

**EVALUATION OF THE SUSCEPTIBILITY OF FOUR GARDEN EGG (*Solanum
aethiopicum*) VARIETIES TO THE MAJOR FIELD INSECT PESTS**

BY

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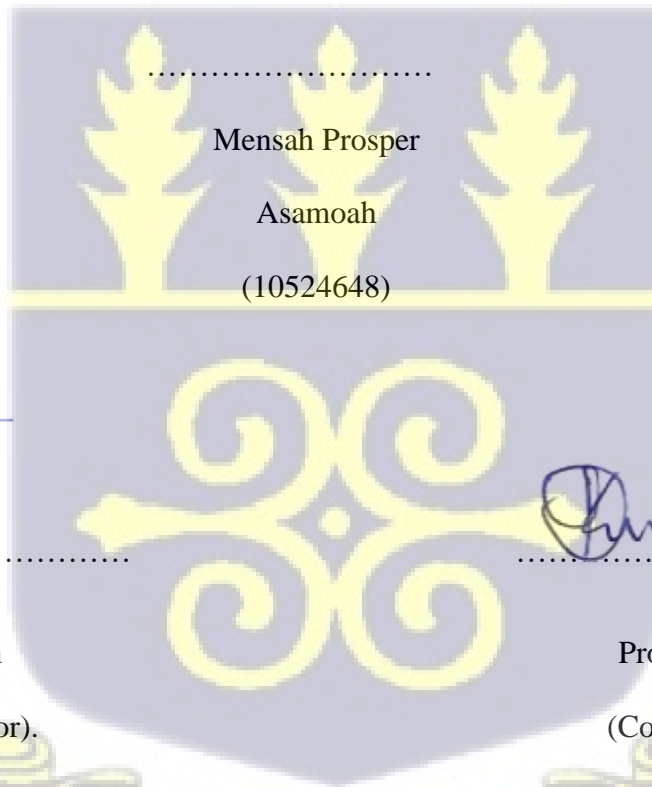
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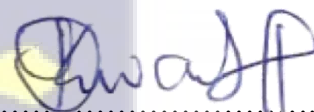
DECLARATION

This is to certify that this thesis, with exception of references, is the result of research undertaken (by, MENSAH PROSPER ASAMOAH, at the Forest and Horticultural Crop Research Centre (FOHCREC) towards the award of Master of Philosophy (M. Phil.) degree in Entomology at the African Regional Postgraduate Programme in Insect Science (ARPPIS), University of Ghana.



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INTEGRI PROCEDAMUS

DEDICATION

I dedicate this thesis to my parents Mr. Richard Kusi Mensah and Mrs. Theresah Arhin and to my beloved Grace Patience Affel.



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I am eternally grateful to God for his infinite grace over my life and throughout my studies.

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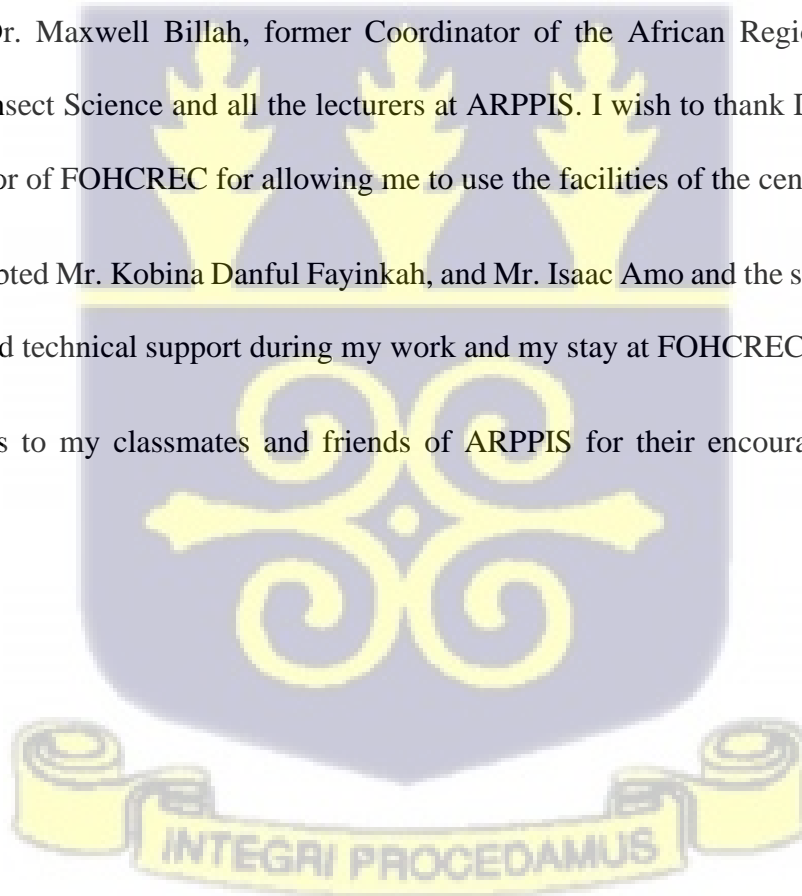
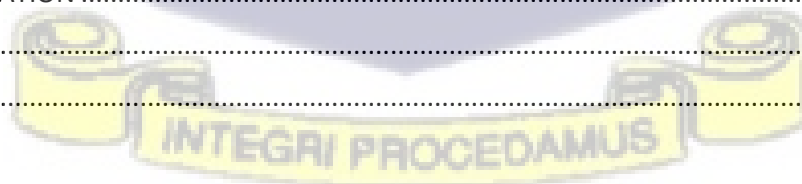


