great effect on its susceptibility to insect pest. For many pests and cropping systems, planting dates will dictate whether or not a pest will be present in sufficient numbers to become a problem (Philips, 2005). Pest appearance, population fluctuation, infestation rate and crop yield are very much dependent on planting date (Hossain, 2009). The performance of sesame has been reported to be strongly influenced by sowing date in Korea (Ree and Park, 1984), and United States of America (Mulkey *et al.*, 1987). In Nigeria, optimum sowing time has been determined for sesame in locations within the North Guinea Savannas, South Guinea Savanna and Forest (Katung and Asenime, 1988). However, such information is not available in the forest zone of the country where most of the staple food and oil crops are cultivated (Olowe, 2007). Hence, this research will concentrate on the Rain Forest zone.

Damage caused from insect pest ranges from 5%-50% of the total sesame production. Weiss (2002) also reported that insects reduce about 25% of the potential yield of sesame in the world. There are a number of known insect pests attacking Sesame, which may be responsible for the low productivity of Sesame. Insect pests associated with the flowering phase usually inflict severe economic damage to crop especially piercing and sucking insect. They may cause serious damage directly by sucking plant crop or indirectly by transmission of virus and Mycoplasma disease.

1.1. PROBLEM STATEMENT

Damage from insect pests can reduce the potential yield of sesame. Not much is known about the potential of mitigating pest damage to sesame by manipulating planting date and using improved sesame cultivars to improve productivity. Efficient research strategy is required to reduce the effect of various yield reducing factors in sesame production in the country. Hence, the need to identify the insect pests associated with the sesame crop to fill its protection research gap in the rainforest zone of Nigeria.

Different response of varieties to sowing date showed that the yields of sesame are decreased with delay in sowing time beyond third week of July (Mahdi *et al*., 2007). Farmers in sesame growing areas of Nigeria plant early maturing varieties at any time of the year without taking into cognizance infestation and abundance of insect pests. To get high yield of a crop, it is necessary to understand the interaction of crops on the appropriate planting dates whether it plays important role in plant growth in order to get optimum yield.

There is increasing evidence that using poor and traditional or non-imported varieties and cultural practices are the main yield limiting factors of sesame plant. Therefore, there is need to identify the best or most efficient variety of sesame for optimum productivity.

1.2. OBJECTIVES OF THE STUDY

The objectives of the study were to:

- Identify field insect pest infestations associated with sesame crop and categorize them into pest status.
- Determine pest population dynamics of different cultivars of Sesame.
- Ascertain the most efficient planting dates for Sesame production in Owerri, Rainforest zone.
- Assess the most effective planting dates on pest infestation of Sesame

- Evaluate the growth, yield performances and levels of damage of different cultivars of Sesame plant in Owerri Rainforest zone

1.3. JUSTIFICATION

Yield is of paramount importance in any research conducted. The impact of planting dates on crop production helps the crop to escape attack from pest and disease infestation which ensures optimum yield. Sesame farmers are not yet conversant with cultivars that may exhibit resistant strain to insect pest and the best time of the year to plant sesame. It is important to fill the gap of knowledge among sesame farmers that plant early maturing sesame cultivars without taking into cognizance pest infestation which will drastically reduce yield. Therefore, if sesame farmers should adopt the most efficient cultivar and planting dates recognized from this research, it will help them achieve high yield of the plant, recognize the economic effects of the sesame plant and develop strategies to manage them.

1.4. SCOPE OF THE STUDY:

To evaluate the most effective planting date of sesame cultivars and the most efficient cultivar of sesame (*Sesamum indicum* L.) in Owerri Rain Forest Zone of Nigeria.

CHAPTER 2

LITERATURE REVIEW

2.1. HISTORY/ORIGIN

Sesame (*Sesamum indicum* L.) belongs to the family of Pedaliaceae, (Wara, 2011) and is one of the most ancient crops and oilseeds known and used by mankind (weiss, 1983). It is also known as Benniseed, Gingelly, and Simsim, Join jolly, Sesamo and Till (Anwar *et al* 2010). It was a major oilseed crop in the ancient world due to its easiness of extraction, great stability, and resistance to drought. Sesame was cultivated and domesticated on the Indian subcontinent during Harrapan and Anatolian eras (Bedigian *et al*., 2003). This is evidenced by the presence of archaeological remnants of the crop dating back to 5500 BC in the Harappa Valley in the Indian subcontinent (Weiss, 2000; Ashri, 2007). The Assyrian tablets depict how the gods ate bread and drank sesame wine together prior to battling and restoring order to the universe.

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated plants in the world (Raghav *et al.*, 1990). It was a highly prized oil crop of Babylon and Assyria at least 4,000 years ago. Today, India and China are the world's largest producers of sesame, followed by Burma, Sudan, Mexico, Nigeria, Venezuela, Turkey, Uganda and Ethiopia (FAOSTAT, 2017). World production in 1985 was 2.53 million tons on 16.33 million acres (Oplinger *et al*, 1990). Sesame was introduced to the United States in1930s. Domestic production has been limited because of the lack of cultivars that can be harvested mechanically. In 1987, the sesame acreage in this country was less than 2,500 acres, about half of which were Texas. The U.S. imports about 40,000 tons of seed and 2,200 tons of sesame oil annually, primarily from South America (Oplinger *et al*, 1990).

Sesame seed is considered to be one of the oldest oilseed crop known to humanity (Raghav, *et al.*, 1990). The genus has many species, and most are wild. Most wild species of the genus *Sesamum* are native to sub-Saharan Africa. *S. indicum*, the cultivated type (Ogasawara *et al.*, 1988) originated in India (Bedigian and vander-maesen, 2003); (Zohary, 2012).

Archaeological remnants suggest Sesame was first domesticated in the Indian subcontinent dating to 5500 years ago (Oplinger *et al.*, 1990). Charred remains of sesame recovered from archeological excavations have been dated to 3500-3050 BC (Bedigian, 2004) Fuller claims trading of sesame between Mesopotamia and the Indian subcontinent occurred by 2000 BC (Fuller, 2003). Some reports claim sesame was cultivated in Egypt during the Ptolemaic period while others suggest the New Kingdom (Serpico *et al*., 2000). Records from Babylon and Assyria, dating about 4000 years ago, mention sesame. Egyptians called it *sesemt*, and it is included in the list of medicinal drugs in the scrolls of the *Ebers Papyrus* dated to be over 3600 years old. Archeological reports from Turkey indicate that sesame was grown and pressed to extract oil at least 2750 years ago in the empire of Urartu (Oplinger *et al.*, 1990); (Rosengarten, 2004).

The Sesame plant was favored by its ability to grow in areas that do not support the growth of other crops. It grows in drought conditions, in high heat, with residual moisture in soil after monsoons are gone or even when rains fail or when rains are excessive. It was a crop that could be grown by subsistence farmers at the edge of deserts, where no other crops grow. Sesame has been called a survivor crop (Langham, 1946). Bedigian (2004) demonstrated that the crop was first domesticated in India, citing morphological and cytogenetic affinities between domesticated sesame and the south Indian native *S. mulayanum* Nair, as well as archeological evidence that it was cultivated at Harrapa in the Indus Valley between 2250 and 1750 BC. All these assertions make it difficult to say with certainty the exact origin of the crop. Due to its relatively low productivity sesame ranks only ninth among the top thirteen oil seed crops, which make up 90% of the world production of edible oil.

2.2. BOTANY/GROWTH HABITS:

The genus *Sesamum* is a member of Pedaliaceae family, which contains 16 genera and60 species. Many occur in Africa (18), 8 occur in the Indian – Ceylon region (5). Almost all of the wild species are prevalent in Africa. (Purseglove, 1977). *S. indicum* is an annual plant which, depending on the cultivar, varies in height from 0.5 to 2 m; however, varieties that are 1.0 to 1.4 m high are more common (Ashri, 2007). Some plants grow 50 to 100 cm (1.6 to 3.3 ft) tall, with opposite leaves 4 to 14 cm (1.6 to 5.5 in) long with an entire margin; they are broad lanceolate, to 5 cm (2 in) broad, at the base of the plant, narrowing to just 1 cm (0.4 in) broad on the flowering stem (Weiss, 1983). When planted early and under high moisture and fertility conditions, sesame can reach 4-6 feet in height. In dry land conditions, it is generally 3-5 feet, depending on rainfall (Angus *et al.*, 1980). Some varieties are highly branched, while others are unbranched. Leaves are variable in shape and size and may be opposite or alternate. The bell shaped white to pale-rose flowers begin to develop in the leaf axils 6 to 8 weeks after planting and this continues for several weeks. Multiple flowering is favored by opposite leaves (Oplinger *et al*., 1990).

It has a large tap-root which can reach up to 990 cm in length and a dense surface mat of feeder roots, which makes it drought tolerant. However, under differing soil and moisture conditions, the plants may have a stronger tap root or a stronger group of fibrous roots (Khirdir, 1997).

Roots of short-season single-stemmed cultivars have a more rapid rate of elongation than longer-season branched ones. Its erect stem is usually square with definite longitudinal furrows. Stem color can range from light green to almost purple but is most often dark green. The stem can be glabrous, slightly hairy or very hairy. Sesame varieties vary markedly in their branching pattern. Some cultivars have numerous branches; some have few whereas others have no branches. There is variation for the location of the branches - whether they grow from the base or higher up on the plant. The degree of branching is influenced by the environment and genetics (Oplinger *et al.*, 1990).

2.2.1 CULTIVARS

Sesame indicum has a number of local cultivars. However, it is often claimed that the genus *Sesamum* has only three cultivated species reported grown in Nigeria for various purposes: *Sesamum alatum, S. indicum, and S. radiatum* with *S. indicum* being the most popular (Dabir. 2000). A range of collections of *Sesame* spp. and cultivars exist in the USA, India, Russia, China, Kenya, South Korea and to a lesser extent Japan, providing a valuable gene pool; South American collections resemble those from India and the Ethiopia-Eritrea area, and similar types occur in East Africa, where varieties usually are well branched and single flowered. The Indian regional cultivars can be broadly divided into early, little branched, few-flowered, and late, many-branched multi-flowered types (El-Naim *et al*, 2010). Depending on the cultivar, the crop matures in 75 to 150 days after sowing. In Nigeria, the cultivation of Sesame has been limited to the Northern states: Adamawa, Kogi, Jigawa, Kano, Katsina, Nassarawa, Plateau, Yobe e.t.c (Ingawa *et al.*, 1986).

2.2.2. LEAVES

The first true leaves are normally small and entire, and then they increase in size. The fourth or fifth leaves are the largest; they are flat and sometimes tri-lobed. The leaves are very variable, hairy on both sides, margins ciliate, estipulate. The lower leaves are opposite, broad and palmate lobed or palmate compound. Higher up on the plant they are alternately arranged, narrow and lanceolate and measure 3.0 to 17.5cm in length and 1.0 to 1.7cm in width. The petiole is about 1.0 to 1.5cm long. Leaf color varies and, depending on the variety, is lighter green or dark gray – green; in some cases there is a reddish anthocyanin pigmentation, expressed in the petioles and the stems (Khirdir, 1997).

2.2.3. FLOWERS

The flowers are yellow, tubular, 3 to 5 cm (1.2 to 2.0 in) long, with a four-lobed mouth. The flowers may vary in colour, with some being white, blue, or purple. Sesame seeds occur in many colours depending on the cultivar. (Weiss, 1983).The most traded variety of sesame is off-white coloured. Other common colours are buff, tan, gold, brown, reddish, gray, and black. The colour is the same for the hull and the fruit (Weiss, 1983). Flowering starts about 35-45 days after planting while flowering stops 75-85 days after planting (Angus, 1980).

Plate 1(a) Sesame flowers

Plate 1(b) Sesame capsules containing seeds

Sesame flowers have five petals with the lower petal being longer, forming what is known as the lip. The lip is folded over the top of the flower keeping it closed to around sunrise; when it opens it forms a running strip for bees (Langham, 2007). Flowers are produced in the leaf axils, each axil bearing up to 3 white, yellow, pink or purple flowers. Plants have usually numerous flowers whose fruit is a capsule containing a number of small oleaginous seeds. The fruits are erect capsules, which form from flowers in the leaf axil about 4 – 6 nodes pairs to the top of the plant (Langham, 2007).

The flowers normally open at dawn between 5 and 7 a.m., pollen is shed shortly after remaining viable for about 24 hours. On cloudy or cool days, the flowers may open 3 hours after sunrise. As the flowers open, the bifid stigma separates and becomes receptive and is copiously covered with pollen from the stamens. Anthers open longitudinally and release pollen after the flowers open; depending on the cultivar. The stigma is receptive one day before the flower opens and remains receptive for two more days unless fertilized (Ashri, 2007).

During floral bud differentiation, sepals arise first, followed by petals and stamens. Then the carpels are initiated, forming a bi-carpelling, binocular superior ovary with several anatropous ovules. Flowers occur in leaf axils on the upper stem and branches, and the node number on the main shoot at which the first flower is produced is a characteristic of the cultivar and highly genetic. Although sesame also grows well in long-day areas, it is generally considered a short day plant. It flowers in about 45 days under 10-hour day length. Long-term selections in regions with different day length and light intensity have produced genotypes with different photoperiod requirements (Ashri, 2007).

2.2.4. CAPSULES

Sesame fruit is a capsule, normally pubescent, rectangular in section, and typically grooved with a short, triangular beak. The length of the fruit capsule varies from 2 to 8 cm, its width varies between 0.5 and 2 cm, and the number of loculi varies from four to 12 (Oplinger *et al*, 1990). The fruiting form of sesame is a capsule, often called pods. They have divided sections much like a cotton boll. Some varieties have a single capsule per leaf axil and others have triple capsules per leaf axil. Branched and single capsule varieties are best adapted to the some specific growing areas. (Angus, 1980). As soon as the capsules on dehiscent cultivars are mature, they split from the top downwards over about two-thirds of their length and shed their seeds which, if not timely harvested, leads to yield losses.

2.2.5. SEEDS

Sesame seeds are small. Their sizes vary with the thousands of varieties known. Typically, the seeds are about 3 to 4 mm long by 2 mm wide and 1 mm thick. The seeds are ovate, slightly flattened, and somewhat thinner at the eye of the seed (hilum) than at the opposite end. The weight of the seeds is between 20 and 40 mg (Oplinger *et al*, 1990). The seed coat (testa) may be smooth or ribbed. The seed is produced in these capsules with about 70 seeds per capsule. The first capsule is 1-2 ft from ground (Angus *et al*., 1980).

The seed color can be white, yellow, and grey, brown, chocolate or black (Heuze *et al*, 2017). Seeds germinate usually within 5 days after sowing. If there is no dormancy, the seeds can remain viable for at least one year. The seeds are very rich in iron, magnesium, manganese, copper, and calcium (90 mg per table spoon for un-hulled seeds, 10 mg for hulled), and contain vitamin B1 (thiamine) and vitamin E (tocopherol) (Balasubaramaniyan, 2001); they contain, including unique content of sesamin, which are phytoestrogens with antioxidant and anti-cancer properties. Among edible oils from six tested plants, sesame oil had the highest antioxidant content (Hansen, 1990). Sesame seeds also contain phytosterols associated with reduced levels of blood cholesterol. The nutrients of sesame seeds are better absorbed if they are ground or pulverized before consumption, as in tahini (Bedigian, 2004).Sesame seeds contain 50-60 % oil and 19-25 % protein with antioxidants lignans such as sesamolin and sesamin, which prevent rancidity and give sesame oil a long shelf life. The lignin contents have useful physiological effects in human animal health (Ashakumary *et al*., 1999). The principal unsaturated fatty acids are oleic and linoleic with about 40 % of each and about 14 % saturated acids. It has a lot of medicinal values (Nadeem *et al*., 2015).

2.2.6. POLLINATION

Sesame is normally self-pollinated, although cross pollination by insects is common. The fruit is a deeply grooved capsule (1 to 3 in. in length) that contains 50 to 100 or more seeds. The seeds mature 4 to 6 weeks after fertilization. The growth of sesame is indeterminate; that is, the plant continues to produce leaves, flowers and capsules as long as the favourable environmental condition exist. Sesame seeds are very small and vary in colour. One thousand seeds can weigh about one ounce. The light coloured seeds are considered higher quality in oil production (Oplinger *et al*., 1990). Sesame is considered a self-pollinated crop; but this is mainly because pollinating insects prefer flowers of other species if available (Ashri, 2007). Where insect activity is high, out-crossing can reach high levels, but cross-pollination is under 1 % when sesame is surrounded by other flowering crops.

2.3 ENVIRONMENT REQUIREMENTS

Environmental factor affect seed yield of sesame because the seed yield is polygenic in character. Sesame crop have wide adaptation to environmental factors such as water and light intensity and it grows throughout the year (Langham, 1946). The total production of sesame varies from year to year mainly due to fluctuations of rainfall, cultural practices, cultivars and prices (Omran, 1985).

2.3.1. CLIMATE

Although sesame also grows well in long-day areas, generally it is a short-day plant and normally will flower in 42 to 45 days depending on the cultivar. However, long term selections in regions with varying day length and light intensity have produced genotypes with different photoperiod requirements. In areas where sesame is grown in two or three seasons per year (for example India and Myanmar), cultivars varying in photoperiod responses have been developed (Ashri, 2007) and many have become adapted to local light periods. Considerable variation in growth and yield frequently occurs when cultivars are introduced in areas with similar day length but different rainfall or temperature patterns. Commercial varieties of sesame require 90 to 120 frost free days. Daytime temperatures of 77°F to 80°F are optimal; below 68°F, growth is reduced, and at 50°F germination and growth is inhibited (El-Naim,2010); (Oplinger *et al*., 1990).

2.3.2. TEMPERATURE

Temperatures below 15^{o}C or above 40^{o}C lead to pollen sterility, reduced fertilization and lower seed set, although there are exceptions. Langham (2007) reports sesame growing in Arizona where the day temperatures during the reproductive phase are seldom below 40o C and often reach 50o C. The rule of thumb is that 150 frost free days are needed for sesame (Kinman and Martin 1954). Work has been done in the greenhouse on optimum temperatures, but the conditions cannot approximate the interactions between temperature, sunshine, and wind in the field. (Khirdir and Khatab, 1991)).

Many publications have repeated that temperatures above 104°F affect fertilization and seed set implying that sesame crops should not be grown in hot areas; however, excellent crops have been grown in Arizona where the day temperatures during the reproductive phase are rarely below 104°F and often reach 120°F (Weiss 1971).

On the cold side, as stated earlier, low temperatures can prevent or inhibit germination; will lead to slower growth; and will slow down ripening. Planting on time will normally keep the crop from frosts through the full maturity stage, but after that point, frosts are possible and are an advantage. Frosts can accelerate the drying phase, which moves harvest into a better weather window. Given the right temperature, sesame seeds can germinate once they are dry

2. 2.3. MOISTURE/ RAINFALL

Sesame is very drought-tolerant, due in part to an extensive root system. However, it requires adequate moisture for germination and early growth with a minimum rainfall of 20 to 26 mm per season is necessary for reasonable yields (Langham, 2007). Moisture levels before planting and during flowering have the greatest impact on yield. Sesame is intolerant of water-logging. Rainfall late in the season prolongs growth and increases shattering losses (Sarkar and Khatuna, 2016),

The timing of the rains can have as much effect as the quantity of the rains can help the field while an adjacent field just planted may get crusted in and not able to emerge (Langham,2007). The ideal rain pattern is enough rain prior to planting the crop to fill the soil profile; a planting rain that will provide enough moisture to plant and to join top and bottom moisture; 30 days of dry weather (in a dry area so the root goes deep); rains about every week for the next 50 days, and then no rain until the crop is harvested (Khirdir and Khatab, 1991). The rains should be light enough for moisture to percolates into the root zone. Continual rains saturate the soil and keep oxygen out, yellowing the plants, and delaying vegetative phase.

The actual rain has the following effects on the stages:

1. In the germination stage, a rain will often move the seed deeper in the soil, delaying emergence. In certain types of soils, a rain can create a crust, delaying or preventing emergence. A rain will also cool down the soil, and if planting at close to the minimum required temperature, the coolness can prevent germination.

2. At the seedling stage, rain can splatter mud up on to the cotyledons and first few leaves, reducing the photosynthetic surface and delaying growth. In some cases, a rain can cause erosion and cover seedlings with mud. Once the cotyledons have inverted and opened, the seedling has little push. If the seedlings are totally covered, they will die. If part of the seedling is exposed, it can recover, but the stage will be delayed (Khirdir and Khatab,1991).

3. In the ripening phase, if there has been a drought, a rain can lead to re-growth.

4. In the drying phase, rain can reduce shatter resistance, but with the new improved non-dehiscent varieties, there is significant less shattering and loss of seed. Rain can germinate seeds that were in dry soil at planting. The greater the difference between the initial germination and this late germination, the greater the farming problems due to differing maturity dates. Sesame plants suffer from standing water and will usually die if the water is on the stem for even a short period of time. Excessive rain that leads to water logging in low spots can kill sesame in any phase. In trying to predict production in an area, it is more important to know the timing of the rains in relation to the stages than to know the total amount of rain. (Angus *et al*., 1980).

2.3.4 SUNSHINE

Light is essential in branch and capsule development. It appears that weak light promotes stem elongation and strong sunshine reduces it; however, it does not appear to change the number of days in the stages (Opplinger *et al*, 1990).

2.3.5 DROUGHT

Sesame is drought tolerant, but as with every crop, will do better with more moisture (Jefferson, 2003). Once the sesame germinated, there was a dry line below the roots that prevented deep penetration. Trying to get the dry soil below wet, the irrigations hurt the sesame more than they helped. Fields with fewer irrigations of around 1" per irrigation had higher yields than fields with more irrigations of around 1.5" per irrigation (Khirdir and Khatab, 1991).

2.3.6. WIND

In any breeding programs, wind should be taken into account because of the potential of lodging. During the germination stage, wind is rarely a problem except for hot continual winds that can pull the moisture out of some soil types. If the farmer does not plant deep enough, the moisture around the seed can evaporate and prevent germination. However, planting deeper to prevent this problem will take the seedling longer to emerge. In the seedling stage, the wind can cover the seedlings with blowing dirt and sand (Langham, 1946). While seedlings covered by rain carrying silt will seldom push through, the silt from wind is looser and occasionally, the seedlings can push through and survive. Normally, the seedlings are low enough to have a low profile to the wind, and there is no lodging at this point.

Winds can be beneficial in the drying phase in that they pull moisture out of the plants faster. Once the plants are dry, the wind, in conjunction with low humidity, can increase the number of harvest hours per day. After the seedling stage, the main peril from wind is lodging. The weight of the plant also makes a difference once the winds start bending the plants. Wet plants from rain tend to lodge more than dry plants.

There are three types of lodging:

1. Plants breaking at the stem, plants bending over but not breaking and plants uprooting and bending over.
2. When a plant breaks over, it will rarely produce any new seed, and the existing seed may or may not mature.
3. If there is a total break, there is no hope, but if there is still some active stem translocation through the break, there can be some yield recovery.

The main causes for uprooting of plants are shallow root systems and fields that have just been irrigated, creating a soft layer of soil. Present varieties are shorter, have smaller leaves, have resistance, and there are fewer lodging problems than there were with earlier varieties.

2.3.7. HAIL

As with any crop, if the hail is severe, it can destroy the crop. However, the present US varieties of sesame have good recovery traits. There is sesame germplasm that will not branch under any circumstance, including losing the growing tip on the main stem. Branches are important in hail damage because the growing shoot of the main stem is tender and a direct hit will often break the tip off. Unless branches start, the production of that particular plant is stopped at the point of the hail strike. The effect of hail depends on development stage of the plant. In the vegetative phase, the hail may lengthen the phase as much as a week, whereas in the later phases, it will shorten the phase. (Langham, 1946).

2.3.8 SALINITY

Sesame is more sensitive to salt than most crops, including cotton and alfalfa. At some point, the salinity will prevent germination, but this subject has not been studied sufficiently. Salinity slows down growth and makes the plants more yellow (Langham, 2008).

2.4 SOIL REQUIREMENTS

Sesame grows best on medium to light, well-drained soil. Heavy clay soils require good drainage or raised beds and light irrigation. It prefers slightly acid to alkaline soils (Ph 5-8) with moderate fertility. It does not like salt. Cotton and alfalfa are more salt tolerant. (Angus *et al*, 1980)

Sesame varieties have adapted too many soil types. The high-yielding crops thrive best on well-drained, fertile soils of medium texture and neutral Ph. However, these have low tolerance for soils with high salt and water-logged conditions. Commercial sesame crops require 90 to 120 frost free days. Warm conditions above 23 °C (73 °F) favor growth and yields (Langham, 2008). While sesame crops can grow in poor soils, the best yields come from properly fertilized farms (Oplinger, *et al.,* 1990). Sesame is adaptable to many soil types, but it thrives best on well-drained, fertile soils of medium texture and neutral Ph. Sesame, which has an extensively branched feeder root system, appears to improve soil structure (Opplinger, *et al.,* 1990). Sesame has a very low salt tolerance and cannot tolerate wet conditions.

2.5 NUTRITIONAL REQUIREMENTS

Sesame is considered to have both nutritional and medicinal values. Sesame oil is sometimes used as a cooking oil in different parts of the world, though different forms have different characteristics for high-temperature frying. The "toasted" form of the oil (as distinguished from the "cold-pressed" form) has a distinctive pleasant aroma and taste, and is used as table condiment in some regions, especially in East Asia. Toasted sesame oil is also added to flavor soups and other hot dishes, usually just before serving, to avoid dissipating the volatile scents too rapidly (Oplinger *et al*., 1990).

The seeds are used either decorticated or whole in sweets such as sesame bars and halva, in baked products, or milled to get high-grade edible oil or tahini, an oily paste (Bedigian, 2004). Tahini is widely used in foods in the Middle East. Sesame seed contains two lignans, sesamin and sesamolin. After roasting sesame seeds, sesamolin is converted to sesamol. Sesamol has been found to have anti-oxidative effects and to induce growth arrest and apoptosis in cancer cells (Lazim, 1973). Oil from sesame seed is rich in protein, fatty acids and carbohydrate (Kahyolu et al., 2006), good source of vitamin B6 (pathogenic acid), vitamin E (Tocopherol) and Minerals like Calcium, phosphorus e.t.c (Balasuaramaniyan, 2001). It is used as salad oil and magarine in cooking, containing about 47% Oleic and 37% Linoeic acids and foods fried in sesame oil has longer shelf life and antioxidant called Sesamol (Khirdir, 1997; Coote 1991).

In recent times, the anti-photo-oxidant activity of Sesamol for oil has been reported to be due to the scavenging of single singlet oxygen. Sesamol has a phenolic and a benzodioxide group in its molecular structure. The phenolic groups of molecules are generally responsible for the anti-oxidant activity of many natural products. On the other hand, benzodioxide derivatives possess anti- tumor, anti-oxidant and many other biological activities; It is noteworthy that in recent times sesame seeds have been found to contain immunoglobulin E (IgE) - mediated food allergens, with research reports from France (Agne *et al.* , 2003), Israel, Italy and the United States. The more prevalence of sesame seed allergy is probably attributed to the wider and expanding use of sesame seed in baked products and fast foods.

Sesame seeds (approximately 50% oil and 25% protein) are used in baking, candy making, and other food industries. Oil from the seed is used in cooking and salad oils and margarine, and contains about 47% oleic and 39% linoleic acid (Khirdir, 1997). He oil can be used in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides (Oplinger *et al*., 1990). In a 100-gram amount, dried whole sesame seeds provide 573 calories and are composed of 5% water, 23% carbohydrates (including 12% dietary fiber), 50% fat, and 18% protein. Whole sesame seeds are rich (20% or more of the Daily

Value) in several B vitamins and dietary minerals, especially iron, magnesium, calcium, phosphorus, and zinc (Sarkar and Khatuna, 2016). The byproduct that remains after oil extraction from sesame seeds, also called sesame oil meal, is rich in protein (35-50%) and is used as feed for poultry and livestock(Hensen, 2011);(Heuze *et al*., 2017)

Sesame oil is used in cooking, used for salad oils and magarine, the oil from sesame can also used for Ayurveda medicine and as antibacterial agent in preparation of mouth wash. It has reproduction as a selective reliever of anxiety and insomnia, dry flowers are used in curing alopecia, frostbite constipation and in manufacture of soaps, insecticides, paints pharmaceuticals, cosmetics and perfume industries (Shin *et al*., 1972). Till cake is good feed for poultry, goat, sheep, fish, and cattle (Khan, 2009).

2.6 AGRONOMY/ PROPAGATION

Sesame propagation is by broadcasting or seed drilling in rows. Broadcasting seeds is the most common seeding method used by smallholder farmers. The seeds are often mixed with sand, soil or ash and then broadcast or drilled by hand in small furrows spaced at 50 cm apart as is the case in Tanzania. This makes distribution of the seed evenly, thus reducing the number of seedlings lost during thinning. Elsewhere, for example in Guatemala, Paraguay, Thailand and parts of India where sesame is planted by hand, and thus not broadcast, farmers poke a hole with an implement similar to a broomstick, and then put in 3-5 seeds, and cover (Ogasawara *et al*, 1988). Where the crop is grown under large scale production conditions, sesame can be planted mechanically. Commercial farmers in the US fields grow the crop with planters ranging from row planters to drills (El-.Naim and Ahmed, 2010).

2.6.1. SEED TREATMENT

Seed should be cleaned thoroughly and treated with one ounce of 75% Captan per 100 lb. of seed to prevent damping off. This treatment is especially important for varieties that are slower to emerge than the early maturing varieties. Because the seeds of the low maturing varieties spend more time in the soil before germination, they need more protection from fungal pathogens in the soil (Oplinger *et al*., 1990)**.**

2.6.2. SEED BED PREARATION

Sesame requires a warm, moist, weed-free seedbed. Good drainage is important, because the plant is extremely susceptible to waterlogging at any stage of growth. Since sesame is planted late, several generations of weeds can be killed by repeated tillage before planting. (Oplinger *et al.*, 1990)

2.6.3. PLANTING DATE:

The performance of sesame has been reported to be strongly influenced by sowing date in Korea (Ree and park, 1964) and U. S (Mulkey *et al*, 1987). In Nigeria, optimum planting dates have been determined for Sesame locations within the Northern Guinea savanna (Katung and Asenime, 1988), Southern Guinea Savanna and rain forest (Ogunremi, 1985). When planted early and under high moisture and fertility conditions, sesame can reach 4-6 feet in height. In dry land conditions, it is generally 3-5 feet, depending on rainfall. Sesame should not be planted before the soil reaches a temperature of about 70°F—roughly one month after the last killing frost. (Oplinger *et al*., 1990). Sesame is intolerant to wet conditions (Lim, 2012). Nath and Charkarbolhy, (2003), mentioned that sesame can be cultivated in sub-optional conditions mainly during February – May or June- September.

Most researchers studied the influence of planting on yield of sesame. Mulkey *et al*., (1987) and Olowe, (2003) found out that plant height increased by planting sesame on 29^{th} April, 26^{th} February, 1st

July, and 15th June respectively. Capsule and seed yield recorded the highest values when planting is done on 26 February, 1st July, 22 July and 20th June (Olowe 2007). Meanwhile, Ogbonna and Umar-sheba, (2011); found insignificant seed yield effect on planting dates of 1st March, and 20th June.

Optimum planting dates of sesame for achieving higher yield was determined by many investigators and they are as follows25 April; (early planting) in Egypt, on April or May, 1st March in India, 26th February in Bangladesh, 1st July and 22nd July in Nigeria and 20Th June in Pakistan (Olowe,(2007); Ogbonna and Umar-sheba, (2011); Ali and Jan (2014). Early planting has about 73.3% reduction in the incidence of *A. catalaunalis* compared to late planting (Zerewi,2018) indicating that pest might in favour of green cover(weeds) and high temperature rear and reproduce prior to infect sesame. Sowing sesame during onset of rain (May) have less infestation of *A. catalaunalis* than planting in the late season (Olowe, 2007). Similarly, Ahirwar *et al.,* (2010) reported that high temperature (>27mm) and low rainfall (<200mm) during flowering and pod formation stages accelerate the incidence of pest.

Many Indian researchers have reported that pest is active from August (Nath and Charkabolhy, 2003) and early sowing is less infested than late sowing of Sesame. Hence, sowing the crop early helps to escape the sesame webworm damage while the delayed sowing results in a significant higher level of damage to leaves, flowers and pods (Zerewi, 2010). This could be associated with the fact maximum number of larva population and incidence of pest is strongly correlated with maximum temperature and lower rainfall (Ahirwar *et al*., 2010).

2.6.4. PLANTING METHOD AND RATE OF PLANTING:

Sesame can be seeded with a row crop planter equipped with vegetable planter boxes, Populations of 250,000 to 300,000 plants/acre in 18 to 30 in. rows have given the highest yields. This is about 1 lb. /acre for 30 in. rows (Oplinger *et al.*, 1990). Most farmers' plant between 2.5 to 4.5 lbs. /ac, depending on row spacing and planting conditions. The cheapest insurance for sesame is to plant enough seed the first time. Over-seeding is much better than under-seeding. Sesame can adjust to the population. If the population is too high, it will self-thin itself in most situations. In low populations, it will branch more to fill the spaces. There have been no statistical differences in yield between 3-8 plants per foot at harvest in studies on 30”, 36”, 38”, and 40” row spacing. Seed per foot of planted row is more important to yield than population per acre (Angus *et al*, 1980).

2.6.5. PLANTING DEPTH

Depth of planting varies with soil type and soil moisture from 1 to 2 in. Uniform depth and seed rate are essential for stand establishment resulting in maximum yield (Oplinger, 1990).

It can be achieved by placing the seed 1/2 inch to 3/4 inch below the defined moisture line with a 1/4 inch to 3/4 inch dry covering of dry soil above that line. The total seeding depth would be from 3/4 inch to 1.5 inches. It is preferred to be less than one inch if possible (Angus *et al*, 1980).

2.7 GROWTH AND DEVELOPMENT

Sesame is characterized by a slow growth rate in the first 30 days while the root is growing faster than the leaves and stems in rain-fed conditions, the final plant heights are lower, but the pattern of very slow growth followed by fast growth during the reproductive phase exists under all conditions (Angus *et al*., 1980). There are four stages in the growth and development of Sesame. The phases and stages of sesame are as follows:

1. **Vegetative**: this is measured from sowing to 50% flowering (Mulkey *et al*., 1987). For the germination stage soil temperatures need to be 70ºF at planting depth at 7 AM. Final stand should be judged at 7 days after planting. During the germination stage, a rain can create a crust in the soil over the sesame. If the seed is located inside the crust, there is no hope for

emergence, and the sesame should be replanted. If the seeds are germinating below the crust, there is a possibility that the crust will crack and allow for emergence. The stage ends when the seedlings emerge. (Angus *et al.,* 1980).Emergence is 0-5 days; open flowers 38-44. Adequate rainfall in the soil during the vegetative period is desirable because the number of branches and number of seeds are determined during the period (Olowe, 1996).

2. **Reproductive stage:** This is measured from 50% flowering to physiological maturity (Mulkey *et al*., 1987). The white flowers opened the day of the photo and self-pollinated. The larger yellowish buds opened the next day. By the third day after open flower, the capsules are visible and will grow to their final size about 4 days later. The speed of growth will vary by variety. The seed will be mature in each capsule from 40 days at the bottom of the plant to 25 days at the top. However, the bottom capsules will not dry until after all the capsules ripen. Number of capsules 45-52; plants stop flowering 53-81; open flowers 82-90 9(Angus *et al*., 1980).Ripening it starts during the reproductive phase when the first capsule is formed. During this phase, most of the leaves fall off the plants. Generally, leaves will turn yellowish green before dropping. The leaves that drop due to drought are not considered self-defoliation by maturity.

3. **Physiological maturity:** This is when 75% of the capsules on the main stem have seed with final color and a dark tip. The seed will also have a dark seed line on one side and after physiological maturity, the crop is less susceptible to yield loss due to frost. It is also an indicator that the time to use harvest aids is approaching (Angus *et al*, 1980).

4. **Drying Phase: Th**is stage ends when 90% of all plants have seeds mature to the top of the plant. Physiological maturity (PM) 91-106 days. All seed mature 107-112; 1st dry capsules 113-126; Full dry down 127-146 (Angus *et al*., 1980).

2.8 FERTILITY AND LIME REQUIREMENTS:

Studies have reported increase in yield with the application of fertilizer. Olowe *et al*., (2003) reported increases in plant height at maturity from 104.6cm with 0 kg N/ha to 122.9 cm with the application of 90kg N/ha and as well no significant effect of plant height at flowering and maturity with the application of up to 60 kg P_2O_5 /ha. Fertility requirements for sesame are similar to millet: 80 lb. N, 20 lb. P_2O_5 and 20 lb. K_2O per acre. The N is for soils with less than 2% organic matter. Reduce the N to 60 lb. /acre for soils with 2% to 5% organic matter and to 40 lb. /acre if the soil has more than 5% organic matter (Oplinger *et al*., 1990). The P_2O_5 and K_2O recommendations are for soils testing in the "optimum" range. The P_2O_5 and K_2O and up to half of the recommended N could be applied in a band alongside the row at planting if desired (Olowe *et al*., 2003).

2.9 VARIETY SELECTION:

There is great diversity within the several varieties of sesame. However, the sesame varieties are divided into two types: shattering and non-shattering (El-naim *et al*, 2010); (Lazim, 1973).

Shattering varieties: Most of the shattering varieties grown in the United States have been produced from the variety Kansas 10, or K 10. The seeds of this unbranched variety have a high oil content—over 50%—but their bitter flavor limits their value on the whole-seed market. Some shattering varieties grown in the U.S. include: Margo, Oro, Blanco, Dulce, and Ambia (Lazim, 1973).

Non-shattering varieties: Non-shattering varieties have been developed to allow mechanical harvesting. Though these varieties usually contain somewhat less than 50% oil, their seed is used for oil production only. Some non-shattering varieties include: Baco, Paloma, UCR3, SW-16 and SW-17 (El-naim, 2010).

However, there are many varieties of sesame available from which farmers can select (Selvarayanan, 1996). The two types of sesame preferred and produced in Nigeria include:

The white/raw, food grade sesame used in the bakery industry. The brown/ mixed primarily oil grade sesame. Selvarayanan, (1996) stated that the resistant varieties suffers lesser insect infestation than susceptible ones and varieties under high insect pressure resulted to reduced yield.

Basic characteristics of released sesame varieties [by the National Cereals Research Institute (NCRI), Badeggi,Nigeria]

Sesame Variety	Days to Maturity	Characteristics of Seed	% Oil content	Potential yield (kg/ha)	ColorSize
NCRIBEN-01M	102-115	White	3	45	0
NCRIBEN-02M	102-115	Light brown	3	45	750
NCRIBEN-03M	125-140	White	2	40	600
E8	90	Light brown	3.6	50	1000
Yandev	55 -125	Light brown	2.5	45	60

2.10 PEST MANAGEMENT

A wide range of weed species, insect pests, and diseases attack sesame around the world. In Ethiopia, weeds presume primary importance, followed by insect pests and diseases (Chaudhry, 1989). Among insects only the sesame webworm, bug, gall midge, green vegetable bug, grasshoppers, African bollworm, and crickets have been recorded. They become more serious as crop acreage expands and mono cropping is practiced largely (Mantilla, 1995).

2.10.1 WEEDS

Weeds are unwanted plants found in sesame fields. They compete with sesame crops for nutrients, moisture, and sunlight, which can decrease the crop quality, higher the production costs due to increased cultivation and hand weeding, and considerably reduce the crop yields. They also serve as alternate hosts of insect/mite pests and diseases. Numerous species of weeds infest sesame, among which grasses are the most abundant weeds in the northwest. For example in Metekel Zone, Graminaceae species are the most dominant ones, 22%, followed by Composite (17%). So far more than 98 weed species in 31 families causing damage to sesame crop were identified only from major sesame growing areas of the country (Oplinger *et al.*, 1990). In sesame field grasses, sedges, bind weeds and some broad leaf weeds are most dominant. Because of their slow early growth, sesame plants are poor competitors against weeds. Thus, it is very important to eliminate weeds from sesame fields as early as possible (Oplinger *et al.*, 1990). Crop yields often depend on the amount, size, and proximity of weeds present after crop emergence. Weed vigor on the other hand is also influenced by crop abundance, size, and proximity.

WEED CONTROL:

1. **Mechanical**: Cultivate sesame fields early and as close to the rows as possible. Shallow cultivation is recommended, because the fine, fibrous sesame roots grow close to the surface and are easily damaged. Early cultivation causes seedlings to grow faster, possibly as a result of improved soil aeration (Weiss, 1971). After the plants reach a height of 3 or 4 in., they grow rapidly. Cultivate only as necessary to control weeds.

2. **Chemical**: No herbicides are currently registered in Wisconsin or Minnesota for use on sesame. In other areas the pre-emergence herbicides alachlor (Lasso) and trifluralin (Treflan) have been used successfully for weed control in sesame. Growers should check current labels for use of these or other products in their growing area.

2.10.2 INSECTS AND OTHER PREDATORS AND THEIR CONTROL:

Sesame plants are often attacked and damaged by Aphids. Thrips will stunt seedlings and injure developing flower buds so that capsules do not set. The gall midge (*Asphondylia sesami* Felt.) and various caterpillars have been important in some countries. Green stink bugs, Red spiders, Grasshoppers, Cut.worms, Armyworms and Bollworms also attack sesame, but do not cause extensive damage. Association of different insect pest with sesame yield was also evaluated with explicit that in insect resistant varieties with less resistant , significant greater yield occurred compared to varieties with less resistant insect pest or susceptible ones (Selvanarayanan and Baskaram, 1996).

Sesame yields are seriously affected by pests. Out of which sesame webworm *(Antigastra catalaunalis)*, sesame seed bug (*Elasmolomus sordidus*), gall midge (*Asphondilia sesami*), termites, green vegetable bug *(Nezara viridula*), African bollworm (*Helicoverpaarmiger*), Grasshoppers, Aphids, Jassids, Whitefly, Field crickets, Warehouse Moth and Red flour beetle (Suliman, 2013).Sesame webworm (*A. catalaunalis)* is the most important insect that affect sesame during various growth stages starting from 2 or 3 weeks after emergence up to harvest (Negesh,2015).

Among the factors of low productivity, insect pest causes the havoc. Chaudhry *et al* (1989) reported that leaf rollers/ Webbers and Thrips are the serious pest of sesame, they cause 15-20 % damage to the crop at vegetative stage and 10-15% at productive stage. However Thrips (*Thrips tabaci*) damage the seedling at germination stage of the crop. Mantilla, (1995) reported that the whiteflies damage in the plant caused reduction in the leaf area and photosynthetic activity causing an increase in empty seed percentage and a reduction in seed size which are negatively related to seed yield. Nenita, (1993) reported that aphid nymph and adult feed on cell sap of sesame plant while plant bug (Stenobis spp) feed on leaves and shoots together considered to be serious pest of sesame in Philippines.

A) Sesame seed bug

Seed bug is considered as a local pest that appears in large numbers at harvest time. Currently, however, infestation of seed bug is increasing from year to year depending on climatic conditions like rainfall and humidity. The seed bug has three developmental stages, egg, nymph, and adult. (Mandal *et al*., 2009); (Mandefro, 2009).The development of egg to adult death ranges between 39 and 54 days. Both nymphs and adults cause damage to sesame by sucking the seed oil and its content, causing two types of losses, qualitative and quantitative. Nenita, (1993) have also reported similar mode of damage and incidence level of this pest of sesame crop.

Seed bug control measures

Cultural*:* Soon after harvest stalk removal, field clearing and plowing under, alternate host destruction around fields, warehouse, and storage cleaning had a significant impact on survival and fecundity of sesame seed bug.

Botanicals: Using 10% Neem seed kernel extract and formulated Neem oil (Nimex 0.03%) controlled seed bugs effectively in closed containers or in airtight warehouses.

Biological: Numerous species of bio-control agents (predators and parasites) were found feeding on seed bugs. Among the recorded predators, ants of different species, termites, spiders, lizards were the major ones found hunting for nymphs and adults. Around Humera, an effective wasp, egg parasite *Grionini sp*. was known to causes 40-80% egg parasitism. The wasp most likely occurs in all places where seed bug egg is available under sesame stalks. However, the number vary from place to place.

Chemical:

Dusting the base of stack and the soil around them with Ethiolathion 5% Dust, and carbaryl 85% WP was well practiced. Fenitrothion and diazinone could also be used as foliar spray before harvest. In warehouses and storage areas Malathion 50% EC, Carbosulfan 25% ULV, Ethiosulfan 25% ULV, Lambda-cyhalothrin (Decis 0.5% ULV and Karate 0.8% ULV) are effective even at very low rates.

B) Sesame webworm

Sesame webworm, *Antigastra catalaunalis*, is a well-established and widely distributed insect pest of sesame (Zerewi *et al*, 2016). It may be a sporadic pest that causes greatest damage during the seedling and flowering stages, and may continue until harvest, feeding on mature seeds hidden inside capsules (Suliman, 2013). The caterpillar does best in the dry conditions that follow rains, so its development and spread is closely linked to the developing climatic conditions. The larvae feed on leaves, flowers, pods, and growing shoots. The young larvae mine young leaves and shoot tips; they fasten together leaves and shoots and feed inside. At later stages, the larvae infest the sesame capsules, making an entrance hole on the lateral side (Narayanan, 2005).

Generally, webworm can cause yield losses of between 25 and 35% and critical period for control action is flowering stage (Zerewi *et al*, 2016). Nevertheless, webworm damaged capsule may inflict up to 100% seed loss (Zerewi *et al*, 2018). Most farmers do not consider webworm as a pest; no action is taken in many cases, especially 7-10 days after the end of flowering. The larvae move from pod to pod and down to already matured pods.

Webworm control measures

Insecticides such as Endosulfan 35% EC at 2 l/ha, Cypermethrin 20% EC at 4.5 l/ha, Lambdacyhalothrin 5% EC at 0.32 l/ha, Pirimiphos-methyl 50% EC at 2 l/ha, and *Bacillus thuringiensis* SC at 2 l ha-1 control the pest effectively. Nevertheless, pesticide application should terminate before capsule opening.

C) Termites

Termite is an important pest of sesame in the field and storages in drier areas, especially in places with low and poor rainfall distribution. Field attack may start from seedling stage and continue to harvest and shocks. (Mandefro, 2009).

Termite control measures

There is no single effective method of control for termites; however, good agronomic practices increase crop tolerance to termite infestation in the fields; Carefully select shocking ground away from termite mounds or tunnels; Make insecticide barriers by applying Chlorpyrifos, endosulfan or malathion 5% dust away from the shocks/hilla; Thrash within 10-15 days' time and move to store with concrete floor; and Do not allow termites to multiply in or near your field. (Mandefro *et al*, 2009).

D) Sesame gall midge

The sesame gall midge, *Asphnodylia sesami* belongs to order Diptera, family *Cecidomyidae*. The gall midge was minor pest of sesame in Humera area, but now days it became key pest mainly due to mono cropping system of sesame production. Where it occurs, the sesame gall midge causes extensive damage and the larvae are the damaging stage. Eggs are laid in ovaries of flowers and the gall begins to develop before the petals wither or become twisted, stunted and do not develop into flower or capsules

Gall midge control measures

Cultural:

Early sowing reduces the damage as the crop blooms before the fly number goes up. Destruction of wild and volunteer sesame plants is recommended in many countries for gall midge management. In Ethiopia, sesame gall midge infestation increased with changes in cropping system, especially mono cropping of sesame. Thus, rotating sesame with cotton, sorghum, and other unrelated species will undoubtedly decrease its severity.

Chemical:

Applying dimethoate, diazinon, Malathion, orphosphamidon as off the flowering period effectively controlled gall midge in many countries. Bait sprays of Malathion or Dipterex could also be used for midge management. In India using 10% neem seed kernel or leaf, extract with weekly application interval reduced fly population. The commercial neem product, Neembicidine (0.03%) and Neemgold were found more effective than the home made neem extracts.

E) Aphids and whiteflies:

Both insects develop similar damage symptom on crops. Nymphs and adults of both species pierce the plant tissues and feed on sap. Heavy feeding of both species on leaves cause crinkling and cupping, induce production of honeydews that serve as the substrates for the growth of black sooty molds, and result in stunted growth. The mold reduces photosynthesis causing poor plant growth. These insects are also known to transmit virus diseases of many crops. Heavily infested Sesame plants will turn yellow, eventually wilt because of excessive sap removal, and finally die off (Mahmound, 2012). Research conducted by Coty (1988) argued the damage symptoms in whitefly attacked sesame which consequently reduced yield.

Whiteflies and Aphid control measures

Botanicals: Add 15 ml of Neem oil into 1 liter of soapy water. Constantly shake the container or stir the extract while in the process of application to prevent oil from separating.

Chemicals: Treat the seeds with 300-350 g Gaucho or Cruiser before planting. At vegetative growth stages apply carbosulfan 25% ULV 2 l/ha, Polo 500 SC 1 l/ha, Deltanate 200 EC/ULV 2 l/ha, Applaud 3 l/ha, Thiodan 35% EC 2.5 l/ha, Karate 2 l/ha or Decis 2 l/ha.

2.11. DISEASES MANAGEMENT

The most common sesame diseases are leaf spot, leaf and stem blights, Fusarium wilt, charcoal rot and root rot. Some of the disease organisms are carried on the seed. It is advisable to use disease-free seed and treat it with a fungicide before planting. Currently among sesame diseases bacterial blight in humid and phyllody in drier areas are very important, while powdery mildew and wilt are sporadic and minor economically.

A) Bacterial blight

Bacterial blight and bacterial leaf spot of sesame are caused by two pathogens *Xanthomonas sesami* and *Pseudomonasa sesami*. Both pathogens may occur together or separately and can cause complete crop failure in years of favorable conditions for disease development. Bacterial blight incidence and severity varies depending on topography, altitude, and weather conditions. Disease incidence may reach up to 100% in areas such as Wellega, Pawe, and Gambella where high humidity persists for longer time while it is about 10-50% in semi-arid areas like Werer and Humera. Water logging encourages the spread of the disease. (Geremew and Tereffe, 2012)

Bacterial blight management

Variety selection: Use tolerant varieties such as Obsa and Dicho for Wollega, Abassena for Pawe and Tate for southern areas.

Cultural: Use of clean seed, stable removal, burning, deep plowing, and crop rotation controls blight incidence.

Physical method: Hot water treatment at 52oC for 12-14 minutes reduces initial blight infection but avoid field re-infection.

Chemical: Streptomycin solutions of 750-1000 ppm were found to reduce blight incidence, but field re-infection was a problem that could not be managed.

B) Phyllody

Phyllody is most destructive disease of sesame in drier areas like Werer, Babille, and Bisidimo and partly in the north-west. The disease causes deformation of leaves and flowers, which remain green with the calyx and corolla, sometimes stiff, forming a half-open hood (Geremew and Tereffe, 2012). The deformed top parts have shorter internodes, much brunched, and change to broom shape or become bunchy. Phyllody infected plants do not bear capsule, if does they are deformed and crack before maturity and seeds are shriveled. Phyllody and other virus diseases are transmitted by Jassids and whiteflies, thus, managing these pests reduce further spread of the disease (Anwar, 2010).

Phyllody control measures

Cultural: Do not use seeds harvested from phyllody infected fields. Destroy sesame plants with disease symptom from field and burn them immediately. Alternate host of jassids should also be destroyed from field edges.

Chemical: There is no chemical that controls phyllody disease, but insecticide application against its vector (jassid = *Orosius albicnatus*) minimizes its spread.

C) Wilt

Wilt is caused by a fungus, *Fusarium oxysporium f. sesami*. Infected terminal leaves turn yellowish, desiccate, and drop, the symptom progressing down to the stem. Mostly infection is patchy and when mature plants are attacked, only one side of the plant shows symptoms. When uprooted, roots will be wholly or partially rotten.

Wilt control: Seed selection, early plowing/cultivation and exposing the fungus to desiccation, avoiding water logging conditions in the field, field sanitation, and crop rotation are highly recommended.

2.12. MATURITY

According to Tewolde *et al*, (1994), sesame capsule is matured when the subtending leaf defoliate due to normal senescence.The length of growing season for sesame cultivars varies depending on the length of the rainy seasons in each agro-ecology and the nature of the crop i.e. its indeterminate nature needs cautions to decide proper planting time. Since flowering occurs in an indeterminate fashion, seed capsules on the lower stem are ripening while the upper stem is still flowering (Geremew and Tereffe, 2012).

At maturity leaves and stems tend to change from green to yellow, then to dark red in color and the leaves will begin to fall off, and normally dries down in 2 to 3 weeks depending on climatic condition. Depending on the moisture and fertility, the currently grown varieties stop flowering at about 72-90 days after planting. Self-defoliation and seed maturity begin as the flowering stops. The plants normally hold on to the top leaves until the upper capsules mature. Sesame plants physiologically mature when the seed in the capsules ¾ up on the capsule zone have turned from milky white to an off-white color. As the capsules dry, the tips will open and expose the seeds. This opening of the capsule is critical to drying the seed faster and to allowing the seed to be thrashed with a minimum of force. The faster the seed dries down, the less exposure to pest attack and wind damage.

2.13. CROP HARVESTING

Since sesame is a small, flat seed, it is difficult to dry it after harvest because the small seed makes movement of air around the seed difficult. Therefore, the seeds need to be harvested as dry as possible and stored at 6% moisture or less. If the seed is too moist, it can quickly heat up and become rancid (Hansen, 2011). Sesame is ready for harvesting 90 to 120 days after planting depending on variety. In general, non-branched varieties mature earlier and harvesting starts when 75% of the pod/capsules are ripened. Timely harvesting and stacking is very essential for quality harvest and decrease losses due to shattering in cases of labor limitations. In harvesting sesame, the mature plants are cut, bundled, and shocked to dry. In some areas, the shocks are left in the field.

After harvesting, the seeds are usually cleaned and hulled. In some countries, once the seeds have been hulled, they are passed through an electronic colour-sorting machine that rejects any discolored seeds to ensure perfect colour. This is done because sesame seeds with consistent appearance are perceived to be of better quality by consumers, and sell for a higher price. (Geremew and Tereffe, 2012)

2.14. YIELD

Sesame as one of the oldest cultivated plants in the world is gaining significance in Nigerian agriculture because of the economic importance of its seeds in the world market (Olowe *et al*., 2003) as well as nutritional content of the leaves when used as vegetables. Although low yield potential coupled with problems encountered during harvesting have tend to discourage growers; leading in the total area devoted to its cultivation (Busari and Ajewole. 1993).