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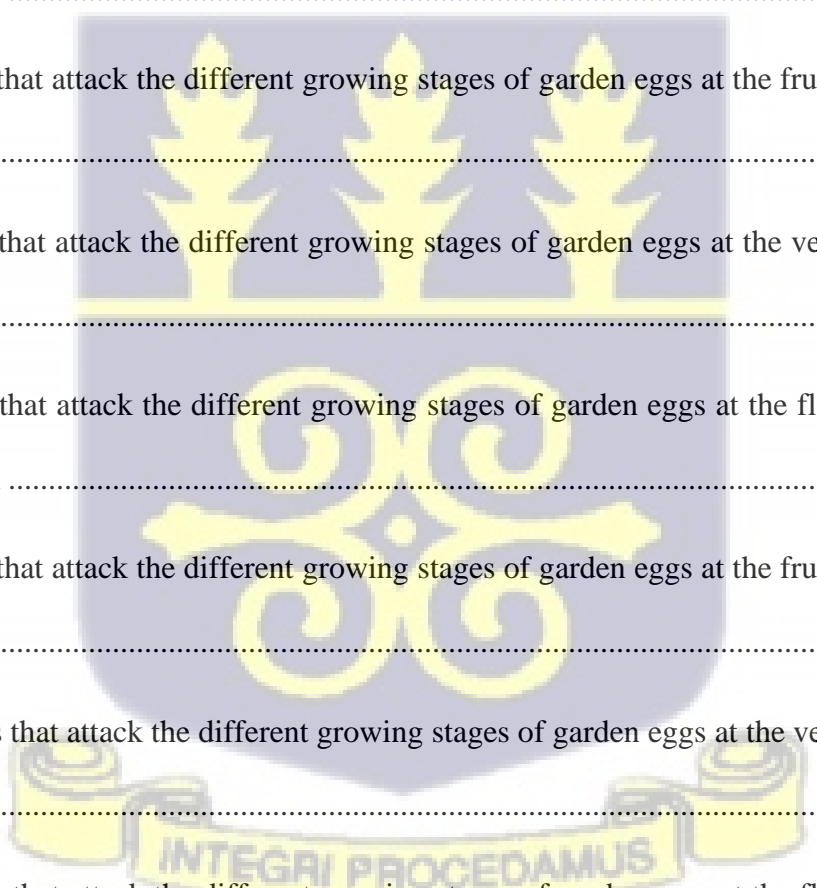


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ABSTRACT

Field experiments were conducted at Forest and Horticultural Crop Research Center, Kade, Ghana during the 2020 and 2021 cropping season. The susceptibility of four garden egg varieties against the major field insect pest under field conditions. The varieties namely: Aworoworo, Yorgbe, Round garden egg and Legon 1 varieties were laid in randomized complete block design with four replicates. The major insects observed to be causing varying degree of damage were *Aphis gossypii*, *Aphis craccivora*, *Urentius hystricellus*, *thrips tabaci* *Leucinodes orbonalis* and lastly *Zonocerus variegatus*. Insect pest infestation varied among the different varieties. The weekly population build-up of the insects per the different varieties were observed. The population of the insects was fluctuating from the time data collection began to harvesting. For insects such as the *Aphis gossypii*, *Aphis craccivora*, their numbers were high whilst insects such as *Zonocerus variegatus*, *Leucinodes orbonalis* were recorded in low numbers. In the minor season, *Urentius hystricellus* was found but was recorded in high numbers in the dry season however, their numbers reduced in the major season. Also, insect pests that attacked the different developmental stages of garden egg were observed. From the study, *Aphis gossypii*, *Aphis craccivora*, *Zonocerus variegatus*, *Thrips tabaci* and *Urentius hystricellus* were found to be attacking all the different growth stages of garden eggs. For *Leucinodes orbonalis*, it was found to be attacking the plant during the flowering and fruiting stages of the plant.

In assessing the resistance level in the varieties, none of the varieties was found to be resistant. Based on the susceptibility index, it was found that the Legon 1 variety recorded the highest susceptibility level and was grade as susceptible whilst the Yorgbe variety recorded the least index and was graded as being moderately resistant. The Aworoworo variety and the Round garden egg variety was graded moderately susceptible and moderately resistant respectively.