With good management, yield should be between 450-550kg/ha (Naturland, 2002). Seed yield per unit area increases with increased population density from 80,000 to 160,000 plants/ ha and beyond this density it becomes counterproductive (Delgado and Yermanos, 1975). Also, increased number of seeds per capsule, number of capsule per seed, dry matter production increased when the intra-row spacing increased from 30-90cm (Weiss, 1983; Olowe, 1996). Allam, (2002) pointed that seed yield per plant substantially decreased with increased plant population while seed rate increased seed yield due to reduction in inter plant competition for assimilates and low pod yield. The local and world mean seed yield is very low, higher yield can be achieved through sustainable cultivars and optimum planting dates. The low yield could be due to lack of improved cultivars, low harvest index, susceptibility of disease, pest and environmental stress as well as capsule shattering (Heuze *et al*., 2017)

2.15. POST HARVEST ACTIVITIES

A.THRASHING

Two weeks after harvesting, thrash and winnow the seeds. However, caution is recommended to minimize seed loss during taking to thrashing ground. Thrashing ground should be concrete floor or use canvases to free from soil, gravel, dust and other inert materials that reduce quality of sesame seed.

B. CLEANING

On dry down the shocks are inverted over a cloth/canvases/plastic sheets in the field. Depending on the amount of shattering, the bundles may be hit with a stick until all seeds fall-off. Clean by repeated winnowing until the seeds are separated from the chaff and other inert matters.

C. TRANSPORTING

Freshly thrashed seed above 7% moisture content should not be left sitting on a truck for a long time to avoid spoilage. Trucks with sesame on board should generally not be trapped on a sunny day, since the cover can increase heat build-up. Clean and dry in sun for about 7days before bagging and transporting. (Geremew and Tereffe, 2012). For maximum protection, sesame seeds have to be moved from the farm to the storehouse in bags weighing approximately 2 kg. The bags with or without seed should not be loaded on pesticide or oil contaminated trucks or put in a damp place or any place where it may be exposed to contamination.

D. STORAGE

Due to small seed size and flat shape of sesame seeds, it is difficult for ambient and fresh air to move through it in storages. Therefore, it is recommended that the seed be thrashed as dry as possible, and stored at moisture content of below 7%. If the seed is too moist, it can quickly heat up and become rancid. The warehouse/stores must be clean and sacks must be free of live insects and their development stages. Equipment as well as working and drying surfaces and preparing and storage rooms, should be cleaned regularly and all sweepings collected from time to time. Bags must be stacked or piled up systematically to ease counting and removing, inspection and management with a minimum of 2 meter spacing between stacks. Stacked sesame should be stored in a dark place at low temperatures (below 18°C) and low relative humidity (El-naim *et al*, 2010).

Under optimum storage conditions, sesame seeds can be stored for up to one year. However, it is very important to protect the seeds from loss of aroma and undesirable smells and tastes from its surroundings. Therefore, storing pesticides, fuel, oil, and other odorizing agents with sesame in the same store is not allowed. Empty bags, tarpaulins and other accessories not in use shall be stored separately (Geremew and Tereffe, 2012). Sesame may be stored at room temperature for approximately 5 years without loss of viability. Freezing temperatures damage seed and make them less marketable (Lazim, 1973).

2.16. POST-HARVEST PEST MANAGEMENT

Among storage insect pests, seed bug, webworm, tropical warehouse moth and red flour beetle are important. Sesame and its oilcake is rich in proteins and fats and, hence, is vulnerable to infestation of stored product insect species resulting in weight loss, contamination and deterioration in quality and flavor because of mould growth and toxin elaborations.

Sesame seed bug is the major pest of sesame in storage and field in the northwest, especially Humera and Metema areas. It sacks all seed contents and causes shriveling and increase in free fatty acid concentration. Bug sacked seeds become unmarketable because of its bitter test, dark color, and shriveled shape. Sesame seed bug that infest staked sesame and sack seeds stored in bags is considered a major pest. Sanitation around storages is the best method of control followed by insecticide application. Chemicals such as Decis 5% EC 2 l/ha, Malathion 50% EC at 2 l ha-1, Thionex and

Thiodan25% ULV at 2.5-3 l ha-1 should be applied on breeding sites but not on feeding sites, such as piled sesame bugs and concrete floored stores. (Geremew and Tereffe, 2012).

Other storage insect pest of sesame could be controlled by application of Fenitrothion 3% dust at 30 g/100 kg, Baythion at 100 g/100 kg, Aluminum phosphide at 5 tablets, and Pirimiphos-methyl at 300 ppm. However, this recommendation works for seeds that are being stored for planting only. Fumigation with phosphine and other alternatives could also control insect pests in modern storage facilities.

2.17. ECONOMICS OF PRODUCTION AND MARKETING

The annual production of the Sudan amounts to 13.5% of the total world production and about 50% of the African production (khirdir, 1997). The total area of production varies from one year to another, mainly due to fluctuations of rainfall, cultural practices, cultivars and prices ((Khirdir, 1997). Sesame seed is a high-value cash crop. Prices have ranged between US$800 and 1700 per metric ton between 2008 and 2010 (Khirdir, 1991).

Sesame exports sell across a wide price range. Quality perception, particularly how the seed looks, is a major pricing factor. Most importers who supply ingredient distributors and oil processors only want to purchase scientifically treated, properly cleaned, washed, dried, colour-sorted, size-graded, and impurity-free seeds with a guaranteed minimum oil content packed according to international standards. Seeds that do not meet these quality standards are considered unfit for export and are consumed locally. In 2008, by volume, premium prices, and quality, the largest exporter was India, followed by Ethiopia and Myanmar (Hansen, 2011). Though the market for sesame seed is strong, domestic production awaits the development of high-yielding non-shattering varieties. It is advisable to establish a market before planting

CHAPTER 3

MATERIALS AND METHOD

3.1. EXPERIMENTAL SITE

The experiment was conducted at the Post Graduate teaching and research farm, Department of Crop Science and Technology, Federal University of Technology Owerri from 14th of April 2018 to14th of August 2018 on soil classified at Ultisols (Eshet, 1993). The site is geographically located between Longitude 7^{o} 12'E and Latitude 5^{0} 27' N of equator at an elevation of 91m above sea level in Owerri Rainforest zone. Meteorological data during crop growing period (2018) showing the Rainfall pattern, average Temperatures and Relative humidity was obtained from Federal Ministry of Aviation Meteorological Station Owerri, Imo State (Table 1).

3.2. SOURCES OF PLANTING MATERIAL

Improved varieties of sesame seeds were sourced from National Crop Research Institute (NCRI), Bagdegi, and Kogi State of Nigeria. They consisted of six cultivars of sesame (*Sesamum Indicum* L.): NCRIBEN O1M, NCRIBEN 02M, NCRIBEN 04E, NCRIBEN 05E and NCRIBEN E-8 respectively. Poultry droppings were sourced from the Department of Animal Science Technology, Federal University of Technology Owerri.

3.3. LAND PREPARATION / PLANTING

An area of land measuring 23.9 m x 13.2 m (315.48m^{2}) were cleared manually using machete and rake and trash packed away for field establishment. Mapping was done with 50m measuring tape, ranging poles, ropes and pegs. Minimum tillage was done and land area was divided into three (3) replications. Each replication consisted of six (6) plots of size2.4m x 2.4m (m^{2}). There were 2.4m pathways between replications and 1.5m between plots.

Planting was carried out on 14th of April as early season planting; 14th of June (mid-season planting); 14th ofk8 August (late season planting) at different locations. Planting distance was at done at 30cm within rows and 60cm between rows at the rate of three (3) seeds per stand during each planting season. Seedling were thinned to one plant per hole at 2 weeks after planting (2 WAP), leaving a population of 32 plants per plot and 55,555 plants per ha.

3.4. EXPERIMENTAL DESIGN/ TREATMENT ALLOCATION

Design of the experiment was a 3x 6 factorial laid out in Randomized complete block design (RCBD) with 3 replications. Factor A comprised of the planting dates (14th of April, 14th of June and14th of August) while factor B comprised of 6 cultivars of Sesame namely: (NCRIBEN O1M, NCRIBEN 02M, NCRIBEN 04E, NCRIBEN 05E and NCRIBEN E-8). The six (6) cultivars were allocated at random to each plot and replicated three (3) times during each planting period, giving a total of eighteen (18) treatment combinations.

Data from the research work was collected on both growth and yield parameters.

3.5. MORPHOLOGICAL PARAMETERS

After seeds were sown, plant went through 3 phases of growth –vegetative phase, flowering phase and capsule phase (see Plates 3a, 3b and 3c). Data were collected and analyzed from the following growth parameters:

1. **Days to Emergence:** The number of days it took sown seeds to emerge.
2. **Germination percentage (%)**: The number of plants that emerged in each plot divided by the total number of seeds sown, multiplied by 100 i.e.

$$\frac{\text{Number of emerged plant}}{\text{Total number of seeds sown}} \times \frac{100}{1}$$

3. **Days to flower bud initiation:** The number of days it took the plants from planting to form flower buds were counted and recorded.

4. **Days to flower opening / Anthersis:** The number of days it took the plants from planting to flower buds opening were counted and recorded.

5. **Days to capsule initiation:** The number of days it took the plants from planting for the first capsule to appear were counted and recorded.

6. **Days to 50% flower opening:** The number of days it took the plants from planting for 50% of the plants to flower were counted and recorded.

7. **Days to 50% capsule formation:** The number of days it took the plants from planting for 50% of the capsule to appear were counted and recorded.

8. **Days to 100% maturity:** The number of days it took the plants from planting for 100% of the plants to mature were counted and recorded.

9. **Plant height at maturity:** Distance from the base of the plant to the point of last leaf at maturity.

3.6. INSECT SAMPLING

Ten plants (i.e. 5 plants per row) from the outer rows were observed during vegetative, flowering and capsule phases and insect visually seen on them during each phase were counted during the early hours of the day between 6;30 and 7:00 am when the insects were still less mobile. While counting, the insects were subsequently collected with sweep nets, preserved with 95% ethyl acetate and later identified using samples from the Department of Crop Science and Technology Laboratory. The identified samples were later confirmed from the insect museum at Ahmed Bello University (ABU), Zaria.

3.7. YIELD PAREMETERS

At crop maturity, capsules from the two inner rows were harvested. As the crop was harvested during the rains, they were oven dried at 40 ^{0}C for one week and thereafter hand threshed and winnowed. The capsules and seed yield were weighed using a sensitive top loading balance (Ohams model: AV13, capacity 410g) at the Laboratory Department of Crop Science and Technology, Federal University of Technology, Owerri.

1. **Capsule yield** (**kgha^{-1}**): This was obtained by weighing harvested capsules from the two middle rows of each plot, and there after converted to kg/ha.
2. **Capsule yield / plot (g**): This was obtained by getting the overall weight of the harvested capsules from each plot.
3. **Capsule yield / plant** (**g**): This was obtained by recording the weight (g) of harvested capsules from each plant in a plot.
4. **Seed yield** (**kg ha^{-1}**): This was obtained by weighing seeds from harvested capsules in the two middle rows of each plot after threshing, and later converted to kg/ha.
5. **Seed yield /plot** (g): This was obtained by getting the overall weight of seeds from the harvested capsules from each plot after threshing.
6. **Seed yield / plant** (g): This was obtained by recording the weight (g) of seeds from harvested capsules from each plant in a plot after threshing.
7. **Thrash yield (kg ha $^{-1}$):** This was obtained by weighing thrash from capsules harvested from two middle rows of each plot after threshing, and later converted to kg/ha.
8. **Thrash yield/ plot (g):** This was obtained by getting the overall weight of thrash from the harvested capsules from each plot after threshing.

9. **Yield/ plant (g):** This was obtained by recording the weight (g) of thrash from harvested capsules from each plant in a plot after threshing.

10. **Damage/ plot and percentage damage (%):** Damage was recorded by sampling ten plants from the two inner rows of the plot. The number of damaged capsules per plot were counted and recorded. These pests feed on leaves and shoots, suck sap from seeds, boring holes on capsules thereby transmitting diseases to plants (Plates 2a-2r). They serve as vectors for disease transmission resulting in leaf spots, leaf and shoot deformation / defoliation of leaves and flowers, powdering mildew on leaves, wilting and yellowing of leaves e.t.c (Plates 4a-4f).

    Capsules infected by disease were assessed by a plant pathologist and damage percentage was recorded by dividing the total capsule damage per plot by the total number of capsules per plot multiplied by 100

Example -

$$\frac{\text{Number of damaged capsules per plot}}{\text{Total number of capsules per plot}} \times \frac{100}{1}$$

3.8. CULTURAL PRACTICES

Poultry droppings (9.5 kg per plot) were incorporated into the soil before planting for soil amendment and to boost its soil fertility. Weeding was also done at 2-3 weekly intervals using hoe to keep the field weed free and avoid weeds that might habour insect pests.

3.9. STATISTICAL ANALYSIS

Data collected were subjected to analysis of variance using Genstat edition, (2017). Data on insect count and damage were first subjected to square root transformation to ensure uniformity of data, before analysis of variance was carried out. Significantly different means were separated using Fishers Least Significant Difference at 5 % probability level (Gomez and Gomez, 1984).

CHAPTER 4

RESULT

Table1**.0 shows** the monthly climatic conditions prevalent during the 2018 planting period in Owerri Imo State. Rainfall pattern was lower in April planting, it increased gradually from April, reached peak at July. It slightly reduced in August compared to its level in July, and rose again in October and there after maintained a very low rainfall till end of year. Temperature and Relative humidity increased in June with peak flow recorded in July. They got reduced in August and September but rose again in October.

4.1. POPULATION DYNAMICS OF MAJOR PESTS OF SESAME AT VEGETATION PHASE.

Fig.1. shows the population dynamics of Brown grasshopper (*Cantantops erubescens)* on planting dates of Sesame cultivars in Owerri Rainforest zone. Sesame cultivar recorded higher population of Brown Grasshopper on Majigida at 14, 21 and 28 DAP respectively. Lowest population of brown grasshopper was recorded on NCRIBEN 05E at 21 with small increase at 28 DAP and reached zero population at 35DAP. April planting showed highest population of Brown Grasshopper at 14 and 28 DAP while lower population was recorded on August planting (Fig 1b).

Fig.2a shows that NCRIBEN04E had the highest population of bean fly at 28 DAP while lowest significant population of bean fly was shown with Majigida at 14 DAP; NCRIBEN at 28DAP and 35 DAP. With respect to planting dates, the highest population of bean fly was recorded on April at 28, through 35 DAP followed by June planting at 28 DAP, while August planting had zero population of the bean fly (Fig 2b).

Fig.3a shows that Population of Brown foliage beetle was high on Majigida which fluctuates from 14 DAP till 35 DAP while lower significant (P<0.05) population was seen with NCRIBEN 01M at 35 DAP.

Planting dates showed very high population of brown beetle on June planting at 14 DAP and 35 DAP while lower population was noticed on August planting at 14DAP and 28 DAP which later increased at 35 DAP. Brown beetle was not seen in April planting (Fig. 3b)

Fig 4a. Shows the population dynamics of Black Anton planting dates of Sesame (*Sesamum indicum* L.) cultivars. Black thrips population was high with NCRIBEN 02M at 21 DAP, It was low at 14 DAP, increases to maximum at 21 DAP and dropped again at 35 DAP. The lowest population of black ant was seen with NCRIBEN 05E at 14 DAP.14thof June planting had the highest population of brown ant, both at 14 DAP and 21 DAP which later dropped at 35 DAP. Least population was noticed on14thof August planting at 21 DAP (Fig. 4b).

Fig. 5a shows the population dynamics of Green Grasshopper (*krausaria angulifera*) on planting dates of Sesame (*Sesamum indicum* L.) cultivars at vegetative level. Highest population of Green Grasshopper was shown with NCRIBEN E-8, NCRIBEN 01M and NCRIBEN 05E at 14DAP, and 28 DAP respectively. NCRIBEN E-8 was high at 14 DAP and later dropped at 21DAP. NCRIBEN 01M was high at 14 DAP, decreased at 21 DAP increased again at 28 DAP and dropped at 35DAP. However, NCRIBEN 05E was moderate at 14 DAP dropped at 21 DAP but rose to its maximum at 28 DAP. Lower population of Green grasshopper was noticed at NCRIBEN 05E and NCRIBEN 04E at 14DAP and 21 DAP respectively. Planting dates showed higher population of Green grasshopper on April planting at 14 DAP which dropped to the minimum at 21 DAP but rose to an average at 28 DAP and dropped at 35DAP while August had a lower population of Green Grasshopper at 21 DAP and 28 DAP respectively (Fig 5b).

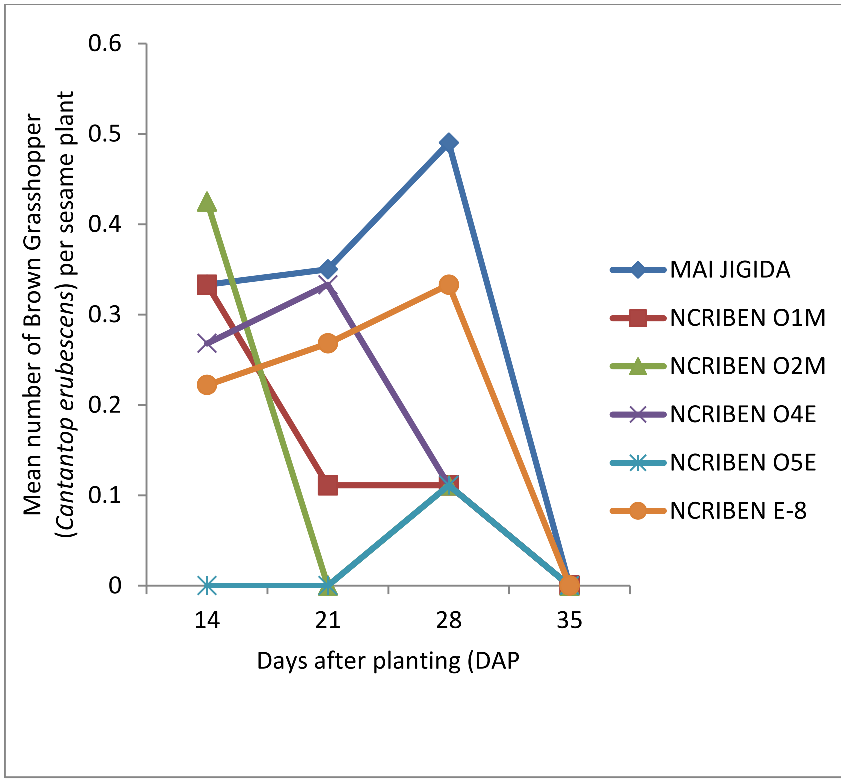
Population of Fruit/stem flies was higher with Majigida at 28 DAP compared with other cultivar (Fig 6a). The lowest population of Tachnid flies was seen with NCRIBEN 01M and NCRIBEN E-8 at 14DAP, 21DAP, 28DAP and 35 DAP respectively. NCRIBEN E-8 maintained its population throughout the vegetative period. The lowest population of Tachnid flies was during the1April planting at 21DAP followed with the fluctuation of pest from 14DAP, through 35DAPduring the planting season while June planting season maintained steady increase from 21DAP and reached peak population at28 DAP.(fig 6b).

Fig 7a. Shows the population dynamics of Variegated Grasshopper (*Zonocerus variegatus)* on planting dates of Sesame cultivars at vegetative level. Population of variegated grasshopper was high with NCRIBEN 04E, NCRIBEN 05E and Maijigida at 14DAP, 21 DAP, 35DAP respectively. NCRIBEN 04E was low at 14DAP rose to the maximum at 21 DAP, and decreased again at 35 DAP. NCRIBEN 05E dropped from a maximum at 14 DAP to a minimum population at 21 DAP. Majigida continued from the point where NCRIBEN 04E Stopped at 21 DAP and increased to a maximum at 35 DAP. The lowest population of variegated grasshopper was noticed at 21 DAP with NCRIBEN E-8 and 35DAP with NCRIBEN 01M. Fig 7b showed high population of variegated grasshopper on14th of April planting which was initially high at 14 DAP, it dropped to a minimum at 21 DAP and rose to the maximum population at 35 DAP. This was followed by June planting while August planting had no evidence of variegated grasshopper.

Fig. 8a shows the population dynamics of brown bug on planting dates of Sesame (*Sesamum indicum* L.) cultivars at vegetative level. NCRIBEN 05E had higher population of brown ant at 35 DAP compared to other cultivars. Lower population of brown ant was noticed with NCRIBEN 04E at 28DAP and 35 DAP; and with NCRIBEN 01M at 21DAP and 28 DAP. NCRIBEN 01M maintained an equal population at 21DAP and 28 DAP which later dropped at 35 DAP while NCRIBEN 04E was low at 21 DAP, and maintained an average population at 28DAP and 35 DAP. There was no evidence of brown ant at 14 DAP. 14th of April planting recorded higher population of brown ant at 35 DAP. It rose from 21 DAP, to an average at 28 DAP then to a maximum at 35 DAP. Lowest population was seen on June planting while August did not experience any activity of brown ant (Fig.8b).

Table 1.0 showing Meteorological Data of rainfall, temperature and Relative humidity For the year 2018

MONTH	RAINFALL DAYS	RAINFALL VOLUME	TEMPERATURE MAXIMUM	MINIMUM	RELATIUVE HUMIDITY
JANUARY	2	110	32	31	77
FEBRUARY	NIL	NIL	32	30	78
MARCH	4	312	32	30	76
APRIL	5	312	32	29	76
MAY	5	413	31	29	77
JUNE	9	437	32	29	76
JULY	11	511	32	29	78
AUGUST	8	359	30	29	76
SEPTEMBER	13	318	31	29	76
OCTOBER	14	510	31	30	76
NOVEMBER	9	429	32	31	78
DECEMBER	NIL	NIL	34	32	78



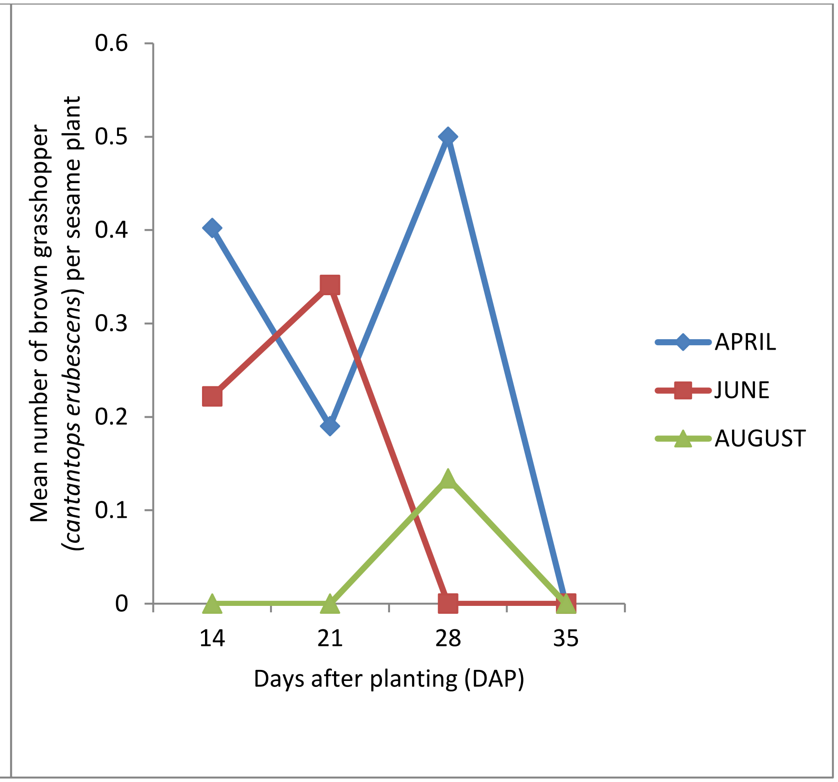


Fig 1a shows the mean population of Brown grasshopper on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

Fig 1b shows the mean population of Brown grasshopper on Planting dates of Sesame at vegetative stage in Owerri Rainforest zone

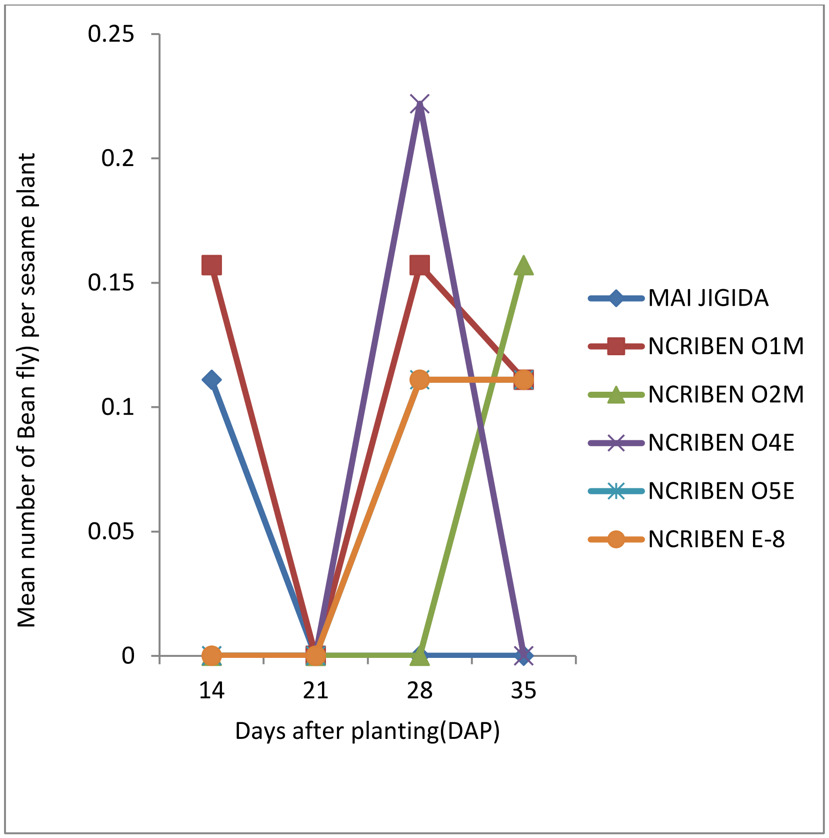


Fig 2a shows the mean population of Bean fly on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

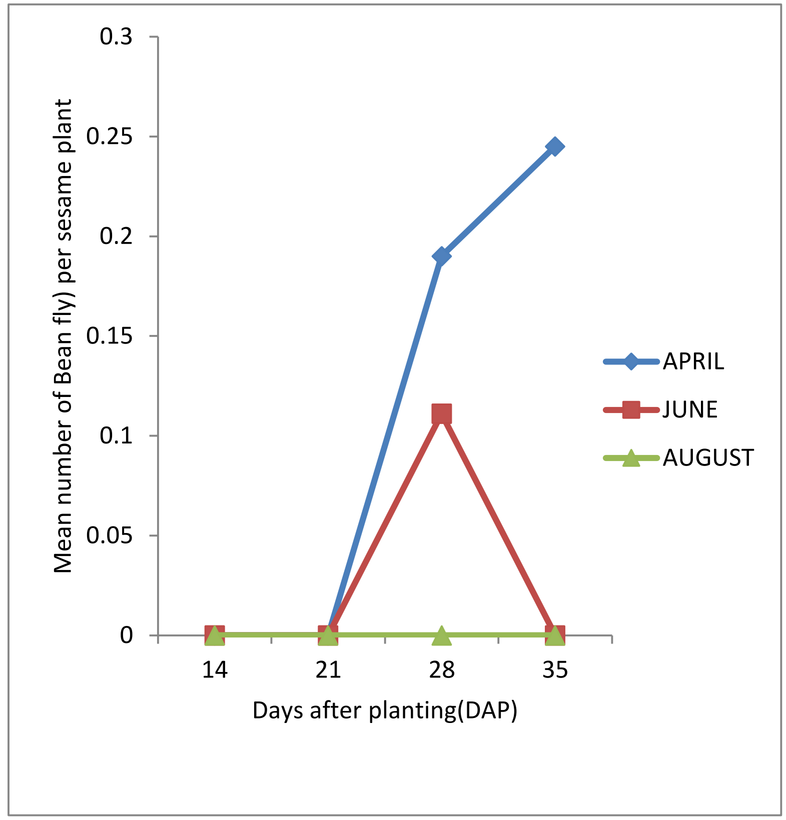


Fig 2b shows the mean population of Bean fly on planting dates of Sesame at vegetative stage in Owerri Rainforest zone

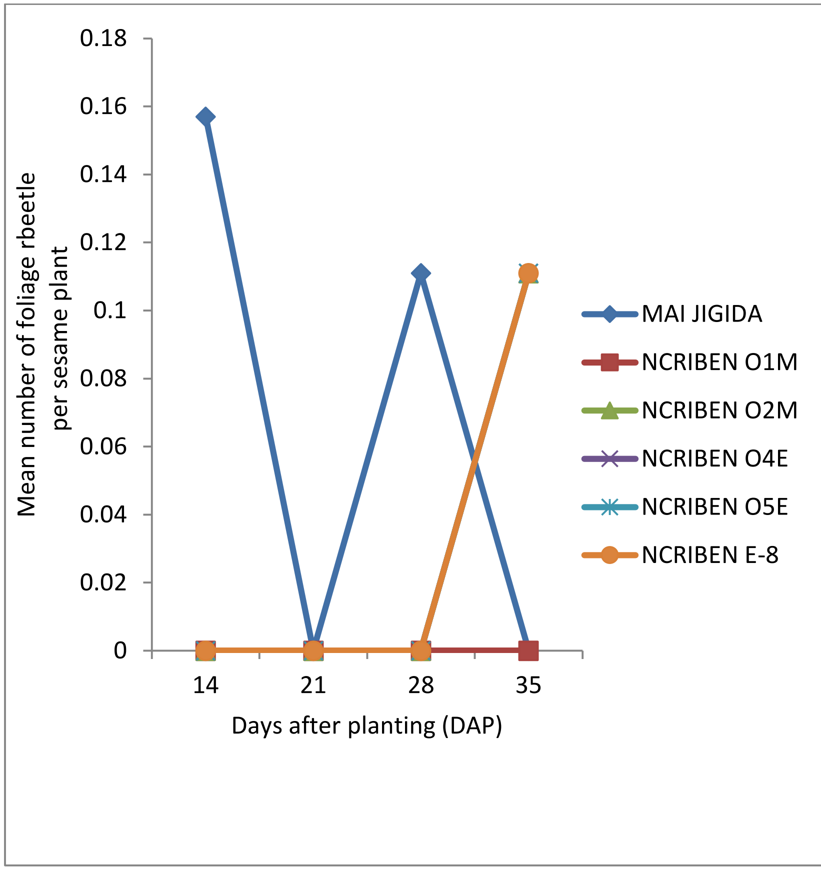


Fig 3a shows the mean population of foliage beetle on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

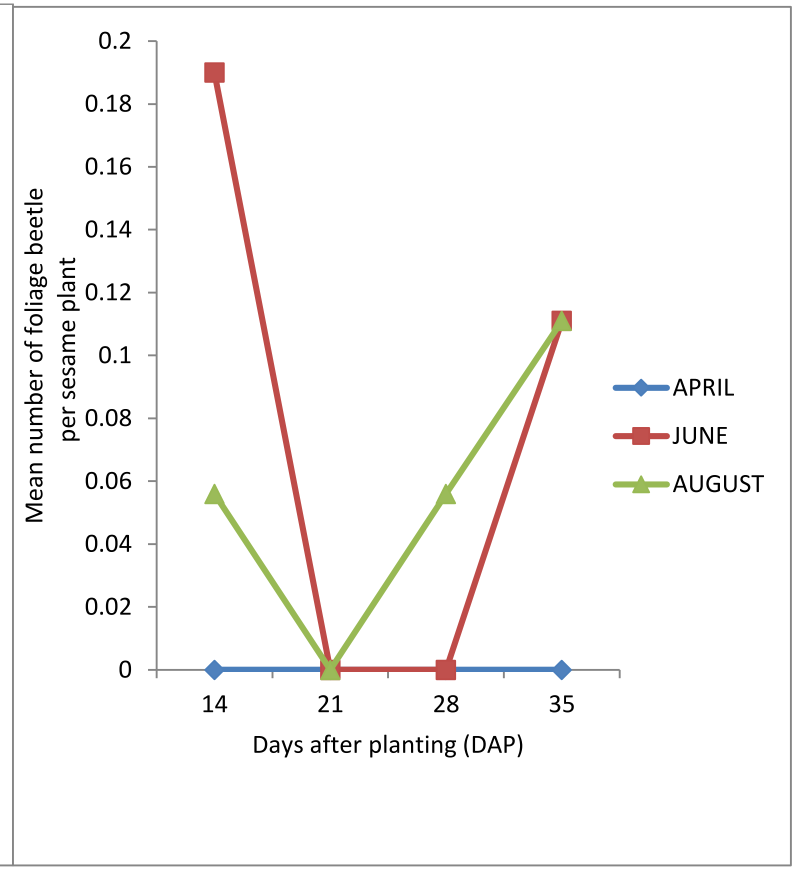


Fig 3b shows the mean population of foliage beetle on planting dates of Sesame at vegetative stage in owerri Rainforest zone

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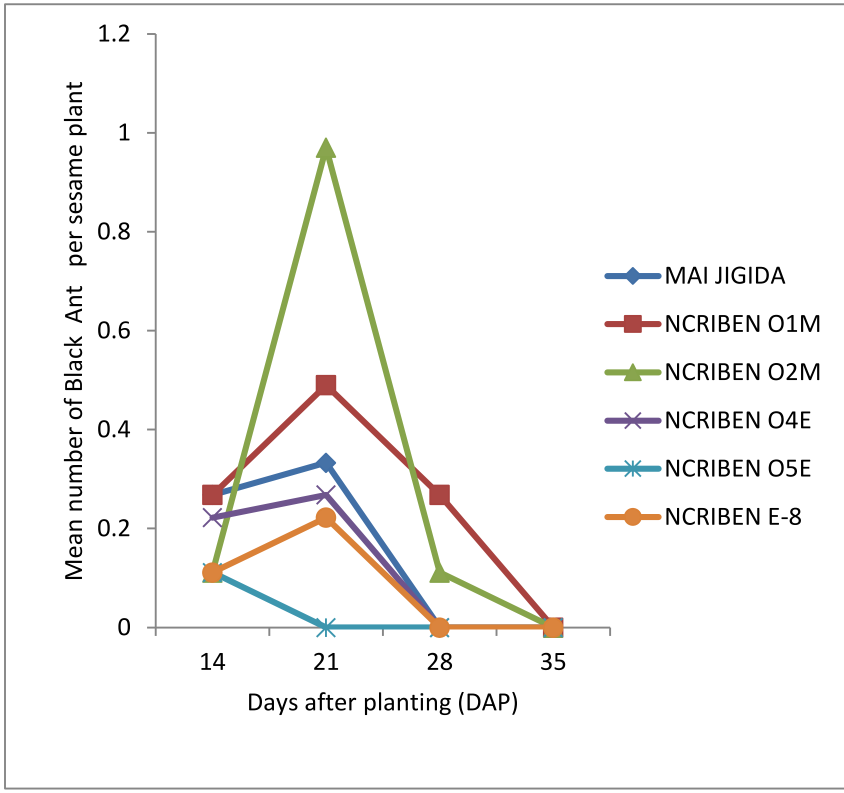


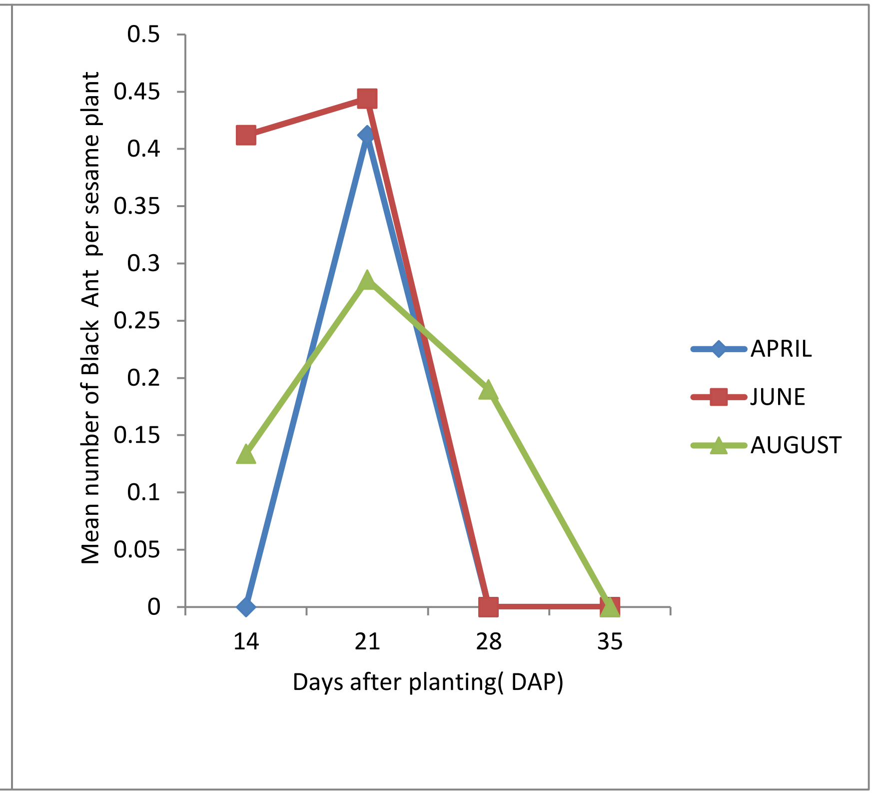
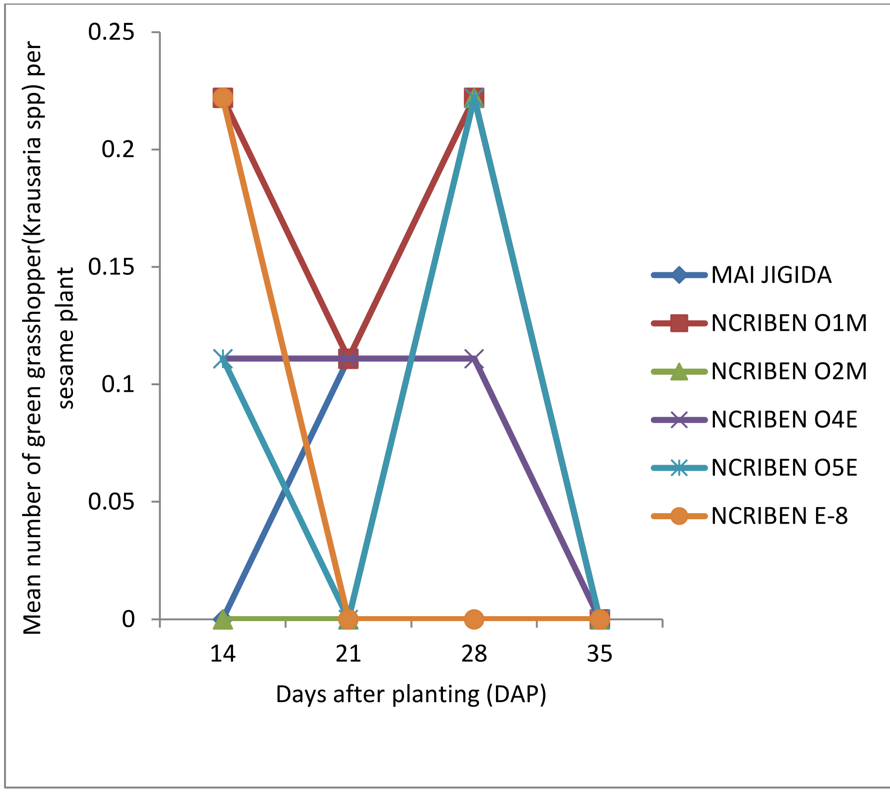


Fig 4a shows the mean population of Black ant on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

Fig 4b shows the mean population of Black Ant on planting dates of Sesame at vegetative stage in owerri Rainforest zone



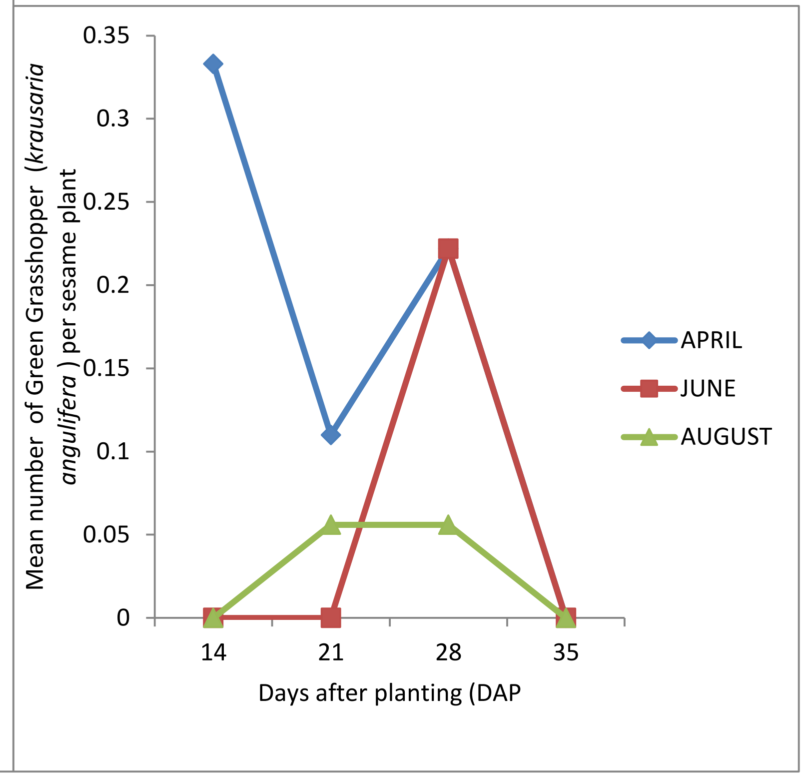
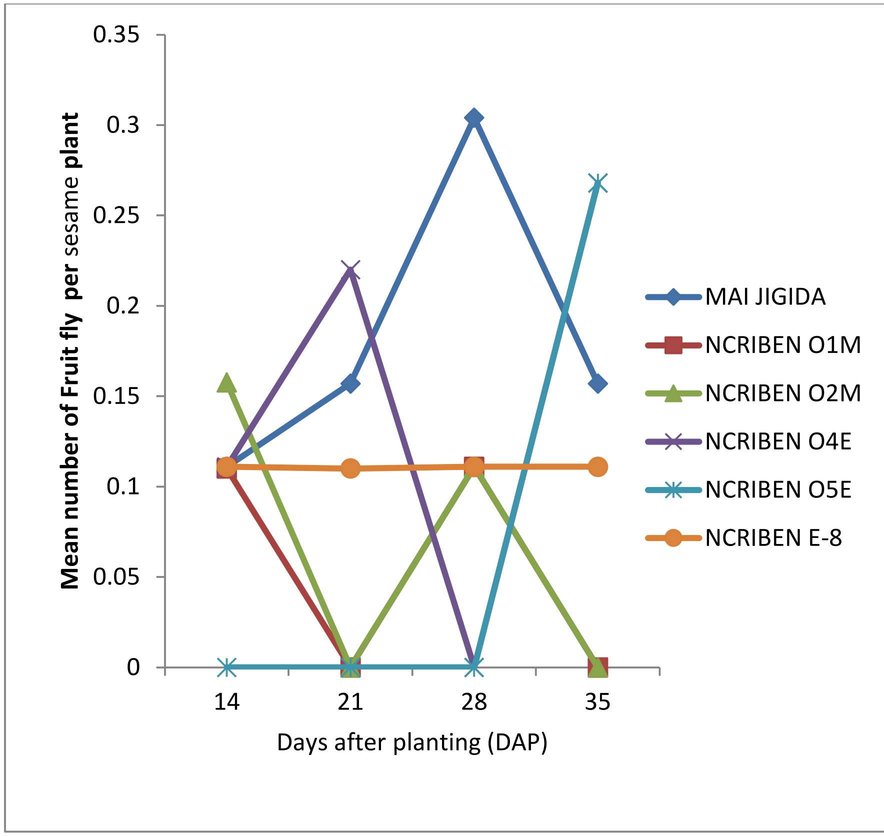


Fig 5a shows the mean population of Green grasshopper on Sesame cultivars at vegetative stage in Owerri Rainforest zone

Fig 5b shows the mean population of Green Grasshopper on planting dates of Sesame at vegetative stage in Owerri Rainforest zone



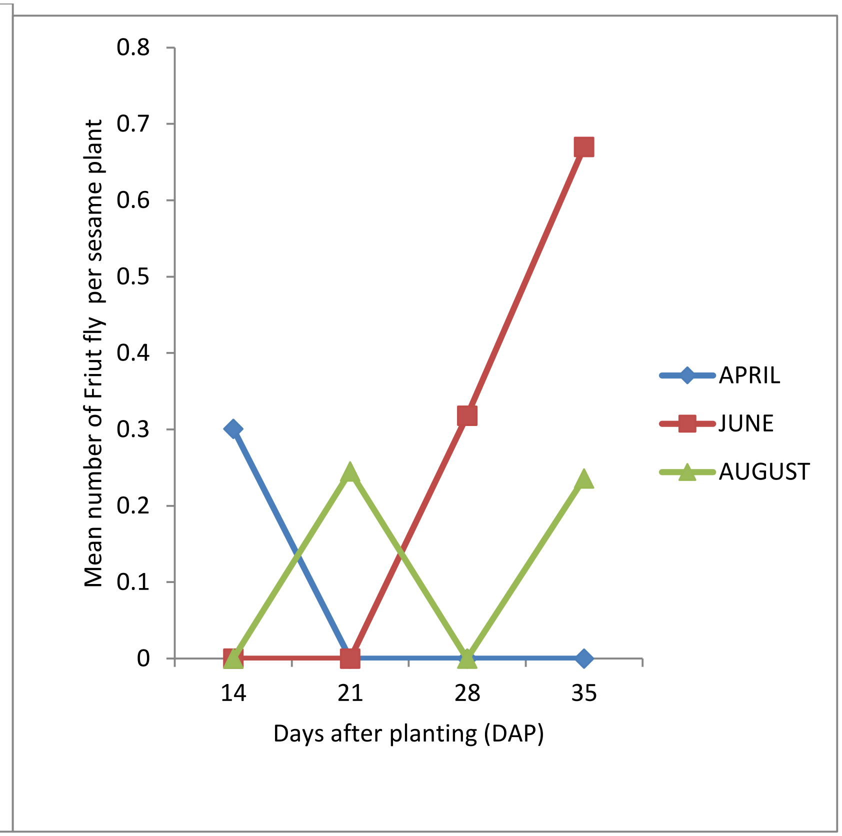
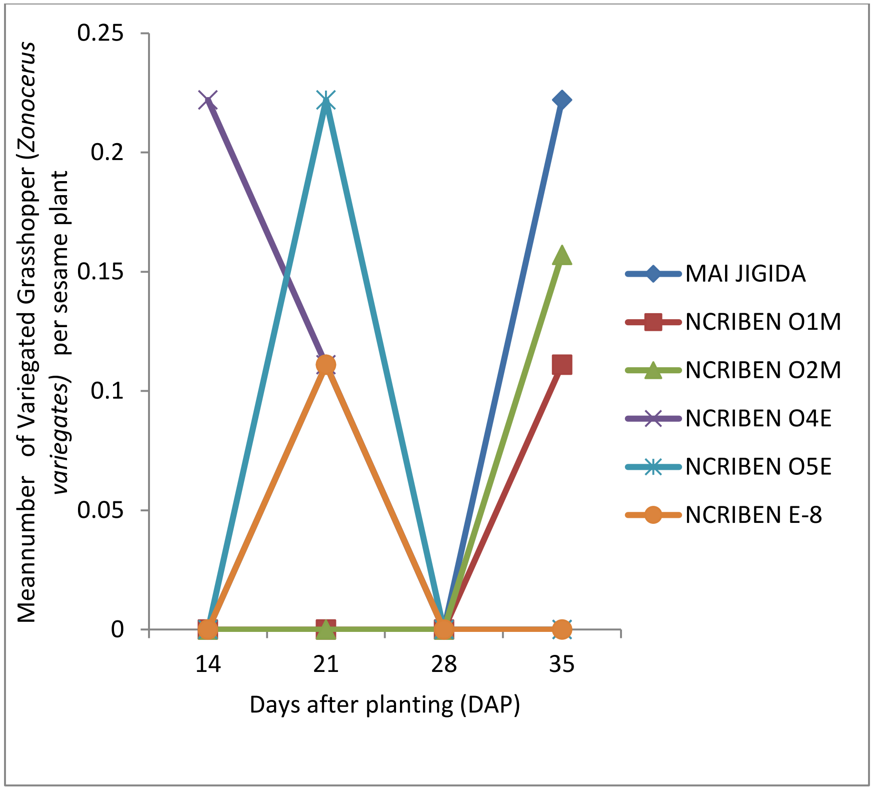


Fig 6a shows the mean population of fruit/ stem fly on Sesame planting cultivars at vegetative stage in Owerri Rainforest Zone.

Fig 6b shows the mean population Friut / stem fly on Sesame at vegetative stage in owerri Rainforest zone



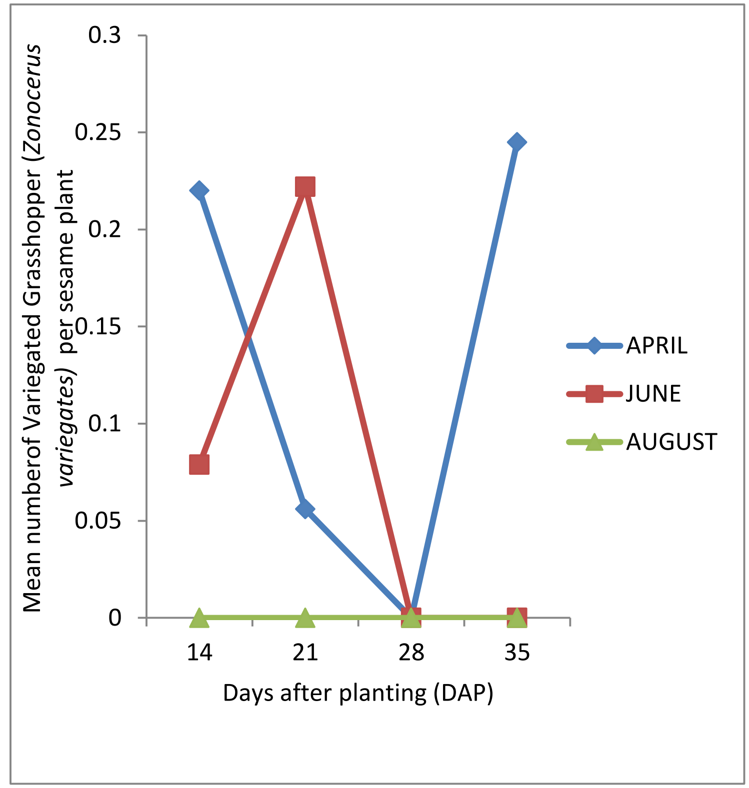
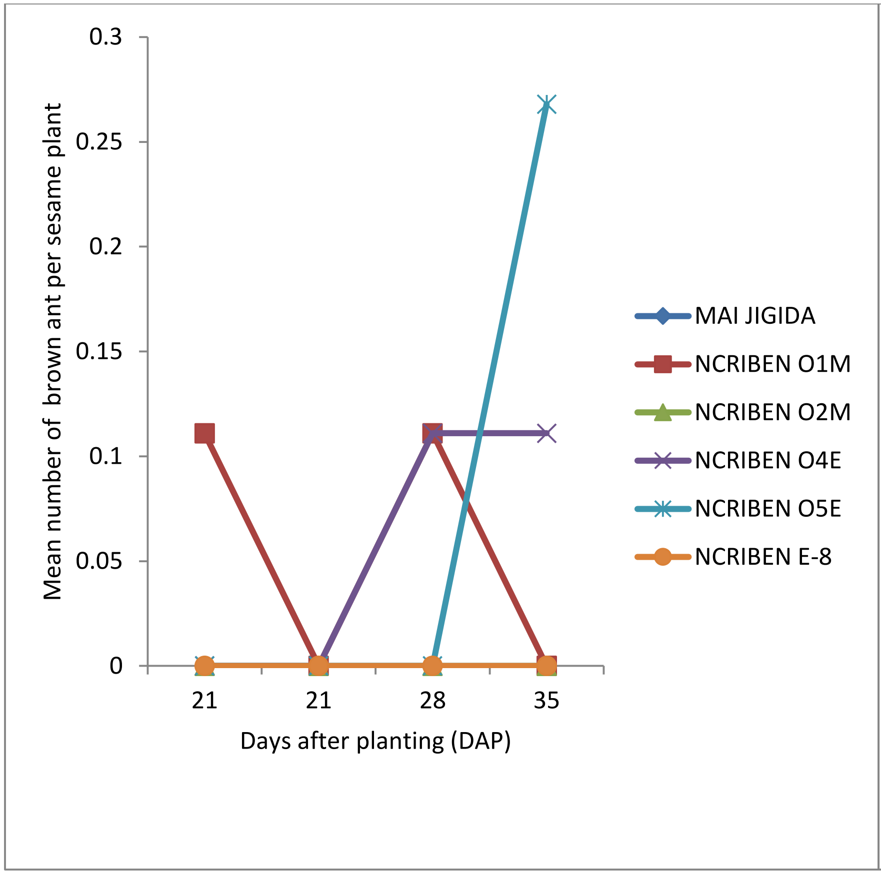


Fig 7a shows the mean population of Variegated grasshopper on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

Fig 7b shows the mean population of variegated grasshopper on planting dates of Sesame at vegetative stage in owerri Rainforest zone



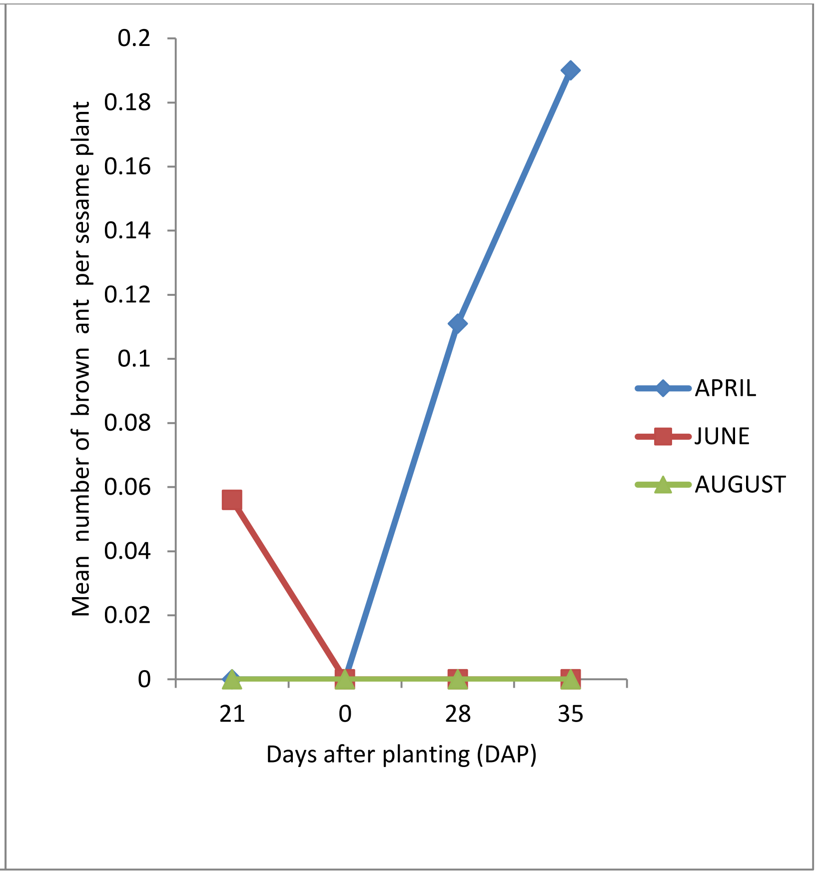


Fig 8a shows the mean population of Brown ant on Sesame cultivars at vegetative stage in Owerri Rainforest Zone.