CHAPTER ONE

1.0 Introduction

Vegetables are fresh parts of plants which are consumed either raw, cooked, canned or processed (Belitz *et al.*, 2005). They are important component of human diet and their intake is necessary for good health and fitness (Aetiba & John, 2015). Vegetables are rich in vitamin A, vitamin C, folate as well as other nutrients (Muimba-kakonlogo, 2018). Due to the health-protective components found in vegetables, the cultivation of vegetables has become a priority in world food production and distribution systems. This focus on vegetables is particularly important for most people in sub-Saharan Africa as vegetables are nutritious (Muimba-kakonlogo, 2018). Garden eggs like all other vegetables is one of the most consumed vegetables in Ghana and West Africa at large (Owosu, 2012). Garden egg (*Solanum aethiopicum*) has a botanical association with tomato, pepper and potato and is a member of the family Solanaceae. It is common in Ghana, particularly in the forest area during the major and minor seasons. It is widely cultivated in Ghana (Owusu-Ansah *et al.*, 2001) and over 2 million hectares of land are allocated for its cultivation (FAO, 2007). This crop is consumed on a daily basis in Ghana especially in rural and peri-urban centres. The crop conforms well to high rainfall and hot-wet environments with high yields regardless of the fluctuation in weather pattern (Bonsu, 2017). Its cultivation has become necessary because it provides a source of income for households in rural areas due to the fact that 60% of their income come from garden egg production (Aetiba & John, 2015). It is reported that about 4,350 households in coastal forest and savannah ecological zones in Ghana are heavily engaged in the cultivation of garden eggs, leafy vegetables, tomato, pepper, onion and okra (Horna *et al.*, 2007). There seems to be a variation in the quality attributes of garden eggs such as colour, taste, size and shape. Garden eggs can be deep green, green, white, cream or yellow. Garden eggs have different size

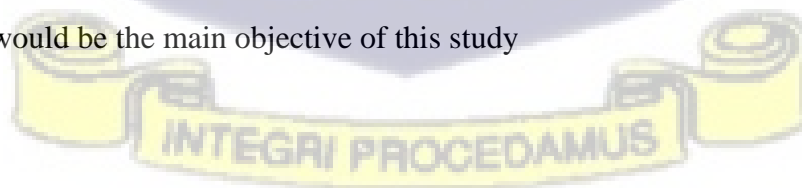
however, there seems to be a preference for medium-to-large sizes (Horna *et al.*, 2007). Taste is another important attribute of garden eggs. Garden eggs can have a blunt, sweet or bitter taste. According to Horna *et al.* (2007), round type garden eggs tend to be bitterer than elongated types. In terms of consumer preference, they normally adjust to what the market offers them however, generally, consumers prefer larger, fresh and white garden eggs but there also exist a market for garden eggs changed colour, aged and lost water (Horna *et al.*, 2007). The cultivation of local varieties of garden eggs help to preserve intra-species biodiversity however in Ghana, there is no specific cultivar grown by farmers as farmers often have a mix of cultivars in their fields (Horna *et al.*, 2007). A study conducted by Horna *et al.* (2007) showed that farmers gave different names when asked about their preferred varieties with many of the names depicting where they are grown. The common varieties grown include aworoworo, obolo, white beauty, antropo, or yorgbe. Others also gave more descriptive names such as long white, round white, white local, black local or adopt the name of the places they are produced such as kwashie, kpando, techiman and agogo. The round white garden egg can also be called obolo, akutuku, tin toro, kukruwa, Techiman or Kpando. This variety is cropped mainly in the Greater Accra, Central and Volta regions of Ghana. Other varieties such as Aworoworo is commonly grown in Ashanti, Brong Ahafo and Central regions whilst Yorgbe is commonly cropped in the Volta region. Even though much of the cultivation of garden eggs goes to the local market, small amounts are exported to Europe (Horna & Gruère, 2006). According to Bonsu (2017), there was an increase in the exportation of garden egg in Ghana from 500 metric tons in 1996 to 1,867 metric tons in 2003. Again Ministry of Food and Agriculture (MoFA, 2010) reports that the production of garden eggs is estimated at 15 metric tonnes/hectare/year but its production averages 8 metric tonnes/hectare/year. Although the cultivation of this crop has the potential to contribute to poverty alleviation and improve the

livelihoods of rural and peri-urban households, pest and diseases seems to be a major constraint in the production of garden egg (Owusu-ansah *et al.*, 2001). Garden eggs are infested worldwide by a vast number of insect pests. According to Owusu-ansah *et al.* (2001), the pest of garden eggs include *Selepa docilis* Butler (Lepidoptera: Noctuidae), *Scrobipalpa blapsigona* Myerick (Lepidoptera: Gelechiidae), *Urentius hystricellus* Richter (Homoptera: Tingidae), *Thrips tabaci* Lindemann (Thysanoptera: Thripidae), *Bemisia tabaci* (Hemiptera: Aleyrodidae), *Tetranychus urticae* (Trombidiformes: Tetranychidae), *Empoasca decipiens* (Hemiptera: Cicadellidae), *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae), *Aphis gossypii* Glover (Hemiptera: Aphididae). A study of vegetable pests showed that the most harmful pest in many major egg-producing countries are the shoot and fruit borers (Owusu, 2012). Significant damage is caused by the shoot and fruit borers where the larvae tunnels within fruit thereby reducing the quantity and quality of the marketable fruit yield (Bonsu, 2017). It is estimated that the larvae causes about 70% damage to garden eggs (Netam *et al.*, 2018). Due to damage caused by these insect pests, the use of pesticides to confer protection against insect pests is one of the widely used management method (Owusu-ansah *et al.*, 2001). Their use offers numerous advantages especially in crop production. Despite these benefits, the use of pesticides particularly synthetic insecticides have deleterious effects on humans, beneficial and non-target organisms as well as on the environment. In order to achieve sustainable vegetable production, it is important to find alternative methods that are less harmful to the environment. As a result, integrated pest management (IPM) where different management practices are used is the best in managing insect pests. Control methods including cultural control, physical or mechanical control, biological control, host plant resistance among other control methods are integral part of IPM. Host-plant resistance has been found to interact well with IPM programmes. It represents the ability of crop plants to restrict, retard or overcome

pest infestations (Dent *et al.*, 2003). Use of resistant varieties has been found to be important part of insect control because in this control method, the benign environment is not harmed and it interacts well with biological control. It is very useful in countries where holdings are usually small and farmers may not be able to afford other methods of pest control (Selvanarayanan, 2019).