Fig 8b shows the mean population of Brown ant on planting dates of Sesame at vegetative stage in owerri Rainforest zone

4.2 POPULATION DYNAMICS OF MAJOR INSECT PEST AT FLOWERING PHASE

Fig. 9 shows the population dynamics of Social bee on planting date of Sesame cultivars at flowering phase. Population of Social bee was higher with Maijigida at 63 DAP compared to other cultivars. Maijigida had average population of Social bee at 42 DAP which later increased at 49 DAP and 56 DAP, but rose to a maximum at 63 DAP. The lowest significant population of Social bee was found with NCRIBEN 05E which was low at 42 DAP, increased slightly at 49DAP, reduced to nothing at 56 DAP and increased again at 63 DAP. Planting date showed high population of Social bee on August planting at 63 DAP compared to other cultivars. It started at 56 DAP and continued increasing up to 63 DAP. April and June plantings experienced very low population of Social bee.

Fig.10a shows the population dynamics of Solitary bee on planting date of Sesame *(Sesamum indicum* L.) cultivars at flowering stage. NCRIBEN E-8 showed higher population of Solitary bee at 56 DAP compared to other cultivars. It was very insignificant at 42DAP, increased at 56DAP and decreased to its minimum at 63DAP. Lower population of Solitary bee was noticed in NCRIBEN 05E at 49DAP; NCRIBEN 02M at 42 DAP, and 63 DAP. June planting had the highest population of Solitary bee, than other plantings. It was low at 42DAP, increased to an average at 49 DAP, reduced slightly at 59DAP and rose to the maximum at 63DAP. August was lower in Solitary bee population but April had no sight of solitary bee (fig. 10b).

Fig.11a shows the population dynamics of Black ant on planting date of Sesame *(Sesamum indicum* L.)Cultivars at flowering level. NCRIBEN E-8 had the highest population of black ant at 63 DAP. It was high at 42 DAP, reduced slightly at 49 DAP, dropped drastically at 56 DAP and rose to the maximum 63 DAP. Lower population of black ant was noticed in NCRIBEN 02M at

49DAP and 56 DAP respectively. Planting was highly populated with brown ant on August at 42DAP which later reduced at 49 DAP and 56 DAP but rose again to an average population at 63 DAP. June planting had the lowest population of black ant.

Fig 12a shows the population dynamics of Black bee planting date of Sesame cultivars at flowering stage. NCRIBEN 01M had higher population of black bug and at 56 DAP. Population was high at 42 DAP, reduced drastically at49DAP and rose again to a maximum at 56DAP and reduced slightly at 63DAP. Lower population was found in NCRIBEN 05E at 42 DAP and 49DAP respectively. April planting had higher population of black bug at 42DAP, it reduced to minimum at 49 DAP and rose again at 56DAP and 63DAP. June was moderately populated but there was no sight of brown bug on August planting.

Fig.13a shows the population dynamics of Bean fly *(Ophiomyia spp)* on planting date of Sesame cultivars *(Sesamum indicum* L.) at flowering stage. NCRIBEN 02M recorded the highest population of black fly at 42DAP compared to others, which later reduced at 49 DAP, Maintained its pace at 56DAP and again decreased at 63DAP. Lower population of black fly was noticed at 42DAP in NCRIBEN 04E. 14th of April planting was at its maximum at 42DAP, it reduced at 49DAP, increased again at 56DAP and reduced to zero at 63DAP. August was low in population while June had no bean fly population (Fig.13b).

Fig 14a shows the population dynamics of Blister beetle (Mylabris spp) on planting date of Sesame cultivars at flowering stage. Higher population of the pest was found in NCRIBEN 02M at 49DAP.Least population was noticed in NCRINEN 04E and NCRIBEN 05E respectively. Planting on June showed highest population of blister beetle but April was low populated while August did not experience activities of blister beetle (Fig 14b).

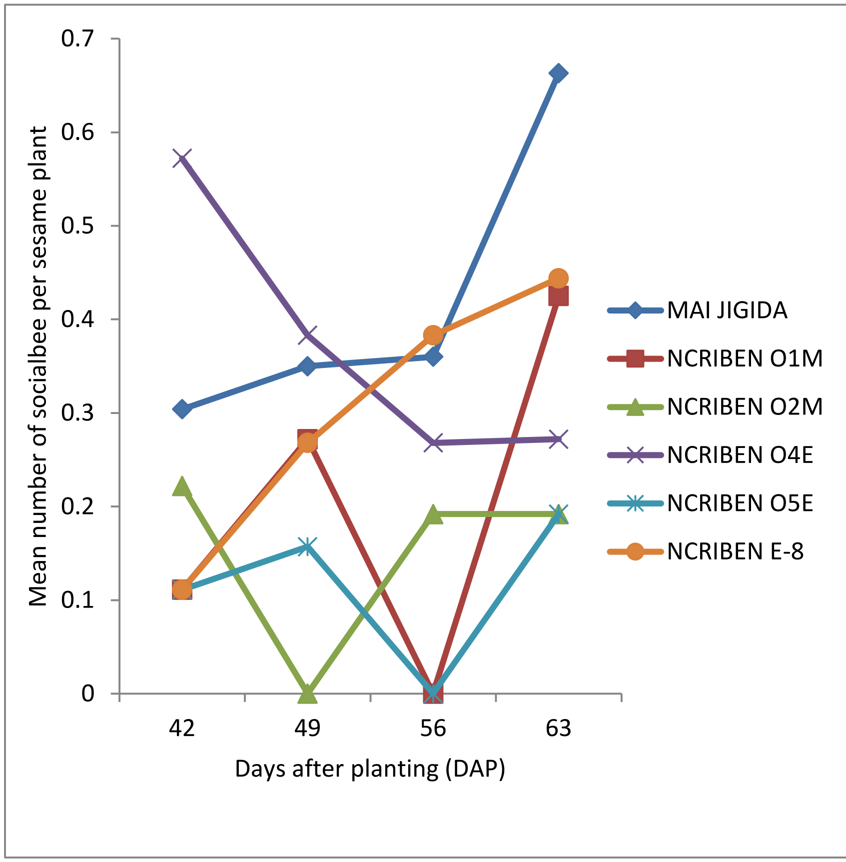


Fig 9a shows the mean population of social bee on Sesame cultivars at flowering stage in Owerri Rainforest Zone.

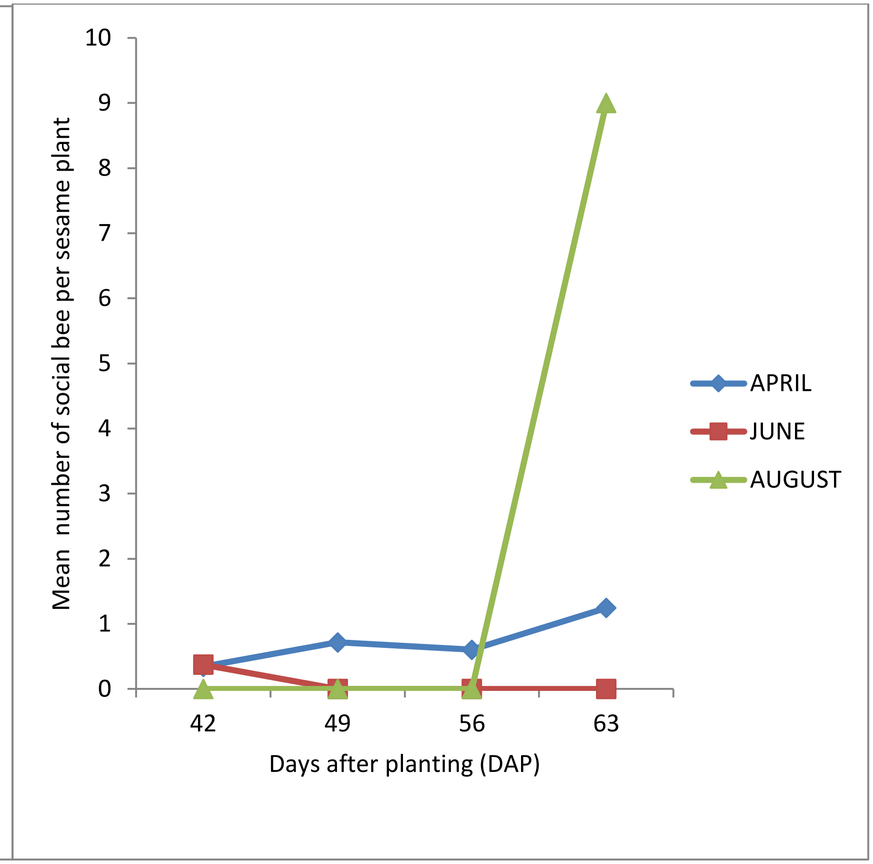
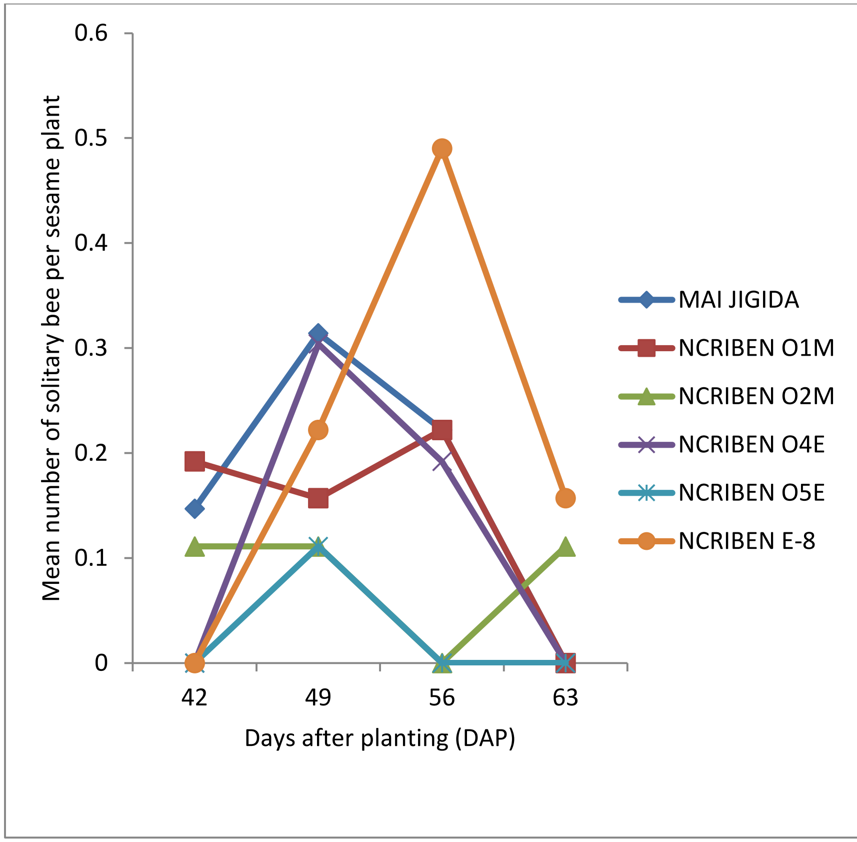


Fig 9b shows the mean population of social bee on planting dates Of Sesame at flowering stage in owerri Rainforest zone



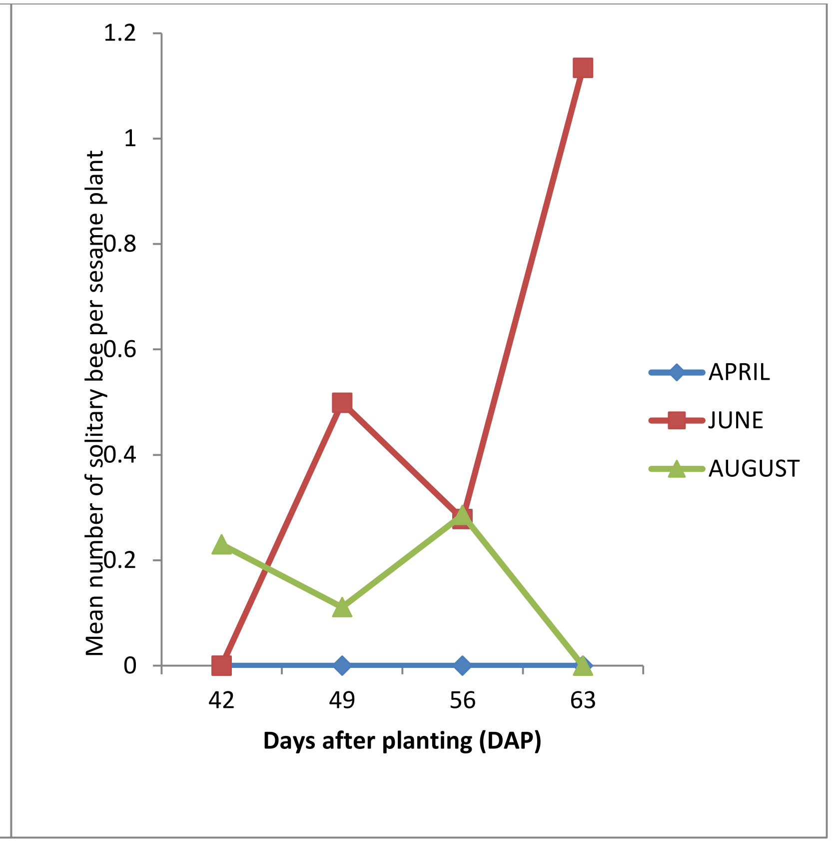


Fig 10a shows the mean population of solitary bee on Sesame cultivars at flowering stage in Owerri Rainforest Zone.

Fig 10b shows the mean population of solitary bee on planting dates of Sesame at flowering stage in owerri Rainforest zone

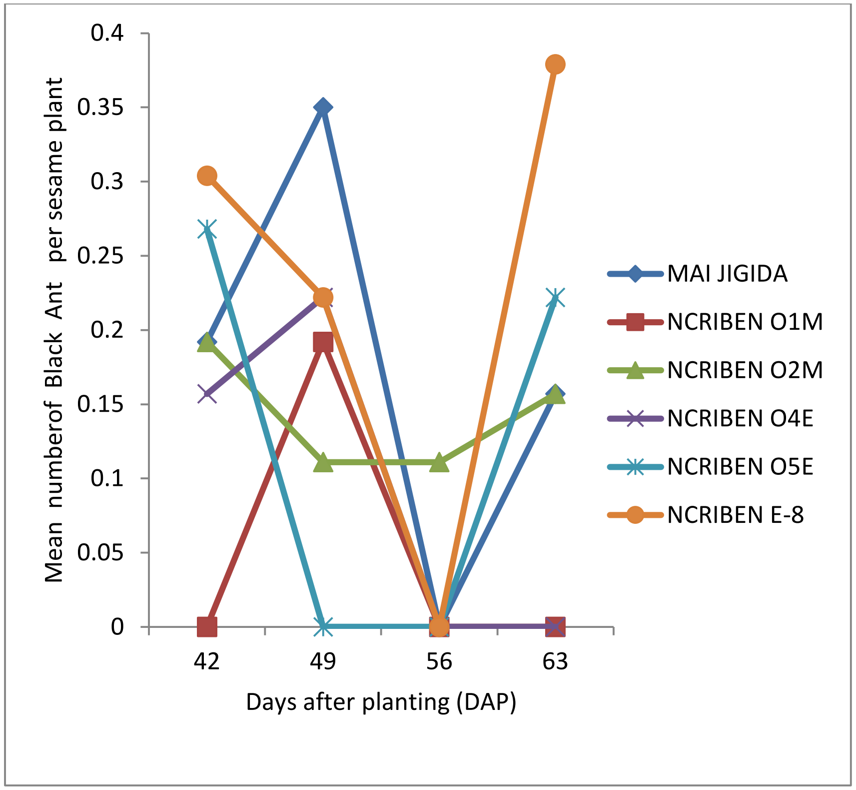


Fig 11a shows the mean population of Black ant on Sesame of cultivars at flowering stage in Owerri Rainforest Zone.

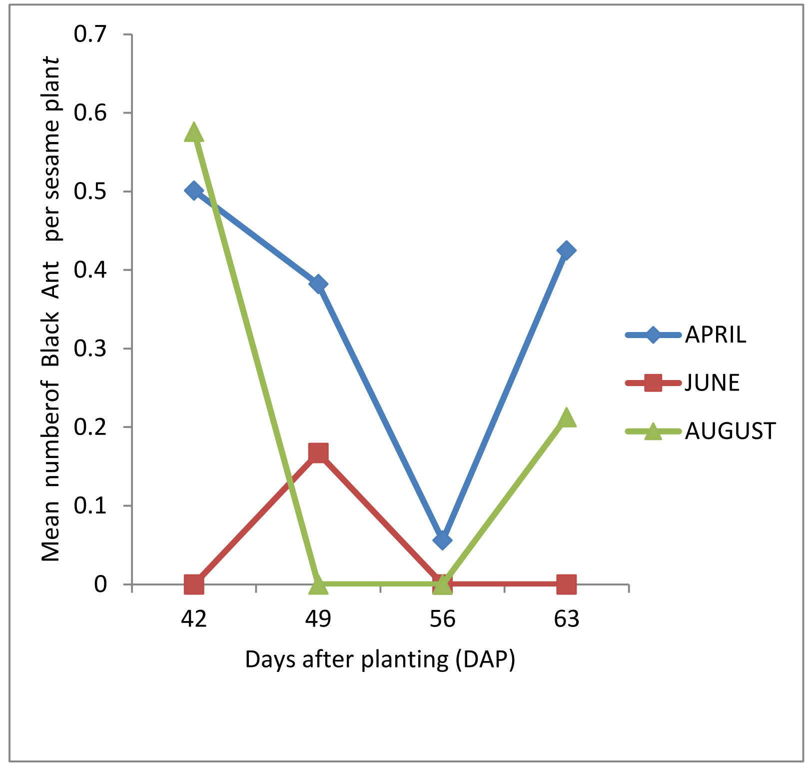


Fig 11b shows the mean population of Black Ant on planting dates Sesame at flowering stage in owerri Rainforest zone

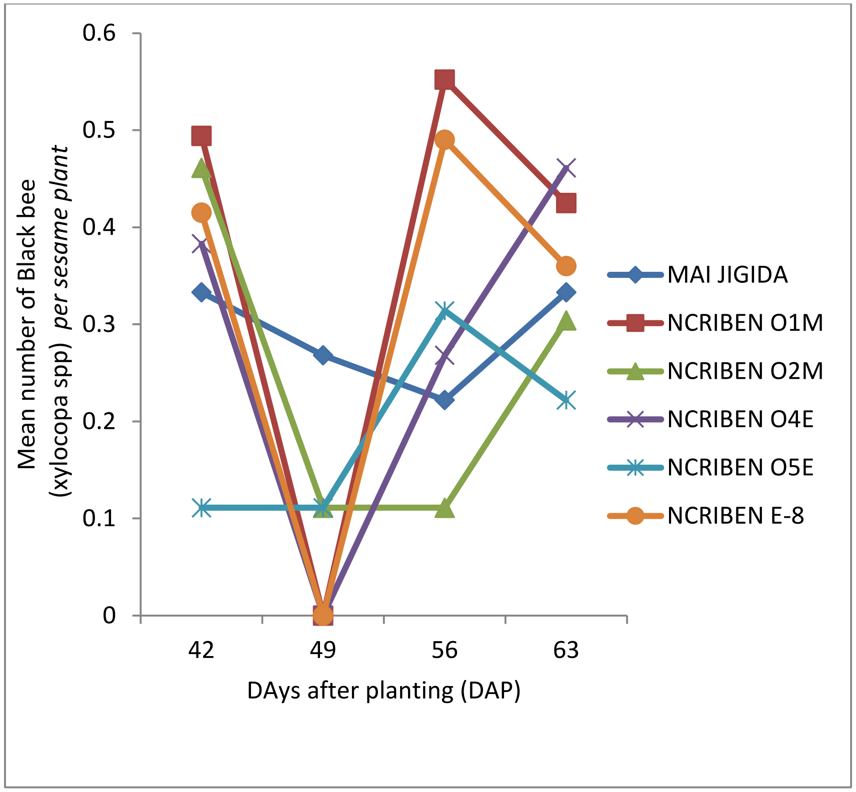


Fig 12a shows the mean population of Black bee on Sesame dates of cultivars at flowering stage in Owerri Rainforest Zone.

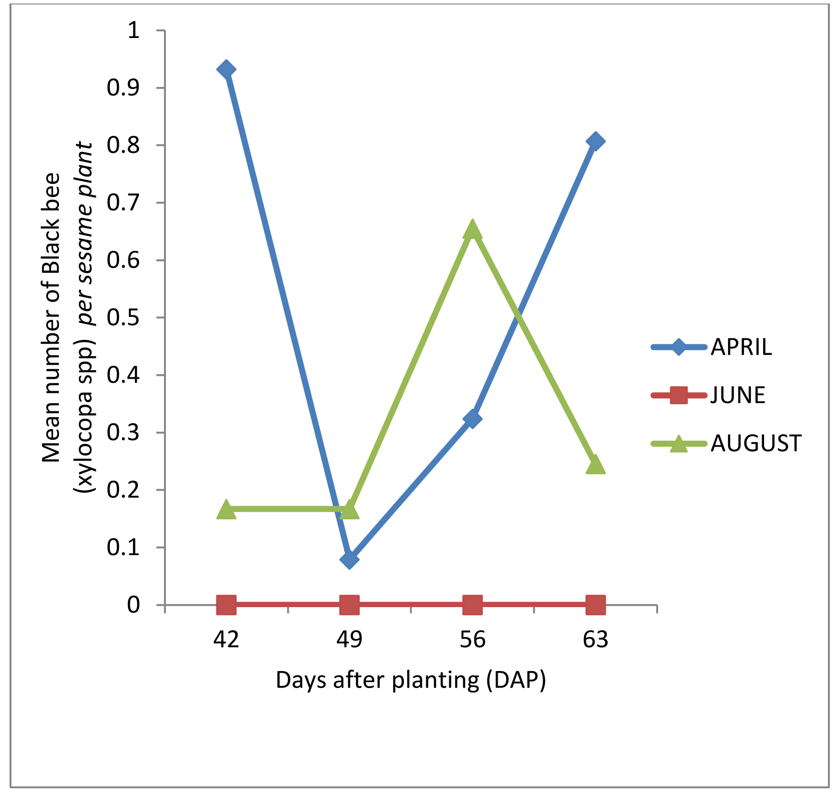


Fig 12b shows the mean population of Black bee on planting Sesame at flowering stage in owerri Rainforest zone

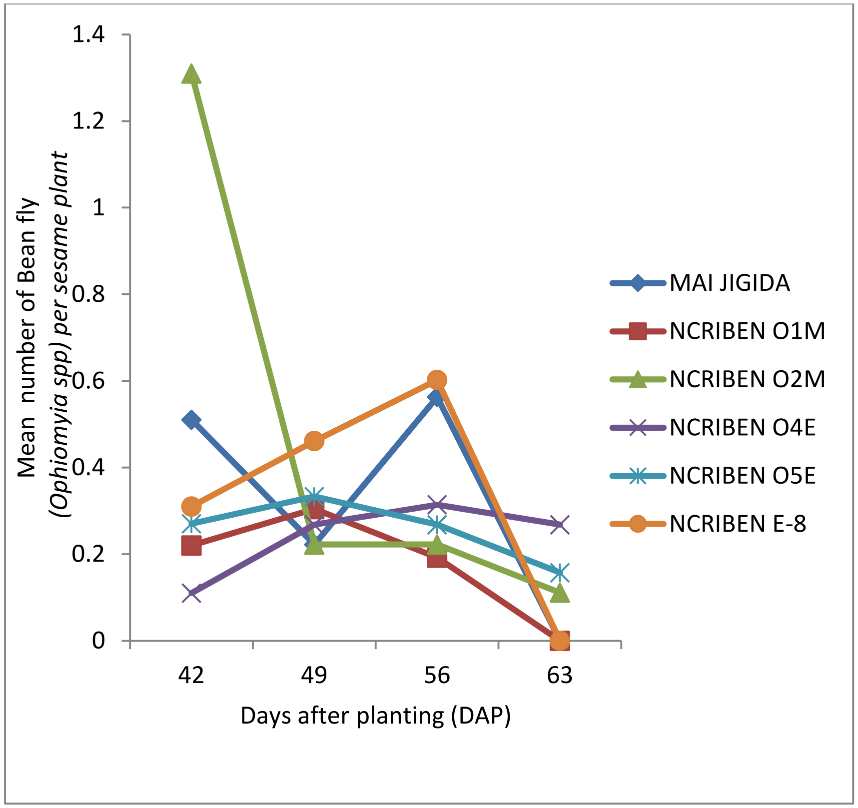


Fig 13a shows the mean population of Bean fly on Sesame cultivars at flowering stage in Owerri Rainforest Zone.