1.1 Justification

In Ghana, chemical control is commonly used to manage pests that damage garden eggs. Different types of insecticides including malathion, perfeckthion, cypermethrin, diaxocarb, roxion are used to control these pests (Owusu-ansah *et al.*, 2001). Despite the ability of insecticides to minimize insect pest harm, indiscriminate use of insecticides poses several problems. Vegetables are mostly consumed fresh and the use of insecticides to confer protection can have serious health implications on humans, affect beneficial and non-target organisms and also lead to the development of resistance in insects. The use of resistant varieties forms the basis for the integrated management of pests to complement other control methods. The basis on which this IPM structure was developed was through varietal resistance to insect pests. The use of resistant varieties can be effective and its inclusion in insect pest management programs can reduce the effect of pests (Ayyaz *et al.*, 2017). Screening for resistant varieties to insect pest infestation, their ability to cause damage to different growing stages of the crops and also the level of damage associated with insect pest infestation would be the main objective of this study



1.2 Objectives

1.2.1 Main Objective

To evaluate the susceptibilities of the commonly cultivated garden eggs varieties in Ghana to the major field insect pests.

1.2.2 Specific Objectives

1. To determine the assessment of population buildup of the major insect pests of garden eggs and the different growing stages of the garden eggs they attack i.e. vegetative, flowering and fruiting stage in the field.
2. To determine the level of damage caused by insect pests to the different varieties of garden eggs.
3. To assess oviposition, larval development and adult emergence of the major fruit and shoot borers.
4. To assess the growth and yield parameters of the different varieties of garden eggs.



CHAPTER TWO

2.0 Background

2.1 The biology of garden eggs

The garden egg *Solanum aethiopicum* belongs to the solanaceae family and the tribe Solanaea which includes several species such as tomato, pepper, potato among others (Frery, 2007). It is commonly found in Asia and Tropical Africa. Eggplant is a woody plant and develops several branches based on a roughly dichotomic ramification pattern (Frery, 2007). Garden egg is the result of the domestication of one wild and one semi-domesticated solanum species that grow in tropical Africa (Grubben & Denton, 2004). The crop is widely cultivated across the continent especially in West and East Africa (Horna *et al.*, 2006). Garden egg has four main cultivar groups including Gilo, Kumba, Shum, and Aculeatum. According to Horna *et al.* (2006), the first three are the most important in Africa with the Gilo and Kumba cultivated for their fruits whist the shum is cultivated for their leaves. Species such as *Solanum melongena* is a bushy plant and reaches a height of between 60cm and 120cm when mature. Frery (2007), reports that variation exist in hairiness, anthocyanins and prickles on the vegetative parts. Its flower type is 5 merous i.e. 5 sepals, 5 petals, 5 stamen however 6, 7 and 8-merous flowers are normally found in globose and round fruited types (Frery *et al.*, 2007). Generally, eggplant is regarded as being autogamous but in warm conditions and open conditions, insects visit the flowers and the allogamy rate is 70% or higher. According to Daunay *et al.* (2004), the presence or absence of chlorophylls and anthocyanins have been reported to control a variety of fruit colours. It has a fibrous or lignified root system and the leaves are simple, lobed, large and alternate on the stems. They produce fleshy berry fruits which differ in shape (round, intermediate, long, snake-like) and size (Owosu, 2012). The fruit colour is either purple, white, green, yellowish or striped with white and yellow. Eggplant

usually undergoes self-pollination, but instances of cross-pollination have been reported and it is recorded to be as high as 48% due to its heterostyly (Owosu, 2012). Garden egg grows best in well drained loam or sandy loam soil with a fair amount of organic matter. Soil pH of 5.8 and 6.5 are best for growth. Usually, moderate amount of fertilizer should be applied to garden egg.

2.2 Distribution and varieties of eggplant

S. aethiopicum is a widely cultivated species that exists but have many importance in sub Saharan Africa and are less known (Daunay, 2008). Species such as *Solanum melongena* is an old world crop that is among the solanaceous species that is cultivated. It is known as eggplant in the United States and aubergine in England and France. However, in its home country i.e. where it has been domesticated for many years and also where the great diversity of this crop exists, it is called brinjal (Daunay, 2008).

Arabic traders introduced *Solanum melongena var* to South Europe and the Mediterranean area (Aetiba & John, 2015). The crop is widely grown and common in the temperate and tropical regions of Asia, Middle East and the parts of the Mediterranean basin but presently, it is cultivated worldwide.

According to Daunay (2008), evidence points to the fact that based on studies on morphometrics, crossability, seed coat scanning electron microscopy, leaf isozymes, and seed protein electrophoresis on a large number of accessions showed that the ancestral forms of *S. melongena* emerged from Africa tropics and the Middle East. In these regions are found the closest wild relatives of *S. melongena* which are part of the *S. incanum* aggregate. The *S. incanum* aggregate includes four groups namely

1. Group A (*S. campylacathum*) which is found in the East African tropics
2. Group B (*S. delagoense*) which is distributed in South-Eastern Africa
3. Group C (*S. incanum sensu stricto*) is found in North-Eastern Africa and Middle East
4. Group D (*S. lichtensteinii*) is found in South-East Africa.

Garden eggs derive its name from the shape of the fruits which are white in colour and looks very much like chicken eggs. Under species melongena, three varieties exist. These include the egg-shaped cultivars which are grouped under var. *esculentum* (common eggplant), var. *Serpentinum* which is the long and slender type and lastly var. *depressum* (dwarf eggplant) which are small (Aetiba & John, 2015).

2.3 Use and the nutritional content of eggplants

It is reported that *Solanum melongena* var is one of the most consumed vegetable in Ghana and West Africa at large (Owosu, 2012). The unripe fruit of eggplant is used to prepare a variety of dishes around the world. This crop is consumed on a daily basis in Ghana especially in rural and peri-urban centres. It also provides a source of income for households in rural areas due to the fact that 60% of their income come from garden egg production (Aetiba & John, 2015). Again, garden egg has medicinal purposes. Generally, garden egg is regarded as a low calorie vegetable. Garden egg contains vitamins, minerals, proteins, fiber and other important nutrients such as phenolic compounds and flavonoids which are good for human health (Daunay, 2008). The phenolic compounds such anthocyanins and phenolic acids eggplant contain including alkaloids have biological and pharmaceutical properties (Gürbüz *et al.*, 2018). The Eggplant has been used in the traditional medicines because of its high level of alkaloids. Its tissue extracts are used for the treatment of asthma, bronchitis, cholera, and dysuria and fruits and leaves are beneficial in

lowering blood cholesterol. Recently, it has been shown that eggplants also possess antimutagenic properties (Kole *et al*, 2010).

2.4 Garden egg production in Ghana

The African garden egg is one of the most important vegetables in Ghana and West Africa. This crop that is particularly diverse in Ghana is not only consumed on a daily basis by rural and urban families but also represents the main source of income for many rural households in the country (Bonsu, 2017). According to Daunay (2008), an estimated 31 million tons of eggplant was produced worldwide. From this data, China had the highest production amounting to 16.5 million, and India produced about 8.2 million tons of eggplant. Countries such as Egypt produced 1.1 million tons, Turkey produced 900,000 tons where as Japan produced 400,000 tons. However, according to Taher *et al.* (2017), current data suggests that the annual production of eggplant is around 50 million tons with a net value of US\$10 billion from the production eggplant which makes it one of the economically important solanaceous crop after potato, tomatoes, pepper and tobacco. Over 90 percent of eggplant is produced in seven countries including China, Egypt, Turkey, Japan (Weese & Bohs, 2010).

In Ghana, national production is around 30,000 tons exact number are not available for the whole country. Data exists for the Greater Accra Region where urbanization has contributed to a steady decline in the total output, areas cultivated and yield

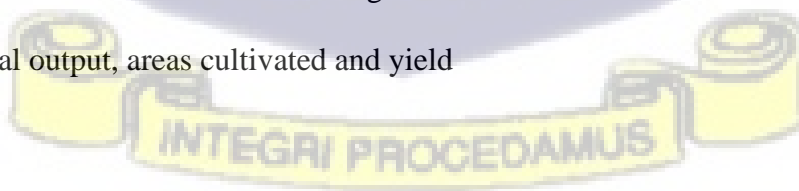


Table 1: Production performance of garden egg in the Greater Accra Region

Year	Production (t)	Area (ha)	Yield (t/ha)
1993	10,100.00	3,100.00	3.26
1994	12,250.00	3,140.00	3.90
1995	1,296.40	280.00	4.63
1996	Not available	Not available	Not available
1997	6390.00	809.00	7.89
1998	1613.00	461.00	2.62
1999	1527.00	509.00	2.25
2000	1470.00	491.00	2.19
2001	916.00	322.00	1.80
2002	962.00	322.00	1.80
2003	531.00	178.00	1.79
2004	570.00	190.00	1.97

Source: Horna *et al*, 2007

According to Horna *et al.* (2007), garden egg is a profitable venture especially in the Greater Accra Region, where production yields more and prices are high and fluctuates a great deal in the year. Some producers are close to the Volta River Dam and can still produce even in the dry season as result, they are able to get high returns from their venture.

2.5 Constraints to eggplant production in Ghana

There many constraints faced by farmers in the production of garden eggs including the fact that it is labour intensive especially during the harvesting period, limited amount of fertilizer and pesticides but prime among is the insect pest infestation. Due to the fact that garden eggs have a relatively long growth period, it remain exposed to pests, weeds and diseases than other vegetables. Garden egg is attacked by numerous pests including mites, whiteflies, aphids, eggplant fruit and

shoot borer, thrips, leafhopper, spotted beetles, leaf roller, stem borer, blister beetles among other pests (Taher *et al.*, 2017). It has been reported that about 146 species of insect pests are present on eggplant of which 58 species are known to feed on the different parts of the plant.