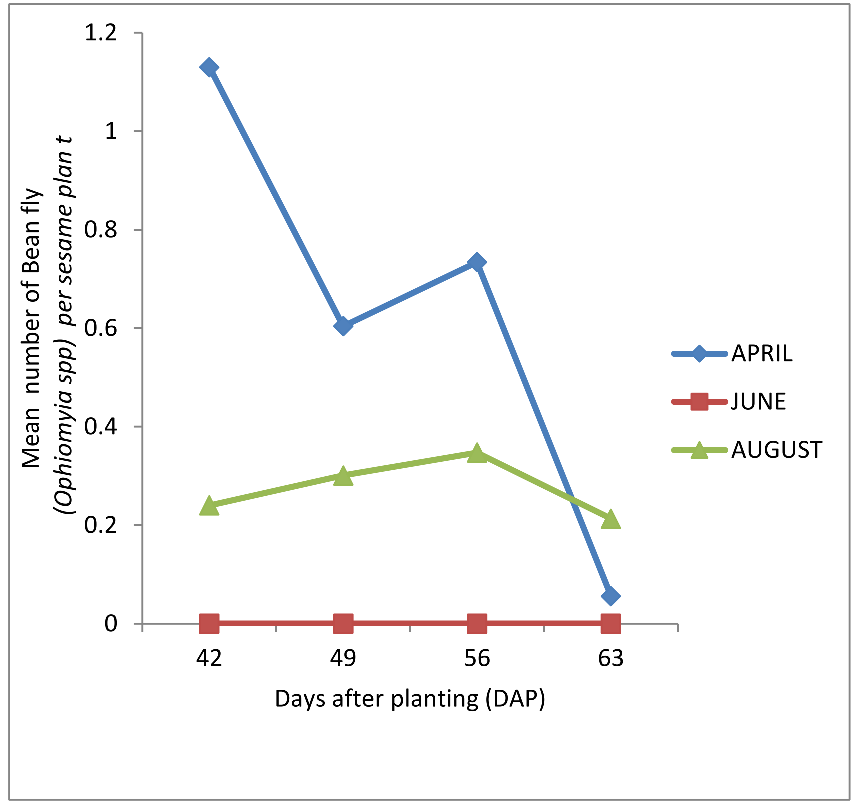
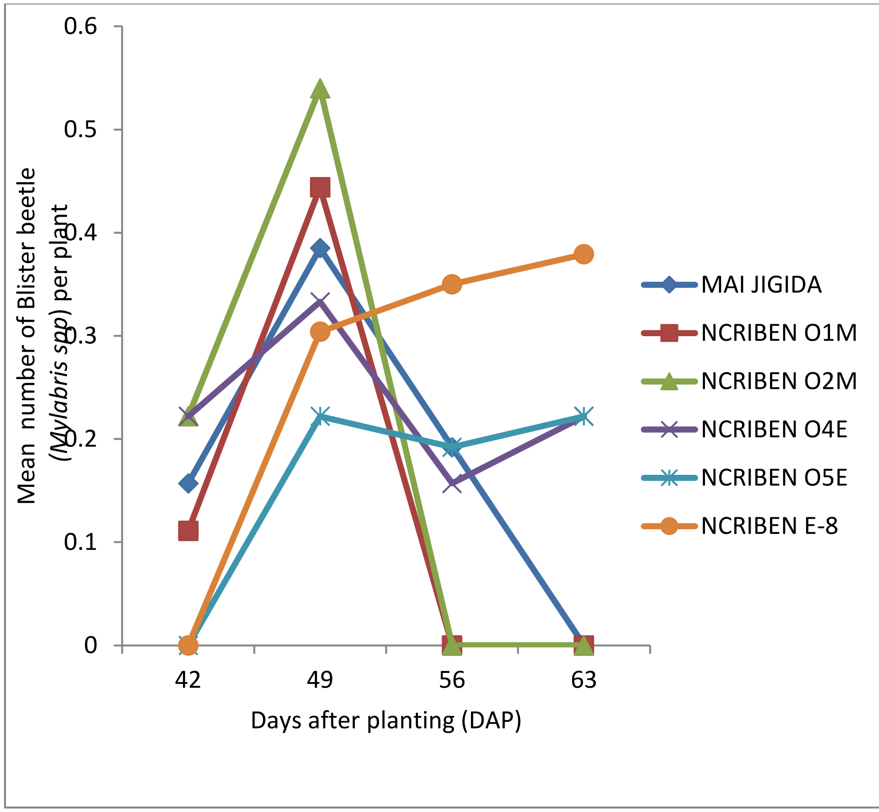


Fig 13b shows the mean population of Bean fly on planting dates of Sesame at flowering stage in owerri Rainforest zone



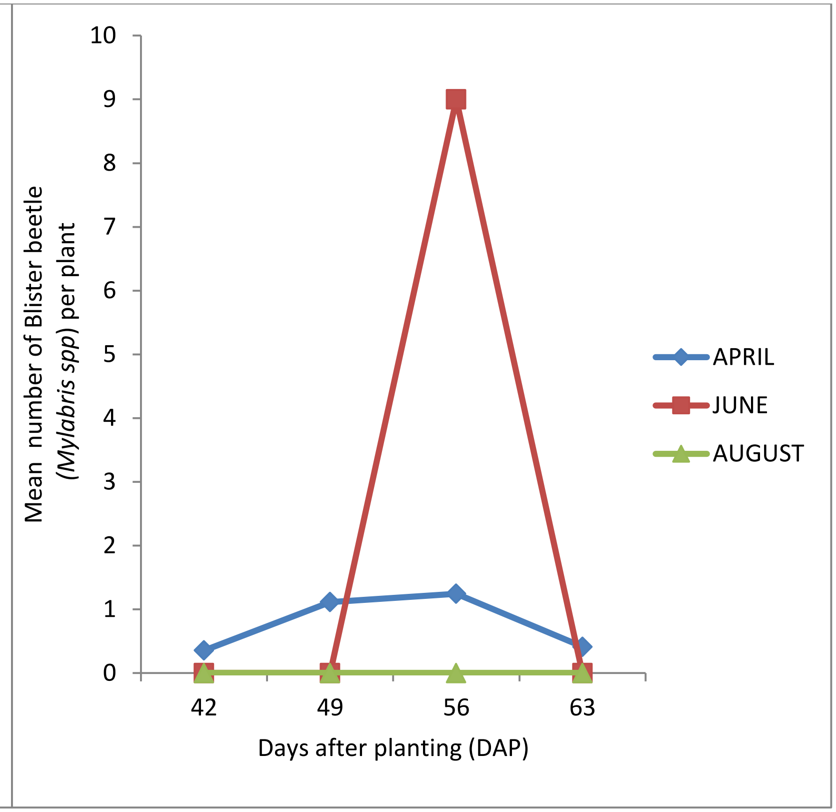


Fig 14a shows the mean population of Blister beetle on Sesame planting cultivars at flowering stage in Owerri Rainforest Zone.

Fig 14b shows the mean population of Blister beetle on dates of Sesame at flowering in owerri Rainforest zone

4.3. POPULATION DYNAMICS OF INSECTS PESTS OF SESAME AT CAPSULATION PHASE.

Fig 15a shows the population dynamics of Brown pod sucking bug on planting date of Sesame cultivars *(Sesamum indicum* L.) at capsulation stage in Owerri Rainforest zone. Brown bug was highly populated in Majigida at 77DAP compared to other cultivars which later reduced at 84DAP. Other cultivars were extremely low populated. Planting on August experienced highest population of brown bug at 70DAP compared to others, which later dropped to a minimum at 77DAP and continued to 91DAP.This is followed by June planting at 77 DAP which decreased at 84DAP and 91 DAP respectively. April maintained a minimum population throughout the capsulation period (Fig 15b).

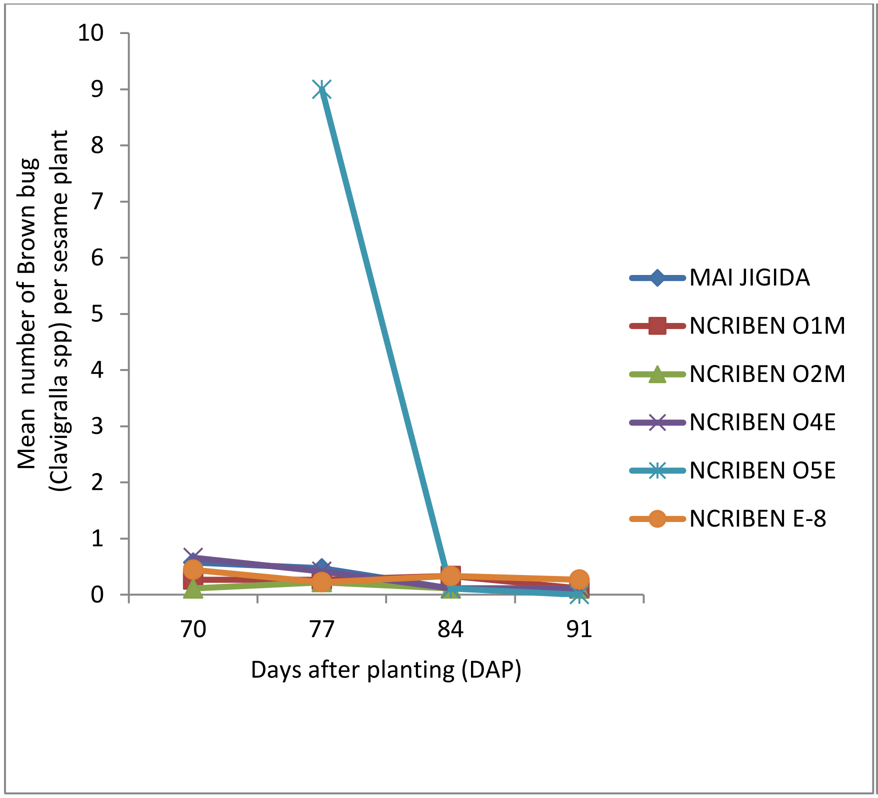
Fig.16a shows the population dynamics of Green stink bug (Nezera viridula) on planting date of Sesame cultivars *(Sesamum indicum* L.) at capsulation stage. Cultivar showed higher population of Green bug in NCRIBEN 04E; NCRIBEN 01M at 91DAP and NCRIBEN E-8 at 77DAP. NCRIBEN E-8 was low at 70DAP, attained maximum height at 77DAP, and decreased again at 91DAP. NCRIBEN 01M was low at 70DAP, increased to average population at 77DAP, maintained the pace to 84DAP and gained maximum population at 91DAP. Lower population of green bug was shown in Majigida at 84DAP. Planting dates showed higher population of green bug on June planting at 91DAP and August planting at 84 DAP. June was scarcely populated with green bug at 77DAP. It decreased to a minimum at 84DAP and rose to maximum population at 91DAP while August planting started low at 70DAP, rose to maximum at 84DAP and decreased again at 91DAP. Minimum population was found on April planting at 70DAP, 77DAP and 91DAP (Fig16b).

Fig. 17a shows the population dynamics of Orange-black pod sucking bug on planting date of Sesame cultivars *(Sesamum indicum* L.) at capsulation stage. NCRIBEN 04E was highly populated with orange-black bug at 91DAP, population was at minimum at 70DAP, it reduced at 77DAP and rose to maximum at 91DAP. Lower population was shown in Majigida, NCRIBEN E-8 at 77DAP, 84DAP and 91DAP respectively. Planting dates had higher population August. Population was low at 70DAP, increased at 77DAP and continued increasing at 84DAP and 91DAP respectively. Lowest significant population was shown on 14th of April at 70DAP, 84DAP and91 DAP respectively (Fig 17b).

Fig. 18a shows the population dynamics of Variegated Grasshopper *(Zonocerus spp)* on planting date of Sesame cultivars *(Sesamum indicum* L.) at capsulation stage. Grasshopper was highly populated with NCRIBEN 04E at 77DAPand 91DAP; and with NCRIBEN 05E at 84DAP and 91DAP respectively. Other cultivars were not noticed. August had the highest population of Grasshopper at 91DAP while lower population was seen on April planting at 77DAP and 84DAP. Grasshopper was not noticed on June (Fig18b).

Fig. 19a shows the population dynamics of Lady-bird beetle on planting date of Sesame cultivars at capsulation stage. NCRIBEN 04E and NCRIBEN 01M had highest population of yellow-black bug at 84DAP and 91DAP. NCRIBEN 01M showed average population at 77DAP, it rose to maximum at 84DAP and declined at 91DAP. However, NCRIBEN 04E population was very low at 70DAP, it rose from there to maximum at 64DAP and maintained it to 91DAP. Minimum population was seen in Maijigida at 77DAP and NCRIBEN E-8 at 84DAP. Planting dates showed high population on June planting compared to others. It was low at 70 DAP, increased to an average at 77DAP, rose to maximum at 84DAP and declined at 91DAP. The lowest population was found on August planting (Fig 19b).

Fig 20 (a) shows the population dynamics of Black ant on planting date of Sesame cultivars *(Sesamum indicum* L.) at capsulation stage. NCRIBEN E-8 was the highest populated of black ant at 77DAP and which later declined at 91DAP. Least population was noticed with NCRIBEN 05E and NCRIBEN 04E at 91DAP and 77DAP respectively. Planting date was highly populated at 77DAP on June planting and August planting respectively. Population of black ant was not noticed on April planting (Fig 20b)



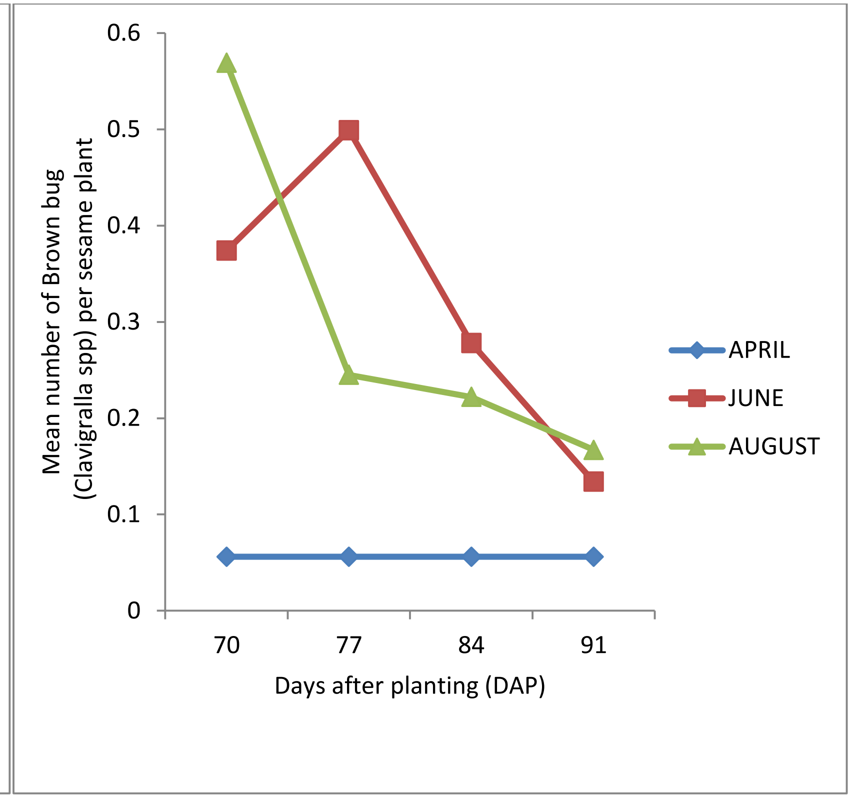
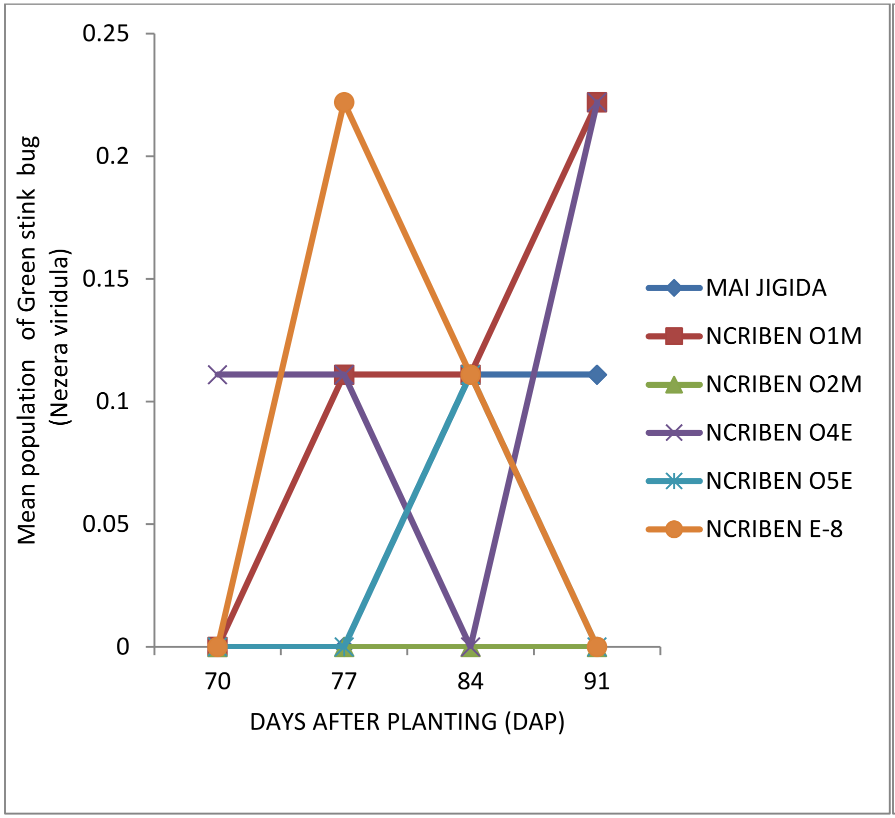


Fig 15a shows the mean population of Brown pod sucking bug on Sesame cultivars at capsule stage in Owerri Rainforest Zone.

Fig 15b shows the mean population of Brown pod sucking bug on Planting dates of Sesame at capsule stage in owerri Rainforest zone



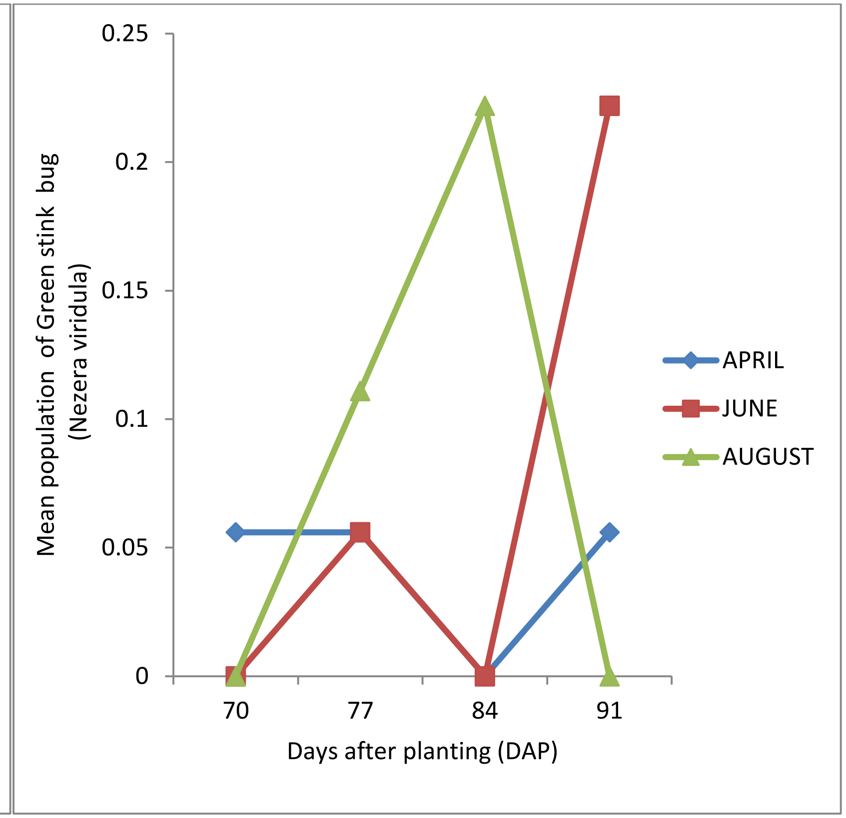
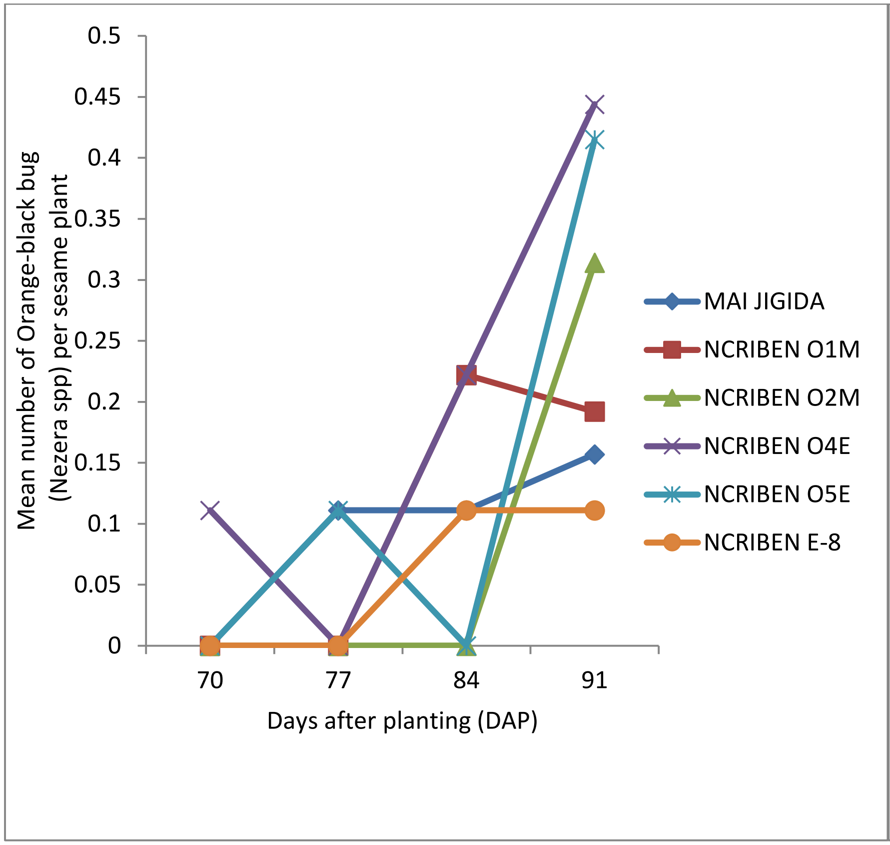


Fig 16a shows the mean population of Green stink bug on Sesame cultivars at Capsule stage in Owerri Rainforest Zone.

Fig 16b shows the mean population of Green stink bug on Planting dates of Sesame at Capsule stage in owerri Rainforest zone



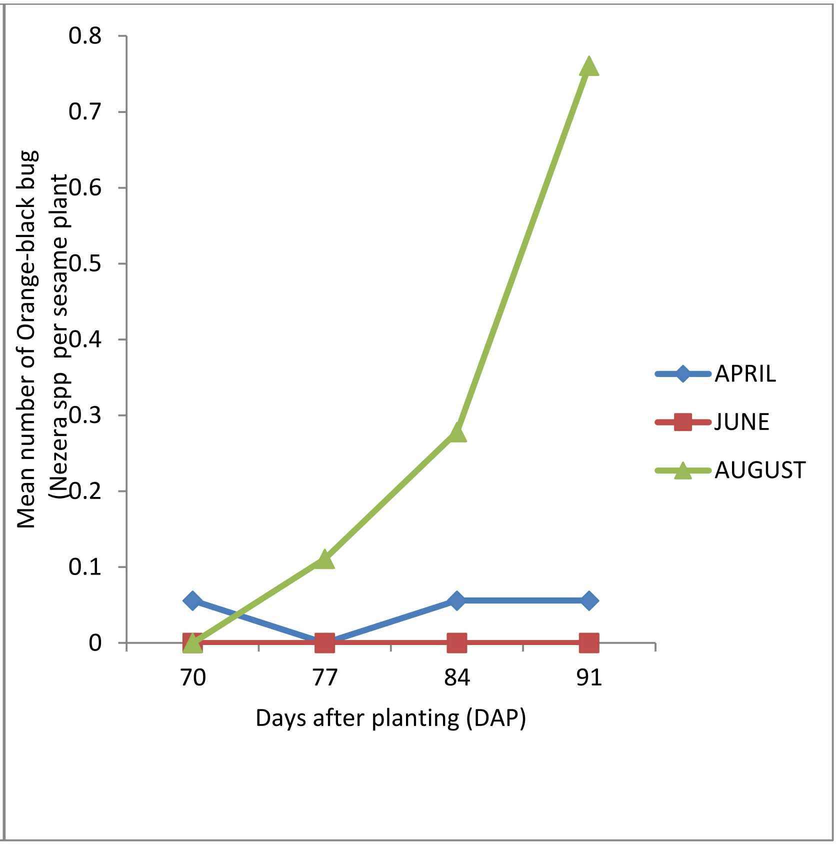
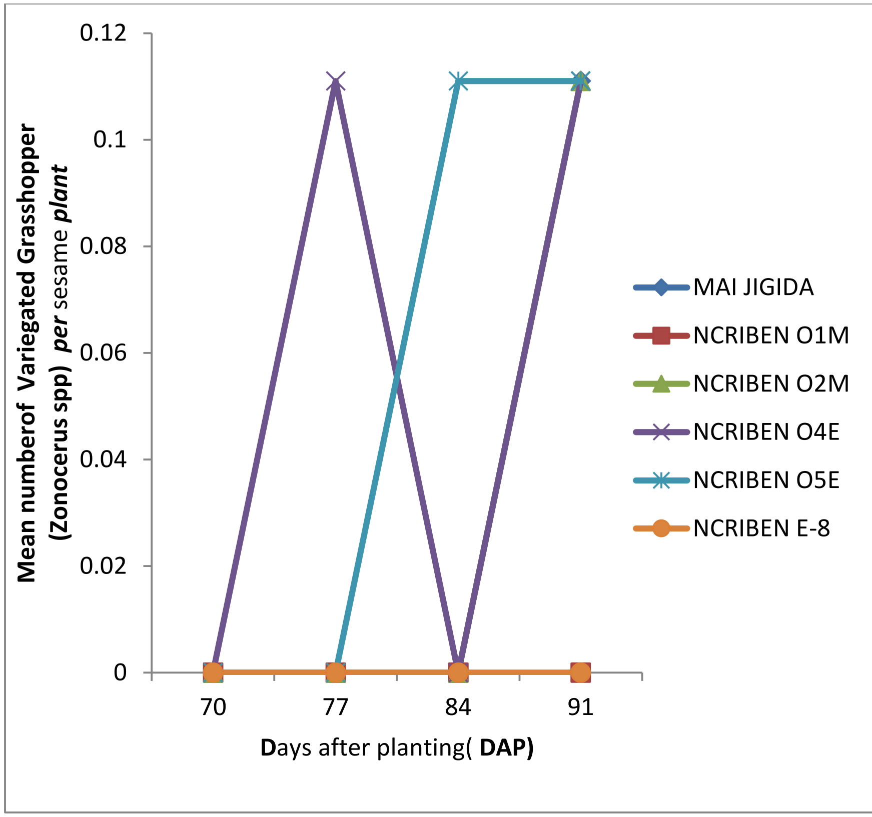


Fig 17a shows the mean population of Orange-Black pod sucking bug on Sesame cultivars at capsule stage in Owerri Rainforest Zone.