Among these insects, the most important and damaging insect pest is the eggplant fruit and shoot borer (*Leucinodes orbonalis*) (Kotey *et al.*, 2013). The larvae of this insect feed inside the fruits and shoots leading to withering and drying of the shoots and fruits making it not wholesome for consumption (Owosu, 2012). Other important pests include the eggplant budworm which oviposits in the flowers. Other insects such eggplant lacebug, variegated grasshopper among other insects are known to be defoliators of garden egg (Owusu Ansah *et al.*, 2001).

2.6.1 Major pests of garden eggs

2.6.1.1 Aphids

These are small insects that exist in groups on the underside of leaves, flower buds and on young shoots. Adult aphids have a colour which varies from ash-gray, black, brown, and green to yellow. On the dorsal side of the body, there exist a black-coloured cornicles (Bonsu, 2017). Winged and wingless forms of aphids exist. Wingless forms are more common with the winged forms produced under high population density conditions among others (Aetiba & John, 2015). Aphids do not lay eggs however they reproduce through parthenogenesis and are viviparous. Each adult female can produce 20 nymphs a day which matures into adult in a week (Srinivasan, 2009). They are r-strategists that tend to be mobile and reproduce rapidly. Generally, r-strategists utilizes the resources available to them making them achieve the pest status leading to the destruction of the host before dispersing. According to Wakil *et al.* (2017), aphids damage crops in three ways by sucking the sap from the plant which weakens the plant leading to lower quantity and quantity of

fruit. Secondly, they produce honeydew which can cover the leaves and fruits. The sugary substance produced as a result makes it suitable for the growth of sooty mold fungi. On the foliage, this sooty can be thick that it can reduce the photosynthetic activity on the leaves resulting in poor quality and quantity of fruit. The third and costly type of damage that aphids are efficient vectors of a number of plant viruses.



Plate 1: Aphids on the underside of garden egg leaf



2.6.1.2 Eggplant fruit and shoot borers (*Leucinodes orbonalis*)

Leucinodes orbonalis belongs to the family Pyralidae and genus *Leucinodes*. This insect occurs in tropical Asia. The adult lay 80 to 253 eggs usually on foliage (Owosu, 2012). Laying of eggs occurs in the night usually on the lower surfaces of young leaves, stems, and flowers among others. Eggs of *L. orbonalis* are normally elliptical, flat and about 0.5mm in diameter (Owosu, 2012). The eggs when laid are creamy white but turns red before they hatch. Pre oviposition period is 1.2 and 2.1 days whilst oviposition periods are 1.4 and 2.9 days. In 3 to 6 days, eggs hatch and larvae bore into soft shoots, flowers or fruits (Owosu, 2012). Although there are reports of larvae undergoing 6 instar stages, the larvae usually go through 5 instars. During the larval stage, the larvae go through five instars. The larvae measures about 18 to 23mm in length. Pupation occurs in silken cocoons on plant debris or fallen leaves on the soil surface near the base of the plant. Depending on temperature, the pupal period lasts between 6 to 17 days (Owosu, 2012). The adults are known to emerge at night. They measure about 20 to 22mm. Females are somewhat bigger than the males and the females have abdomen that looks pointed and curled upwards. Males on the other hand have a blunt abdomen. The adult moth is white but there is a pale brown or dark spots on the thorax and abdomen. The moth has white wings with pink or blue spots and have small hairs on the apical and anal margins. There exists a number of black, pale and light brown spots on the forewings (FAO, 2003).

The larvae is considered as the most damaging stage of the insect. The larvae contributes more than 75% damage to garden eggs reducing its quality thereby affecting its price considerably (FAO, 2003). At night, the adult comes to lay eggs on the underside of leaves, stems, flower buds or calyces of the fruit. After hatching, the larvae bores into adjacent shoots, fruits or flower. After boring into shoots or fruits, they begin to feed within the fruit or shoot and block the entrance hole

with frass. Feeding activity of the larvae leads to the wilting of the young shoots. The damaged shoots drop off altering plant growth and as a result reducing the size and the number of fruits. Plants produce other shoots to compensate for lost shoots however plants take longer period to produce flowers and fruits (Biswas *et al.*, 2018). It should be noted that, the larvae prefer the fruit to shoots and damage done is not reversible.



Plate 2: Adult of *L. orbonalis*.



Plate 3: larvae of *L. orbonalis*.



Plate 4: Pupae of *L. orbonalis*.



Plate 5: An affected shoot showing signs of drooping.



Plate 6: Larva of *L. orbonalis* feeding in the shoot of garden egg.



Plate 7: Larva of *L. orbonalis* feeding in the fruit of garden egg.

2.6.1.3 *Thrips tabaci* (Thrips).

Thrips are polyphagous species, and it is known as pests of Cucurbitaceae and Solanaceae (Capinera, 2020). They are very small insect about 1mm long and are brownish-yellow in colour (FAO, 2003). They have two pairs of long narrow wings which are fringed around the edges with hair-like structures. Nymphs are pale yellow, almost similar to adults but smaller and wingless (Capinera, 2020). Thrips are active during the day and can be found on the underside of leaves or at the base of plants however pupae are found in the soil (FAO, 2003). They lay eggs in notches of up to 100 eggs in the stem of young plants and in tissue of leaves. Eggs takes 4-10 days to hatch. Although thrips feeds on cucurbits, but occasionally infests garden eggs. They are known to cause damage to garden eggs in the dry season. Thrips are known to feed on tomato, potato, pepper, watermelon, cucumber among others. Damage caused by thrips is done on the underside of leaves where they look brown and dried up. They are responsible for feeding on the sap of leaves and in heavy infestation can cause stunted growth of the leaves, wilted shoots and can reduce fruit size and possibly cause death of the plant (FAO, 2003). Although, feeding usually occurs on the foliage, scars, deformities and abortion have been reported in the fruits (Capinera, 2020).

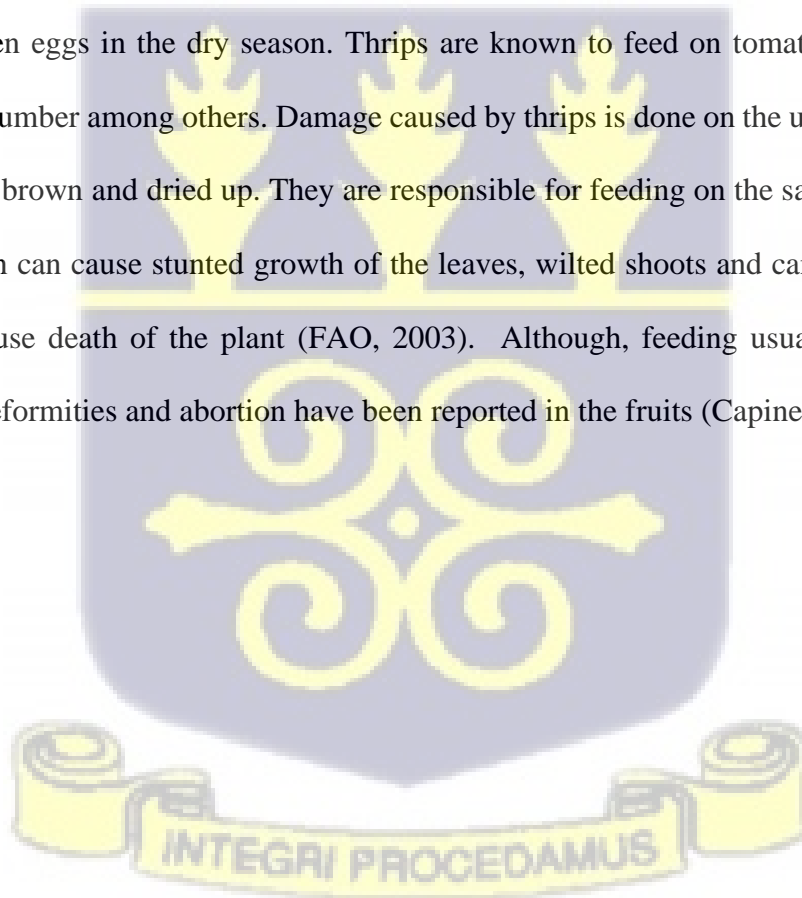




Plate 8: *Thrips tabaci* found on the underside of a leaf

2.6.1.4 *Urentius hystricellus* (Eggplant lacebug).

It is a small bug (about 3 mm in length), brownish in colour. Its body is covered with spines and the wings show a distinct lace-like appearance. Nymphs resemble adults, but are initially wingless, developing wings as they grow. Both adults and nymphs are usually found in groups on the underside of leaves. They suck sap from the leaves causing whitish to yellowish mottled patches on the leaves. In case of serious infestations the leaves turn entirely yellow and drop off. Attacked leaves are speckled with small black shiny spots, which are the faeces of the bugs. Damage to leaves is done by both adults and nymphs however, nymphs are localized whilst adults fly to other plants to cause damage.





Plate 8: Nymphs of *Urentius hystricellus* on the underside of a leaf.



Plate 9: Leaves of garden egg showing yellow-molted patches after feeding by *Urentius hystricellus*.



Plate 10: Leaves of garden egg dropped off after the feeding activities of *Urentius hystricellus*.

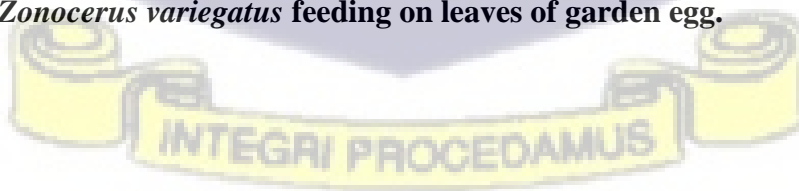
2.6.1.5 *Zonocerus variegatus* (Variegated grasshopper).