Fig 17b shows the mean population of Orange- Black pod sucking On planting dates of Sesame at capsule stage in owerri Rainforest



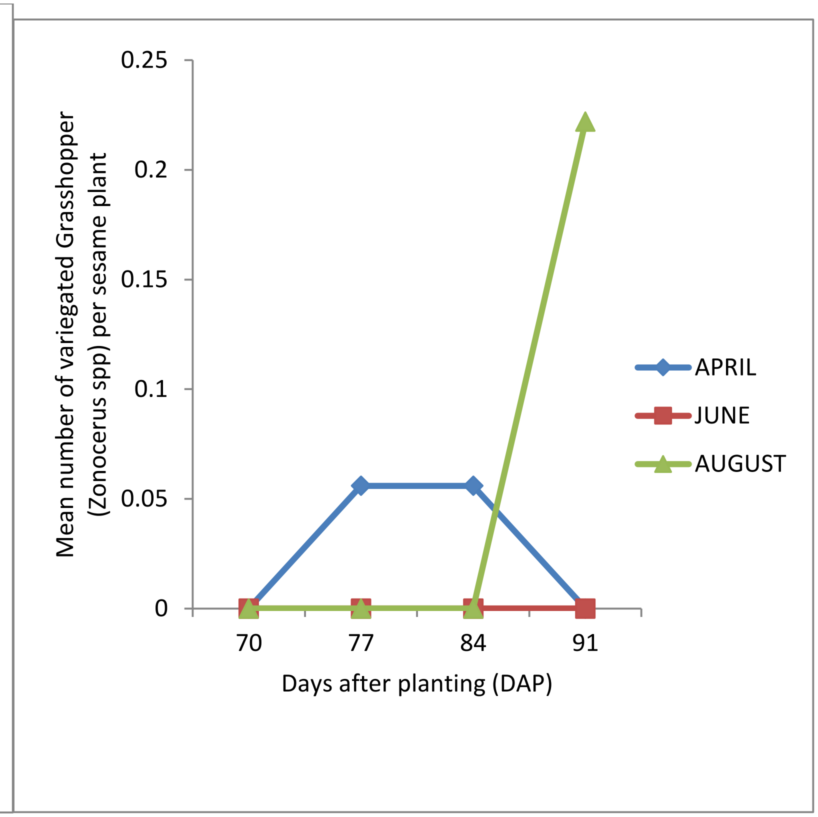
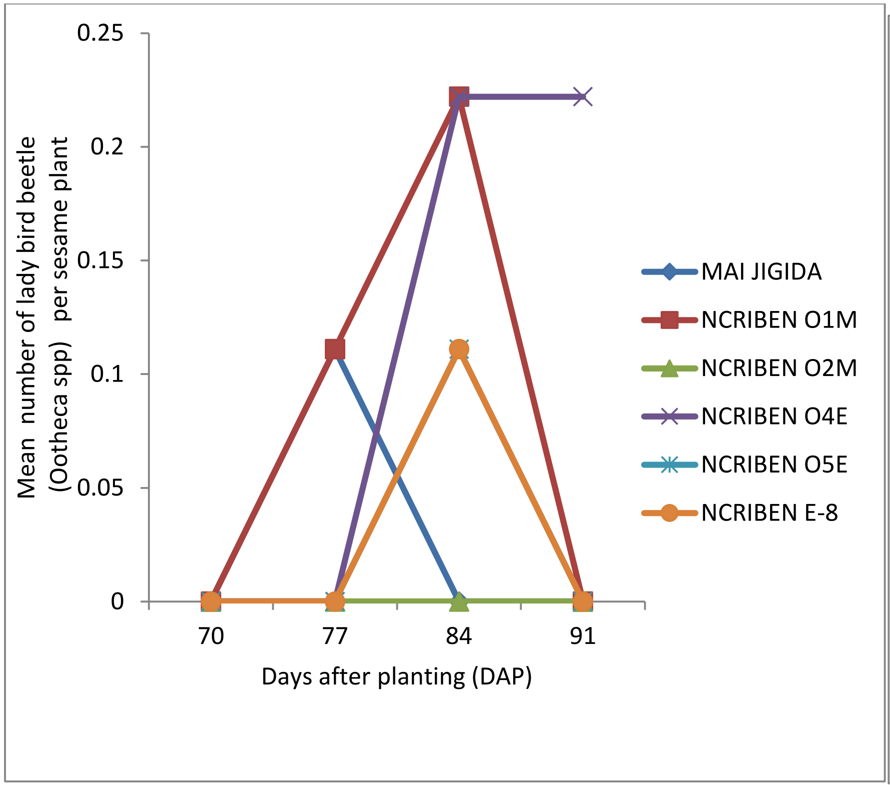


Fig 18a shows the mean population of variegated Grasshopper cultivars at capsule stage in Owerri Rainforest Zone.

Fig 18b shows the mean population of Variegated Grasshopper on Sesame planting of Sesame at capsule stage in Owerri Rainforest zone



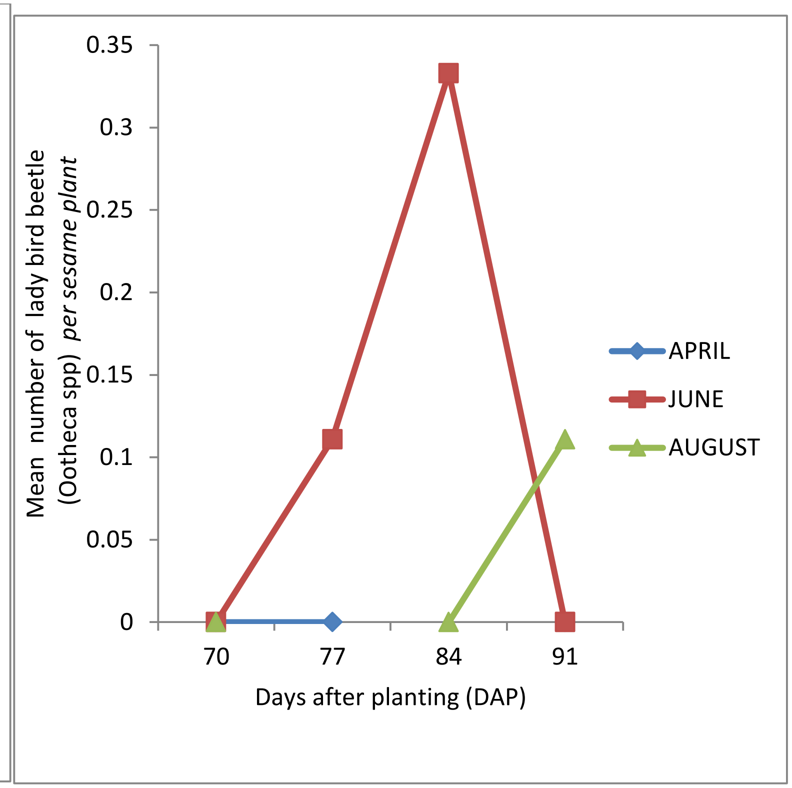


Fig 19a shows the mean population of lady- bird beetle on Sesame cultivars at capsule stage in Owerri Rainforest Zone.

Fig 19b shows the mean population of lady- bird beetle on Planting dates of Sesame in Owerri rainforest zone

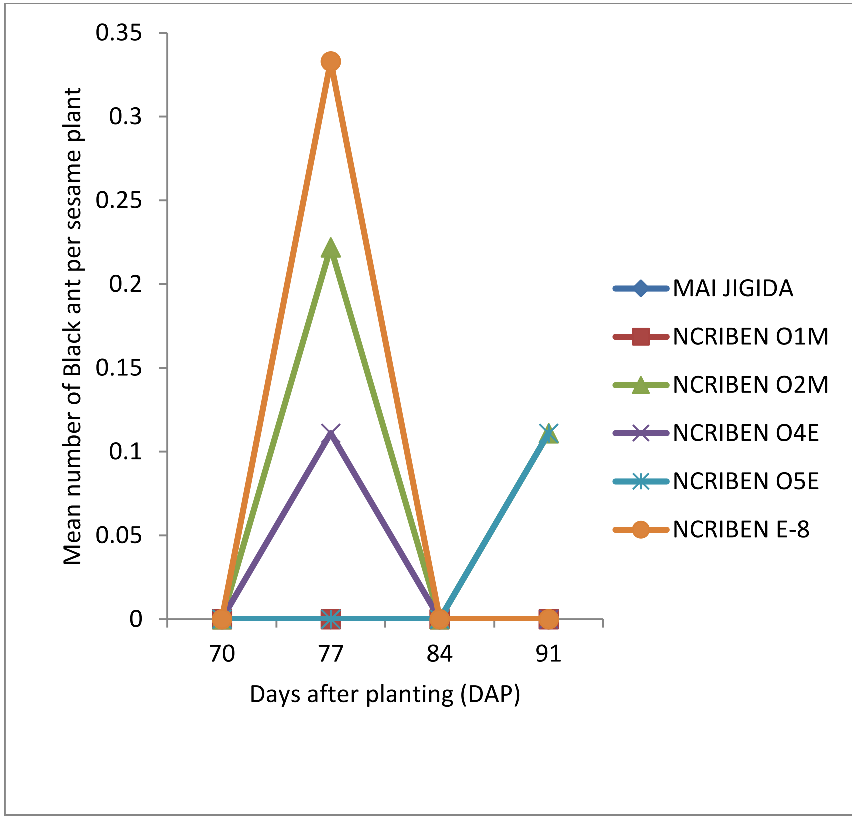


Fig 20a shows the mean population of Black ant on Sesame cultivars at capsule stage in Owerri Rainforest Zone.

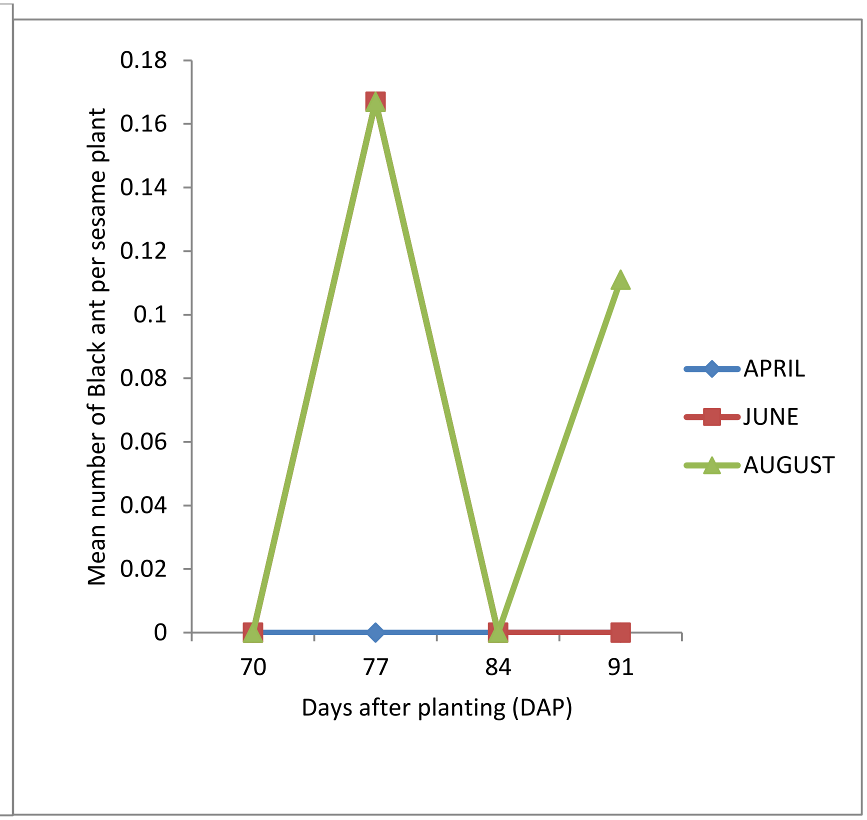


Fig 20b shows the mean population of Black Ant on planting dates Of Sesame at capsule stage in owerri Rainforest zone

4.4. INSECT PEST CATEGORIZATION

The major field insect pest infestations associated with sesame cultivars identified for the planting seasons were categorized into their pest status (Table 2). There were 6 Orders identified at vegetative, flowering and capsule stages of the plant. Order Hemiptera had the highest population of pests, represented by 6 pests while Dipterans and Lepidoptera having the least pest population were represented by only 2 pests. Bean fly was observed both at vegetative and flowering stages; Lady bird beetle and Variegated grasshopper were noticed both at vegetative and capsules stages while black ant (Pod weevil) was seen at all (vegetative, flowering and capsule) stages of the plant. The different pest found in sesame field for the three planting seasons are shown in plate 2(a) to plate 2(r)

TABLE 2 SHOWING THE COMMON PESTS OF SESAME CULTIVARS CATEGORISED INTO PEST STATUS

ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	STAGE OF ATTACK	PART AFFECTED	LEVEL OF DAMAGE
Orthoptera	Acrididae	*Cantantops erubescens*	Brown grasshopper	Adult/ nymph	Vegetative	Feed on leaflets reducing yield
Diptera	Agromyzidae	*Opiomyia spp*	Bean fly	Adult/ nymph	(Vegetative/ flowering)	Stunted plants/ wilting
Coleoptera	Chrysomelidae	*Ootheca* spp	Foliage beetle	Adult/ nymph	Vegetative	Premature senescence
Coleoptera	Apionidae	*Apion benignum*	Black ant(pod weevil)	Adult/ nymph	(Vegetative/ flowering/ capsule)	Ragged effect on leaflet
Orthoptera	Acrididae	*Krausaria angulifera*	Green grasshopper	Adult/ nymph	Vegetative	Feed on leaflets reducing yield
Diptera	Platystomatida	*Rivellia angulate*	Fruit/ stem fly	Adult/ nymph	Vegetative	Yellowing/ stunted growth
Orthoptera	Acrididae	*Zonocerus variegatus*	Variegated grasshopper	Adult/ nymph	(Vegetative/ capsule)	Feed on leaflets reducing yield
Hemiptera	Menbracidae	*Otinotus oneratus*	Brown bugs	Adult/ nymph	(Vegetative/ flowering)	Wilting/ reduced plant vigor
Hymenopter	Megachilidae	*Apis dorsata*	Social bee	Adult	Flowering	Pollination of flowers
Hymenopter	Megachilidae	*Megacille bee*	Solitary bee	Adult	Flowering	Pollination of flowers
Hymenopter	Megachilidae	*Xycolopa* spp	Black bee	Adult	Flowering	Pollination of flowers
Coleoptera	Meloidae	*Mylabris* spp	Pollen/blister beetle	Adult	Flowering	Reduce pod set
Hemiptera	Pentatomidae	*Dolicoris indicus*	Pod sucking bugs	Adult	Capsule	Shrivelled pods/ dark patches
Hemiptera	Pentatomidae	*Nezara viridula*	Green stink bug	Adult	Capsule	Pod rot, shrivellled
Hemiptera	Pentatomidae	*Creonitiades pallides*	Orange pod sucking bug	Adult	Capsule	Defoliation of pods
Hemiptera	Aphididae	*Ahids craccivora*	Lady bird beetle	Adult	Vegetative/ capsule	Twisted leaves
Hemiptera	Coreidae	*Clavigrella gibbosa*	Pod sucking bugs	Adult	Capsule	Shrivelled pods/ dark patches
Lepidoptera	Noctuidae	*Helicoverpa armigera*	Pod borer	Adult	Capsule	Wilting
Lepidoptera	Arctiidae	*Amsacta albistriga*	Moth	Larva	Capsule/ vegetative	Defoliation of pods

Plate 2(a)Pod sucking bugs

Plate 2(b) Empoascaplate

Plate 2(c) Leaf weevil

Plate 2(d)

Plate 2(e)Brown bug

Plate2(f) Moth larvae

Plate 2(g)Moth*(Danaus chrysippus)*

Plate 2(h)Pod sucking buds

Plate2(i)brown bee(*Xycolopa pubescens)*

Plate 2(j) Black bee

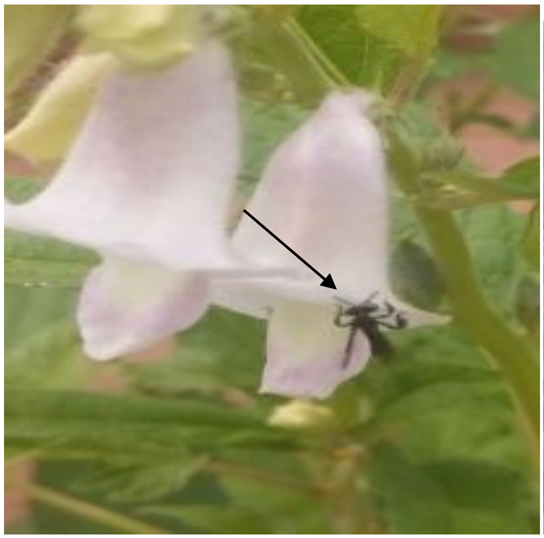


Plate 2(k) Black fly

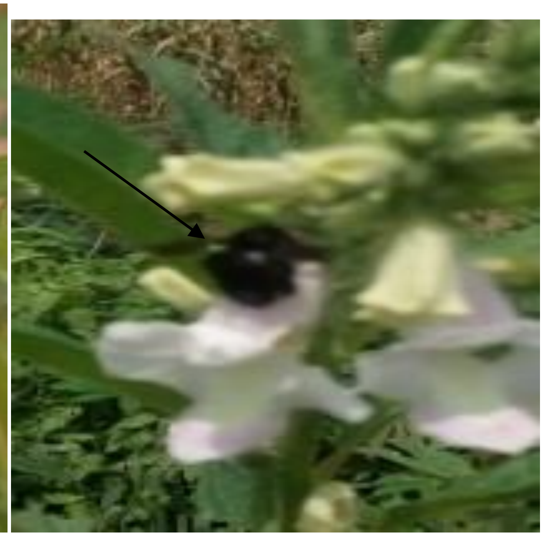


Plate 2(l) Black bee

Plate 2(m)Pod sucking bugs(Anoplocnemis sp.) Plate 2(n) Dragon fly Plate2 (o)Variegated grasshoppers

Plate 2(p) Pod sucking bugs(Dolicoris indicus) Plate 2(q) Fruit fly Plate 2(r) Beetle

Plate 2(a) -2(r) showing different insect pest found on the sesame field

4.5. EFFECT OF PLANTING DATE AND SESAME CULTIVARS ON SESAME GROWTH PARAMETERS

Effect of planting date and sesame cultivars on sesame growth parameters (Table 3a); and the effects of interaction of Sesame cultivars and planting dates on Sesame growth parameters (Table 3b) in Owerri Rainforest Zone. Table 3a shows that there were significant differences ($p<0.05$) among the Sesame cultivars with respect to days to emergence and percentage emergence. The cultivar Majigida took 5 days to emerge with high percentage emergence of 66.3% while NCRIBEN 05E, took 7 days to emerge from planting to emerge from the soil, with very poor percentage emergence of 24%. More so, planting dates recorded high significant differences ($p<0.05$) on the emergence of the Sesame seed. Seeds planted on April emerged earlier at 4 days with high percentage germination of 67% while August planting took 8 days to emerge with percentage emergence of 27%, better than 14th of June that had 18.2%. However, June planting emerged earlier than August planting but recorded low percentage emergence of 18.2%. There was significant interaction ($p<0.05$) of the cultivars and planting dates in respect to days to emergence and percentage emergence (Table 3b).

Also Table 3a recorded no significant difference ($p>0.05$) among cultivars in respect to days to flower bud initiation and flower opening while planting dates repeated a significant difference ($p<0.05$). Seeds planted on April initiated flower buds earlier in 33 days, opened flowers in 41 days after planting and at 50% level of flowering, it took 49 days for flowers to open than other plantings. While August initiated flower later in 47 days and opened in 55 days from planting and at 50% level of flowering, it opened in 64 days. There was significant interaction ($p<0.05$) of cultivars and planting dates (Table 3b).

There were no significant effect ($p>0.05$) among cultivars with respect to days to capsule initiation and days to 50% capsule formation while a significant effect ($p<0.05$) was recorded in planting dates. April planting showed earlier capsule initiation in 43 days and 52 days for 50% capsule formation while August planting initiated capsule later in 56 days and 70 days for 50% capsule formation. There was significant interaction ($p<0.05$) of cultivars and planting dates (Table 3b).

At maturity, there was significant difference among all the cultivars ($P<0.05$). Maijigida cultivar matured earlier at 108 days after planting compared with other cultivars while NCRIBEN 05E matured later in 120 days from planting. Planting dates had significant effect ($p<0.05$) on the maturity of the cultivars. Seeds planted on 14th of April matured earlier at 109 days after planting followed by 14th of August planting with 112 days while14th of June planting matured at 116 days after plantings. Also significant interaction ($p<0.05$) of the cultivars with planting days was observed (Table 3b).

Plant height at maturity was significant ($p<0.05$) among cultivars (Table 3a). NCRIBENE-8 had highest plant height of 183.6cm while NCRIBEN 02M recorded the least plant height of 144.1 cm. Planting dates showed significant effect ($p<0.05$) on plant height. It recorded more vigorous plant height of 224cm on 14th of August planting followed by 14th of April planting with 144cm while14th of June planting recorded the least plant height of 123cm. There was high significant interaction ($p<0.05$) of cultivar and planting dates (Table 3b) with respect to plant height.

Plate 3(a), 3(b) and 3(c) shows the different stages of growth (vegetative, flowering and capsule stages) of Sesame plant.

3a Effects of Planting Dates and Sesame cultivars on Sesame growth parameters in in Owerri Rainforest Zone

CULTIVAR	Days to Emergence	Percentage Emergence (%)	Days to flower bud initiation	Days to flower Opening	Days to 50% flower opening	Days to capsule initiation	Days to 50% capsule initiation	Days to maturity	Plant Height (cm)
MAI JIGIDA	5.22	66.3	38.78	46.11	56.00	48.33	60.56	108.00	164.9
NCRIBEN O1M	6.00	39.6	41.44	48.89	59.22	52.44	64.56	115.33	157.7
NCRIBEN O2M	6.778	28.8	43.67	52.56	61.78	55.11	66.22	111.22	144.1
NCRIBEN O4E	6.333	34.1	40.11	48.00	58.00	50.56	64.22	110.44	173.9
NCRIBEN O5E	7.222	24.00	42.56	50.11	58.33	53.00	65.33	120.00	158.7
NCRIBEN E-8	6.333	33.70	40.22	48.67	56.89	50.44	61.78	110.33	183.6
LSD(0.05) (C)	0.5787	14.06	5.069	5.365	4.559	5.553	4.998	6.046	19.32
PLANTING DATE									
APRIL	4.33	67.40	33.72	41.72	49.06	43.17	52.33	109.06	144.40
JUNE	5.66	18.20	42.28	49.94	61.94	55.33	68.17	116.28	123.00
AUGUST	8.94	27.60	47.39	55.5	64.11	56.44	70.83	112.33	224.00
LSD(0.05)(PD)	0.4092	9.94	3.584	3.793	3.927	3.244	3.534	4.275	3.660

Table 3b Effects of interaction of Sesame cultivars on Sesame Growth in Owerri Rainforest zone

CULTIVAR	Days to Emergence	Percentage Emergence (%)	Days to flower bud initiation	Days to flower Opening	Days to 50% flower opening	Daysto capsule Initiation	Days to 50% capsule initiation	Days to maturity	Plant Height (cm)
APRIL									
MAI JIGIDA	4.00	83.10	31.33	40.00	46.67	42.00	49.67	114.33	150.00
NCRIBENO1M	4.00	81.70	35.67	42.67	52.33	42.33	52.67	105.00	152.20
NCRIBEN O2M	4.33	62.30	32.00	40.00	48.00	42.33	52.67	109.67	140.60
NCRIBEN O4E	4.33	72.30	35.00	43.00	50.33	45.00	56.00	108.33	140.60
NCRIBEN O5E	5.00	36.30	35.67	43.00	49.00	44.00	54.00	112.00	131.10
NCRIBEN E-8	4.33	68.90	32.67	41.67	48.00	42.33	49.00	105.00	152.20
JUNE									
MAI JIGIDA	5.67	53.50	44.33	51.33	66.33	55.67	70.00	113.67	122.30
NCRIBEN O1M	5.00	21.90	42.00	50.67	62.00	58.00	68.67	128.67	111.00
NCRIBEN O2M	7.00	5.00	53.00	60.67	70.67	64.67	75.33	107.00	90.00
NCRIBEN O4E	5.00	15.20	37.33	44.33	60.00	50.00	66.00	108.33	134.30
NCRIBEN O5E	5.67	1.50	35.00	42.00	52.00	49.00	61.00	124.00	155.00
NCRIBEN E-8	5.67	12.10	42.00	50.67	60.67	54.67	68.00	116.00	124.30
AUGUST									
MAI JIGIDA	6.00	62.30	40.67	47.00	55.00	47.33	62.00	96.00	222.30
NCRIBEN O1M	9.00	15.00	46.67	53.00	63.33	56.00	72.33	112.33	210.00
NCRIBEN O2M	9.00	19.00	46.00	57.00	66.67	58.33	70.67	117.00	201.70
NCRIBEN O4E	9.67	14.80	48.00	56.67	63.67	56.67	70.67	114.67	246.70
NCRIBEN O5E	11.00	34.20	57.00	65.33	74.00	66.00	81.00	124.00	190.00
NCRIBEN E-8	9.00	20.00	46.00	53.67	62.00	54.33	68.33	110.00	273.30
LSD(0.05)	1.0024	24.35	8.779	9.292	9.618	7.945	8.656	10.472	33.46

3(a) Vegetative phase 3(b) Flowering phase 3(c) Capsule phase

Plate 3(a), 3(b) and 3(c) showing Stages of growth of sesame

4.6 EFFECT OF PLANTING DATE AND SESAME CULTIVARS ON SESAME YIELD AND DAMAGE PARAMETERS

Effect of planting date and Sesame cultivars on Sesame yield and damage parameters (Table 4a); and the effects of interaction of Sesame cultivars on Sesame yield and damage parameters (Table 4b) in Owerri Rainforest Zone. Capsule yield showed no significance difference ($p>0.05$) among cultivars (Table 4a). Planting dates were significant ($p<0.05$) on yield of Sesame with April planting having the highest yield of 465kg/ha, 268 g/plot and 16.74 g/plant compared to others. June had least yield of 178 kg/ha, 103 g/plot and 6.42 g/plant. Interaction showed no significance ($p>0.05$) in all cultivars and planting dates (Table 4b).

Seed yield kg//ha and seed yield /plot/ (g) showed no significance effect ($p>0.05$) among cultivars (Table 4a). Meanwhile, Seed yield .plant (g) had significant effect ($p<0.05$) among cultivars. Maijigida recorded highest seed yield of 6.44 g/ plant while NCRIBEN 05E had least yield of 2.8g/plant. Planting dates were significant ($p<0.05$) on yield of Sesame with April planting having the highest yield of 182.5kg/ha, 105.1 g/plot and 6.47g/plant compared to others. 14th of June had least yield of 81.6kg/ha, 38.2g/plot and 2.46 g/plant. Interaction showed no significance ($p>0.05$) in all cultivars and planting dates (Table 4b)..

Thrash weight (kg/ha) and thrash weight /plant (g) showed significance difference ($p<0.05$) among cultivars (Table 4a). Maijigida recorded highest thrash weight of 274kgha-1 and 157.8g/ plot compared to other cultivars while NCRIBEN 05E had least yield of 151kg/ha and 87.2g/plot. Planting dates were significant ($p<0.05$) on yield of Sesame with April planting having the highest yield of 296kg/ha, 170.3g/plot and 10.49g/plant compared to others, June had least yield of

116kg/ha, 65g/plot and 4.06g/plant. Interaction showed no significance ($p>0.05$) in all cultivars and planting dates (Table 4b).

There was significance effect ($p<0.05$) among cultivars with respect to damage percentage and damage per plot (Table 4a). The highest damage / plot (g) was recorded with NCRIBEN 02M having 48 (g) of damaged capsules with damage percentage (%) of 42.5% while the least damage was in Maijigida with 9.8 (g) of damaged capsules with damage percentage of 2.9%. Planting dates showed highly significant effect ($p<0.05$) on damage, with maximum damage per plot recorded on June planting (50.7 g) while the least was on April having 3.5(g) of damaged capsules. Highest damage percentage of 42.6% was recorded on June planting while least percentage damage was on April planting with 2.6% damage. August also had a low percentage damage of 19.5%. Interaction showed no significant damage ($p>0.05$) on damage/plot but significant effect was recorded on damage percentage (%) (Table 4b).

Plate 4(a) to 4(f) shows the level of damage of the Sesame plants in the field. Also Table 2 shows the effects of these damages caused by the various pests identified in the field.

Table 4a showing effects of planting dates on yield and damage parameters of sesame cultivars in Owerri Rainforest Zone

CULTIVAR (C)	Capsule yield/ (kg/ha)	Capsule yield/ plot	Capsule yield/ plant	seed yield/ (kg/ha)	seed yield/ plot	seed yield/ plant	Thrash yield/ (kg/ha)	Thrash yield/ plot	Thrash yield/ Plant	Damage Per Plot	Damage percentage %
MAI JIGIDA	434.00	250.00	15.62	178.80	103.00	6.44	274.00	157.80	9.17	9.80	2.9.00
NCRIBEN O1M	282.00	162.00	1.00	110.30	65.60	4.10	177.00	102.20	6.39	22.00	20.20
NCRIBEN O2M	243.00	140.00	8.66	86.80	50.00	3.13	156.00	89.70	5.61	48.00	42.50
NCRIBEN O4E	302.00	174.00	10.53	106.40	61.70	3.93	204.00	117.80	7.74	30.30	14.20
NCRIBEN O5E	237.00	136.00	8.35	114.80	48.10	2.80	151.00	87.20	5.45	32.50	35.90
NCRIBEN E-8	327.00	189.00	12.91	119.50	68.90	4.31	215.00	121.00	7.57	25.00	13.80
LSD(0.05) (C)	133.20	76.6	5.37	65.62	37.34	2.28	80.00	46.88	3.03	17.65	20.02
PLANTING DATE											
APRIL	465.00	268.00	16.74	182.50	105.10	6.47	296.00	170.30	10.49	3.50	2.60
JUNE	178.00	103.00	6.42	81.60	38.20	2.46	116.00	65.00	4.060	50.70	42.60
AUGUST	269.00	155.00	9.88	94.20	55.30	3.42	178.00	102.50	6.41	29.70	19.50
LSD(0.05)(PD)	94.20	54.20	3.803	46.40	26.40	1.617	56.60	33.15	2.144	12.48	14.15

Table 4b shows the effect of interaction of sesame cultivars on the yield and damage parameters of sesame in Owerri Rainforest zone

INTERACTION	Capsule yield/ (kg/ha)	Capsule yield/ plot	Capsule yield/ plant	seed yield/ (kg/ha)	seed yield/ plot	seed yield/ plant	Thrash yield/ (kg/ha)	Thrash yield/ Plot	Thrash yield/ plant	Damage per plot	Damage percentage %
APRIL											
MAI JIGIDA	572	329	20.59	276.6	159	9.94	353	203.3	10.63	3.5	1.7
NCRIBENO1M	391	225	14.06	173.6	100	6.25	246	141.7	8.86	3.5	3.5
NCRIBENO2M	421	242	15.15	144.7	83.3	5.21	276	159	9.94	3.6	3.1
NCRIBEN O4E	432	249	15.54	141.8	81.7	5.11	280	166.7	11.55	3.5	2.9
NCRIBEN O5E	480	276	17.24	173.6	100	5.63	301	173.3	10.84	3.4	2.4
NCRIBEN E-8	494	285	17.79	185.2	106.7	6.67	309	78.3	11.13	3.5	2.2
JUNE											
MAI JIGIDA	388	223	13.96	150.5	86.7	5.42	23.7	136.7	8.54	13.3	3.9
NCRIBENO1M	194	112	6.98	69.4	40	2.5	124	71.7	4.48	94	35.8
NCRIBENO2M	87	50	3.13	34.7	20	1.25	52	30	1.88	80	87.5
NCRIBEN O4E	174	100	6.25	61.7	36.7	2.71	110	63.3	3.96	48	15.2
NCRIBEN O5E	28	16	1	104.2	6	0.38	17	10	0.63	75	90
NCRIBEN E-8	198	115	7.19	69.4	40	2.5	153	78.3	4.9	43.3	23.3
AUGUST											
MAI JIGIDA	341	197	12.1	10	63.3	3.96	231	133.3	8.34	12.7	3
NCRIBENO1M	260	150	8.96	88	56.7	3.54	162	93.3	5.84	18.7	21.3
NCRIBENO2M	220	122	7.71	81	46.7	2.92	139	80	5	60.3	37
NCRIBENO4E	301	173	9.79	115.7	66.7	3.96	214	123.3	7.71	39	24.7
NCRIBEN O5E	203	117	6.77	66.6	38.3	2.4	136	78.3	4.9	19	15.1
NCRIBEN E-8	289	167	13.75	103.8	60	3.75	184	106.7	6.67	28.3	15.9
LSD(0.05)	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	34.67

4(a) Ragged leaf 4(b) Leaf spots 4(c)leaf lesions/ mosaic virus

4(d) Capsule lesions **4(e) leaf blight** **4((f) dark patches on capsule**

Plate4 (a) – (f) showing levels of capsule damage in the field

CHAPTER 5

DISCUSSION

The early season planting (April) having good growth performance may be attributed to the minimal rainfall favouring the juvenile stage of the plant; this in turn helped in the production of more flowers in the flowering stage of the plant which attracted more pollinating insects thereby leading to more capsule formation and increased yield. April planting had low rainfall and high temperature allowing the plants to outgrow pest activities at vegetative stage. Excessive rainfall, temperature and relative humidity in June (Mid- season planting) could be the reason for difficulty in establishment of plants at vegetative stage and few flower bud formation.

Though excessive rainfall, higher humidity do not favour pests like pod borers as confirmed by Dialoke *et al*.,(2017), but has influenced the population of pests like *Maruca vitrata* as reported by Minja and Shanower., (1999). More so, high rainfall and relative humidity in August (late- season planting) could have lead to plants having low flower budding which lead to fewer capsules, more insect activity leading to malformation of capsules and powdery mildew on plants.

Sesame is generally a warm weather crop and the temperature recorded during this study were optimum for sesame growth and development since it is below the critical temperature of 40^0C (Langhan, 2008) which adversely affect flower fertilization and capsule production (Ahirwar *et al*, 2010). Temperature range of 24-27^0C encourages rapid germination, initial growth and flower formation while temperature below18^0C inhibit germination and growth (Opplinger *et al.*, 1990). In order to determine the accumulated temperature for sowing to flowering and maturity, 18^0C was considered as the threshold temperature for sesame growth and development (Opplinger *et al*., 1990). It gives the approximate index for comparing the thermal needs of plants and the suitability of a location for specific crops.

Recommended range of rainfall is between 500-800mm for successful production of sesame in tropical Africa (Khan *et al*., 2009). Adequate moisture in the soil during the vegetative period is desirable because the number of seeds per plant are usually determined during the period (Lim., 2012). However, at reproductive stage, adequate moisture in the soil enhanced enlargement of seeds and consequently increase sesame grain yield.

Higher population of Brown, Green and variegated Grasshoppers recorded in respect to planting dates shows that Grasshoppers in general are more prevalent in early season planting (April) and as time progresses, it's population declines and they are more susceptible to high yielding cultivars. This shows that grasshoppers thrive in warm sunny conditions, so drought stimulate an increase in its population. This suggests that although rainfall is needed to stimulate plant growth, prolonged periods of cloudy weather will slow nymphal development of Grasshoppers.

Bean fly and Fruit / Stem fly attacked Sesame more in June during the rains which shows that these could be a humid loving pest this shows that densely populated areas may have lower rate of fruit fly due to environmental constraints and it may limit the survival and reproduction of fruit fly. The flies appeared at juvenile stages of plant and its population progressed with time. They suck sap of plant causing wilting of young plants.

Black ant and brown Ant population were prevalent across all planting and during the three stages of planting showing they are among the major prevailing pests of sesame . This confirms that black ants do not explore their environment only during early summer months. Black ant proved to be the most abundant of all the identified pests at vegetative level. Observation shows that NCRIBEN 02M with lower growth performance was the most susceptible cultivar to pest infestation at vegetative level while Majigida that had highest growth performance was more resistant to pest. This is in line with

(Selvanarayanan and Baskarann, 1996) which stated that resistant varieties suffered lesser insect infestation than susceptible ones and varieties under high insect pressure resulted to reduced yield. Growth may have effect on susceptibility to pest infestation as NCRIBEN 02M with less growth had more pest infestation than other cultivars. Plants that grow quickly are better to withstand pest damage (Zehnder, 2014).

Planting season during April planting had higher population of pest at vegetative phase. These pests are regarded as major pests of sesame at vegetative phase since they are neither continuously present nor attack at the middle or end of the crop (Shanower *et al*., 1999). Fruit fly was the most populated of all other vegetative pests. This may be attraction by the smell of the plant.14th of April planting with the highest growth performance recorded more resistant to vegetative pest attack. This shows that growth has effect on pest population. Plants that performed better at juvenile stage may outgrow/ resist pest intation than those that had lesser growth. Environment may have effect on pest activities, rainfall was more on 14th of June and 14th of August plantings than 14th of April and this favoured the multiplication of Fruit fly on 14th of June. It has been reported that heavy rainfall (1600mm annual rainfall) flow and humidity are the major factors controlling pest abundance in the natural environment (Mandal *et al*., 2009). Insect pest which attack plant at vegetative stage vary with those at flowering and capsulation stages. There was more insect pest at reproductive stage than vegetative stage. Shanower. (1999) has noted that insect feeder of flowers, pods and seeds are important biotic constraints to adequate production of crop in Africa. When pest incidence during the sesame growing season is detected, there is less than 1% incidence in seeding and about 70% in capsule development stage (Zerewi, 2018).

Insects infesting the reproductive part cause maximum reduction in Sesame yield. Pod borer, seed feeing dipterans,, caterpillars, pod borers blister beetles and pod sucking bugs are the most common (Minja, 2000). There are many insect species at the reproductive than at the vegetative stage. Shanower, (1999) has noted that insect feeders of flowers, pods and seeds are the most important biotic constraints to adequate production of crop in Africa. At flowering stage, all cultivars experienced high population of pest. These pests are more prevalent at early flowering stage, which depreciates as flower matures; showing that they are mostly major pests at the reproductive phase of sesame, most of which are pollinators e.g. social and solitary bees during June and August planting.

Most susceptible cultivar to flowering insect pest was NCRIBEN 02M with low growth performance recorded more abundance of flowering pest (bean fly) than other cultivars. Majigida having highest growth effect yet experienced much flowering pest (brown bee), confirms report by Minja.,(2000) which says that the most important insect pests of plant in tropical and sub-tropical rejoins are those that attack the crop at reproductive stage and during storage. Majigida with vigorous growth at vegetative level, produced much flower buds. The presence of succulent leaves provided food for feeding, oviposition and multiplication of insect pests. Pollination improve the germination and seedling vigour which is very important since germination is one of the essential stages because if there is poor stand, no subsequent farmer actions or weather conditions can help produce a high yield (Mahmoud, 2012).

The abundance of pest during April planting served as pollinators and enhanced flower bud formation, flower opening and capsule formation. Least significant effect of pest found on June planting may be attributed to the less flower bud formation due to growth stress at vegetative level. Climatic conditions could have affected the development of pest species as very low rainfall generally support high buildup of insect while heavy rainfall discourages them. Dialoke *et al.*, (2013) reported that Impact of heavy rainfall and relative humidity put restriction to the fecundity and survival of the nymph and adult of pest this could be the reason why population was low during 14th of June planting season.

Pod sucking bugs has been reported to cause yield losses up to 90% and reduce seed viability up to 85%. (Dialoke *et al*., 2010).It may be said that NCRIBEN 04E is more susceptible to attack by capsule pest attack and may be attributed to its low yielding capacity which increased damage by pod sucking bugs. Its susceptibility was at early capsule formation while as capsule matures, it reduced gradually. Majigida and NCRIBEN 04E are high maturing plants and had high growth at vegetative level and more capsules are produced hence it may have attracted more pests. Findings indicate that the amount and distribution of rainfall determines the population of pest on early maturing plants in this locality (Dialoke *et al*.,2017).

Dialoke *et al.*, (2018) reported that high population of pests at podding stage could lead to total crop loss especially where there is little or no rains, as in the case with August planting season. This may be due to the distribution of rainfall which was less favourable for pest survival and multiplication. This confirms report by Dialoke et al., (2010) on his work on the survey of insect pest of pigeon pea in Nigeria, he reported on abundance of pod sucking bugs regardless of the rains. It may be said that once growth and yield are favourable, it reduces the effect of pest on plants but plants that undergo stress at growth levels gives room for pest activities.

With respect to pod sucking bugs, August planting experienced sudden cessation of the rains in late planting during maturity of pigeon pea produced dry spell which probably favors feeding, maturity, multiplication of bugs as reported by Dialoke *et al*., (2013) on his work on improved pigeon pea under different plant spacing and time of planting. Insect pest associated with the capsule phase usually inflict severe economic damage to crop. They cause serious damage by directly sucking sap from plant and indirectly by transmission of Virus and Mycoplasma disesases. The marked increase in pest incidence in capsule development could be due to favourable environment like higher temperature, lower rainfall and higher sunshine hours in October (Zerewi *et al,* 2018). With August and June plantings experienced much loss during disease infestations like- Fusarium wilt, leaf spot, powdery mildew ,e.t.c hence damaged Sesame capsules. Zhender, (2014) noted that a maximum mean incidence percentage of sesame webworm was recorded at the end of September during pod setting, capsule formation phase of the crop than vegetative and flowering stages. On the other hand, Dialoke, (2010) reported the incidence of pest (webworm) higher during sunny weather conditions than in wet weather conditions and an outbreak of pest occurred when a long dry spell has been preceeded by heavy rains

The list of insect pests associated with sesame which were categorized into pest status as shown in the result was only a limited number of major pest. Some of these pests (Grasshoppers, Beetles, ,Bugs, Flies, Bees, etc) had caused great loss to Sesame and acted as vectors for transmission of diseases to sesame plant, causing serious damage to plants example fruit fly causing yellowing and stunted growth of plant; blister beetle causing malformation and reduction in capsule size; brown spiny bugs causing abortion of flower buds and deformation of leaves e.t.c. This confirms the report by Dialoke *et al* (2010) that the brown spiny bugs are key pests of leguminous crops in Africa causing significant damage and yield loss of between 44 and 100% in these crops. Most pests at vegetative stage vary with those at flowering and capsule stage while only few were seen throughout the plant growing period example Black ant and Variegated Grasshoppers etc. Also the population dynamics of these pest varied, some were prevalent at juvenile stage of plant, others in mid days of planting and others at plant maturity.

There was high significant effect of cultivars on growth performance (emergence and maturity) of Sesame. Sesame cultivars had effect on crop emergence indicating that emergence rate and initial establishment affect the growth of sesame cultivars. Sesame before or after emergence may be affected by winds that may blow sand and damage or cover them; insects at seedling stage e.t.c.(Langham , 2008). Growth performance of Sesame was significantly higher on Majigida cultivar showing it has high growth capacity. Superiority of majigida may be due to their genetic constitution and its capacity of withstanding water stress condition than other cultivars. Cultivar has been reported as one of the factors which may influence emergence and establishment of sesame (Khan, *et al.*, 2009). The high emergence rate may be attributed to soil temperature, viability conditions of seeds etc (Saleem, 2012). NCRIBEN 05E, having delayed and poor percentage emergence which eventually delayed maturity and other physiological parameters shows that any one variety will be different from another depending on the growing conditions for that field and the weather of the year (Langham, *et al* 2008). In terms of cultivars, Maijigida did excellently better than other cultivars in respect to emergence and maturity. More vigorous plant height was noticed with NCRIBEN E-8, which also recorded an appreciable performance at emergence and maturity even though its percentage emergence was low. This confirm the report by Saleem, (2012) that growth parameters of cultivar are significantly affected by environmental factors such as plant height (cm),number of branches, number of leaves, number of pods, number of capsules, length of capsule(cm), width of capsules (cm), capsule per plant, seeds per plant and yield per plant.

In respect to planting date, 14th of April planting was more productive in all the physiological parameters (days to emergence, percentage emergence, days to flowering, days to flower bud opening, days to capsule initiation, days to 50% flower opening, and days to 50% capsule initiation , days to maturity etc)and appreciable in plant height. This shows that planting date had significant effect on growth, reproduction and yield of sesame. (Angus *et al*, 1980), confirmed that when sesame is planted early and under high moisture and fertility conditions, sesame can reach 4-6 feet in height. In dry land conditions, it is generally 3-5 feet, depending on rainfall. According to Heuze *et al*.,(2017), tallest plants, fruiting zone length, higher number of fruiting nodes per plant, higher number of capsule per hectare, higher values of capsule length, higher number of seeds per capsule as well as greater seed and yield per hectare were recorded by planting sesame on 9th April in both early and late planting seasons.

Furthermore, April planting matured earlier than other plantings (August and June) but height was more pronounced on August planting season. The timing of the rains can have as much effect as the quantity of the rains can help the field while an adjacent field just planted may get crusted in and not able to emerge (Langham, 1946). Weather (rainfall Pattern and temperature) has great effect on planting seeing that rainfall was at the minimal on onset of vegetation and this speeded up emergence but when plant was maturing, rainfall was higher and harvest was delayed despite early maturity. Early emergence contributes to early growth and maturity if temperature and humidity are favorable. Water stress appears to be the critical limiting factor for emergence and seedling establishment. In respect to June planting which showed least significance, emergence was early but the percentage emergence was very low and scarcely seen in plots. This may be attributed to the annual rainfall where June planting experienced more rains during emergence thereby causing stress on the emerged crops which led to their death. This confirms report by Dialoke *et al*., (2015) that plants under environmental stress often are less attractive to pest and more tolerant to seedling damage. Weed and pest activities may also have contributed to the loss of plant after emergence. Shanower (1999) ; Kooner and Cheema, (2006) reported damage caused by insect pests as a major factor responsible for low crop yield and several insect pests attack from the seedling stage until harvest. The impact of the stress on the plants cause the plants to have stunted growth and physiological characters like few flower buds initiation, and few capsulations.

14th of August planting experienced delay at emergence but germination percentage was better than 14th of June planting and this in turn resulted to early flowering, capsulation and most vigorous plant height than other planting. This was probably because of the short dry spell in 14th of August and high evaporation rate which could have reduced the vegetative time thereby hastening maturity (Olowe, 1996). Also, as a result of rainfall pattern (heavy rainfall) on 14th of August when the soil must have been saturated with water which delayed the emergence. This confirms the report by (Langham, 2008), the better the moisture, the faster seed will absorb moisture and germinate; when there is full moisture profile, the plant go through stress. This shows that too much water can slow down development and cause poor production potential of the sesame. This in turn delayed other physiological activities but maturity was earlier in 14th of August than14th of June and plant height was more vigorous compared to other plantings. This is in contrast with Mulkey *et al*.,(1987) who opined that days to maturity were reduced with delayed planting. 14th of April cultivars having best growth performance compared to others shows that 14th of April is the best planting time of sesame. The interaction between planting date and cultivar affected significantly all the morphological parameters including plant height. This is in agreement with Olowe, (1996) that found significant effect on plant height and other yield attributes.

Sesame cultivars differ significantly on seed yield per plant, thrash yield per hectare, thrash yield per plant, this is in agreement with Hansen, (2011) who stated that the local and world mean seed yield is very low, higher yield can be achieved through sustainable cultivars and optimum planting dates. The low yield could be due to lack of improved cultivars, low harvest index, susceptibility to disease, pest and environmental stress as well as capsule shattering (Heuze, *et al*., (2017).

Majigida is a high yielding cultivar with the highest significant seed and thrash yield. It was the best yielding cultivar of sesame plant, its seed and thrash yield were incomparable with other cultivars but did not perform well on capsule yield. This is in contrast with Ehsanullah., (2007) that stated that significant differences were found between two varieties in the number of capsule per plant under warm condition. The least significant seed and thrash yield shown in NCRIBEN 05E proves them to be low yielding cultivars and environment may have contributed to it. This suggest that sesame cultivars can respond differently to their environment, (climate, soil) and crop management.

Timing of planting can have a major effect on the final size of plant and yield (Mulkey, *et al*,1987). Planting on 14th of April was the best sowing time for sesame as yield was exceptionally high, showing that growth has effect on yield of Sesame probably because the plants had enough vegetative growth, adequate photosynthetic activities and assimilates than those sown later in the season (Olowe, 1996). This is in agreement with the report by (Weiss 2000) that planting in late April or early May results in highest yield of plant. Also, optimum planting dates was 9th April which promoted most of yield attributes according to (Heuze, *et al*., (2017). Similar trends were obtained by Mulkey *et al.*,(1987); Nath and Charkabolhy,(2003) who reported that the early planting dates (26th February-29 April) were the optimum dates for higher yield and its components. Conversely, Ogbonna and Umar-shaaba.,(2011) mentioned that the late planting dates (20th June to 1st August) were the optimum ones. The sudden cessation of rains in late planting (August), affected the plant growth with less pod setting (Rati and Shekhon, 1975). There was delay in growth performance of sesame on 14th of August planting but yield was at the considerable side unlike second week of June planting that emerged earlier but couldn't withstand challenges of environment which resulted in its poor yield. This shows that environment has effect on growth and yield of sesame. At the field, 14th of June planting underwent stress in germination, flowering, few flowers were produced, few capsules produced, height was reasonably short and in the same vein resulted to poor yield. Stress caused by insect on the crop may lead to reduction in yield as14th of June planting has been reported to have undergone stress at emergence (Chaudhry *et al*, 1989). Favourable environment and low pest load on April planting could have been responsible for high capsules and seed yield while high pest load amidst of environmental stress on June could be responsible for the total crop failure. This is in agreement with findings by Minja and Shanower, (2000) in their work on yield loss due to insect pest and integrated pest management strategies for pigeon pea synthesis.

Majigida having highest significant yield in all plantings showed it is the best cultivar while NCRIBEN 02M appeared to be the least yielding cultivar in all plantings.

Damage was significant with cultivars due to their susceptibility to pest infestation but Majigida that had low damage effect because of its tolerance and high yielding ability. This shows that high yielding cultivars have low damage effect. Minja and Shanower 2000) recorded that insect pest caused considerable seed damage from 14% to 69 % in the humid regions. The low damage percentage recorded on April planting could be because of its high performance in germination and yield. Furthermore, insect pest activities on April and August was appreciably low compared to that of June that experience higher pest activities and this could be because of environmental effect on June planting i.e. increased rainfall, temperature and relative humidity, could have affected the performance of the plants on June unlike April that had lower amount of rainfall and thereby escaped the vulnerable activities of some destructive pest both at vegetative and reproductive levels. Higher damage of sesame plant parts has been reported on the late sowing while early planting has fewer damage (Zerewi *et al*, 2016). Reproductive parts of sesame are severely damaged by pests compared to the leaves. Karuppauh and Naryarayan (2013) reported that when infestation occur at very early stage, plant dies without producing any capsule and shoot growth was affected, when infestation occurred at later stages. Planting sesame during early planting escape from damage and delay in sowing resulted in a significantly higher levels of damage to leaves, flowers and pods (Karuppaiah, 2014).

Damage by insect is the most serious threat to sesame productivity. Insects served as vectors for transmission of disease. They transmit diseases like Fusarium wilt, powdery mildew, Capsule deformation, Leaf spot, Leaf wilt, Stem rot etc. Damage on flowers and capsules destroyed by insect pests implies that the field insects are big threat to crop production and yield could be enhanced if adequately controlled (Dialoke *et al*., 2013).

Method of assessing yield loss is usually based on the degree of infestation and seed loss in capsules. Severity of damages of sesame plant parts has varied from 5% on leaf to 28% on reproductive parts (Zerewi *et al*, 2018). Similarly, Karuppiaiah and Nadarayan (2013) have reported that 32.67% flower damage and 24.69% capsule damage were than most exposed sesame parts to damage by *A. catalaunalis.* Therefore, flower and capsule were the most exposed sesame parts to damage by the pest. The higher level of damage in flowers and capsule could be due to the favorable weather conditions (Higher temperature and low rainfall during the reproductive stages of the plant and the pest likely persistent on the young and soft plant parts. Also, the lower level of damage on leaves was not because of low infestation of the pest recorded on the leaves; but due to the higher number of total leaves per plant which definitely lowered the value (Zerewi *et al*, 2018).

5.1 CONCLUSION / RECOMMENDATION

Early maturing sesame cultivar (Maijigida) takes three to four months(90-100 days) to mature and it is best planted when productivity will be high and pest infestation very low in order to meet the food security need in Nigeria. From the available result, it could be seen that the growth, yield, pest population dynamics and damage of sesame were much dependent on the prevailing climatic conditions of the cropping season.

Majigida cultivar is an early maturing cultivar and it recorded highest growth performance and maximum yield. Even though it harbored population of pest at vegetative and flowering but was able to show some level of resistance to pest damage. This contributed to the optimum yield and productivity of this cultivar and is being recommended for adoption by farmers. NCRIBEN 02M is a late maturing cultivar having emerged and matures late, attracting less pest effect but could not resist pest effect thereby having lower productivity and high damage. Any farmer that adopts it should be ready to find preventive measures for loss.

Pest damage needs to be mitigated by manipulating planting dates and using improved cultivars for optimum productivity. This is to say that, planting of sesame during April (Early season) planting is best recommended as against June and August plantings that were more susceptible to damage. Also, early planting (April) recorded an appreciable growth and yield performances, less damage than mid planting (June) and late planting (August). Late planting in August was better than June planting, though August planting experienced emergence stress at juvenile stage, disease infestation at maturity because of its planting time but June planting was non- productive and environment contributed to that effect. Therefore ensuring food security and sesame productivity, early maturing sesame (Majigida) should be planted early enough within14th of April in Owerri Rainforest zone, Nigeria.

From this research findings, I recommend that –

1. Early identification and eradication through planting of early maturing cultivar (Maigijida) during early season planting (14th of April planting) will reduce pest abundance and damage since majority of insect pests associated with sesame cultivars can drastically reduce yield of the plant.
2. The most efficient and effective planting date for sesame production and pest infestation is 14th of April at the onset of rain, for plants to outgrow infestation before its spread and abundance.
3. The most efficient, early maturing and best performed sesame cultivar in Owerri rainforest zone in terms of growth and yield is Maijigida because of its high yielding attributes and is therefore recommended for adoption by farmers.

CONTRIBUTION TO KNOWLEDGE

1. Several known insect pests attack Sesame in the field especially at flowering and capsule stages of sesame cause severe damage to the crop which results to crop loss. Early identification and eradication through cultural practices, early planting and using early maturing cultivars will help increase productivity.
2. Growth has great influence on the yield and damage of Sesame.
3. Insect pests have significant influence on the growth and yield of Sesame.
4. The choice of cultivar has significant influence on the growth, pest infestation and yield of sesame.
5. Time of planting great influence on pest infestation, growth yield and damage of sesame.
6. Majigida is an early maturing, highly resistant and high yielding cultivar.

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APPENDIX

3.4. FIELD LAYOUT