Zonocerus variegatus is a species that is native to tropical West and Central Africa. In Ghana, Ivory Coast, Nigeria, Congo Brazzaville, Southern Benin, and the Sahel region, it is a significant agricultural pest. It is a polyphagous insect that feeds on a variety of crops. Both nymphs and mature *Zonocerus variegatus* cause crop damage, most notably cassava, groundnuts, and vegetables, and it has been linked to the spread of mosaic viruses of cowpea and okra. They are

active during the day and spend the night and cooler hours of the day resting on crop leaves. Although it primarily feeds on cassava, this pest has also been found to feed on vegetables, including garden eggs, where it can cause a 25–80% yield loss (Kekenou *et al.*, 2005). It is considered an important pest in Nigeria, Ghana, and the Ivory Coast, among other countries, due to the damage it causes to crops. The adult and nymph of the *Zonocerus variegatus* chew on crop leaves reducing the area available for photosynthesis.



Plate 11: Adult *Zonocerus variegatus* feeding on leaves of garden egg.

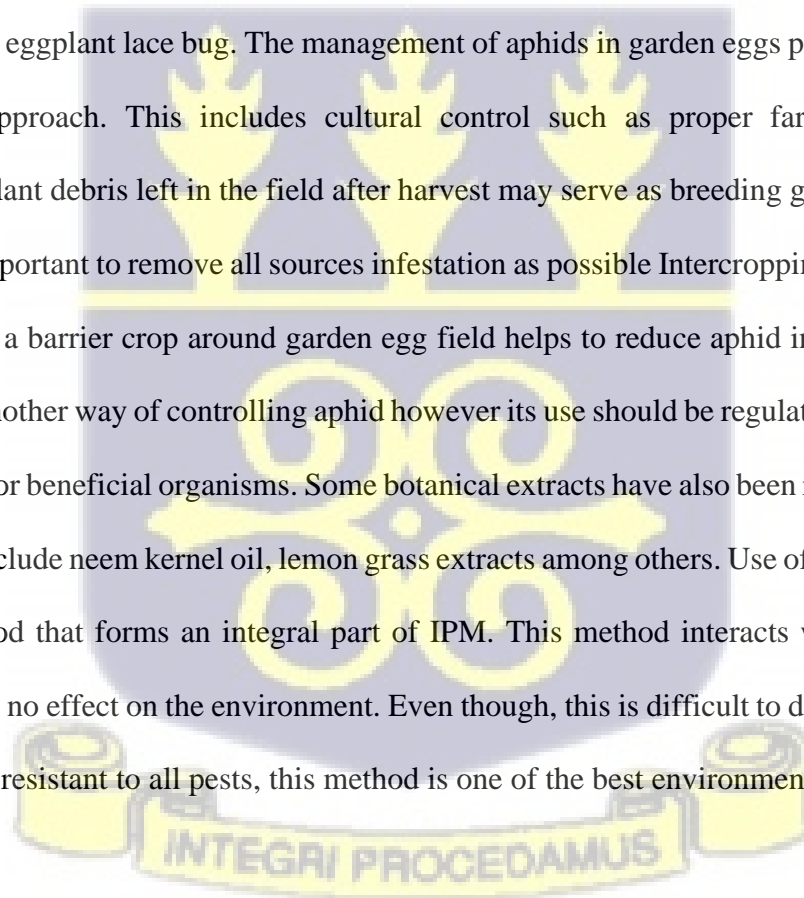


2.6.2. Integrated pest management of pests of garden eggs

Garden egg is known to have a long growth period and as a result, remains in the field for a long time. This exposes the crop to variety of insect pests, diseases among others. Consequently, the use of one control method would not be ideal to take care of the numerous pests that attack this crop. The use of a particular management strategy to control a particular insect would not be able to deal with other pests. Therefore, integrated pest management that requires a holistic approach to controlling insect pests should be adopted. This method works better when together than separate.

Integrated pest management approach involves methods such as cultural, biological, mechanical, chemical control among many other control methods. Cultural practices such as harvesting of fruits promptly, removal of infested shoots and shoots and picking and crushing larvae or pupae of insect pests can help to control them. For eggplant shoot and fruit borers, several management practices have been employed to manage the fruit and shoot borers. This includes the breaking clods of the soil before transplanting. This helps to reduce population. Also avoid planting over-aged seedlings. Seedlings should not remain in the nursery for too long as they become weak due to competition for space, light and nutrients (FAO, 2003). Seedlings when crowded can be a breeding ground for fruit and shoot borer. Sanitation practices such as cleaning the soil to remove fruit and shoot borer pupae should be encouraged (Dent, 2003). Intercropping with herbs such as *Nigella sativa*, *Foeniculum vulgare*, *Coriandrum sativum* help to reduce infestation of fruit and shoot borer. Again, natural enemies help to reduce insect pest of garden egg. For instance studies have shown *Trathala flavo-orbitalis* an ichneumonid wasp to be a parasitoid of eggplant fruit and shoot borer. *Trichogramma chiloni*, *Eriborus sinicus*, *Cotesia sp.* have also been reported to be a parasitoid of eggplant fruit and shoot borers (FAO, 2003). For thrips, use of resistant varieties is one way of controlling thrips infestation. Other methods include mulching which has the ability of reducing

damage caused by thrips. White plastic or silvery plastic mulch has the potential to reduce thrips infestation however, straw mulch can be used. Flooding the field can also be used to manage thrips. This has the potential of reducing thrips population presumably drowning thrips pupae in the soil. The use of insecticides is also recommended for the control of thrips however its use should be regulated because there is strong indication that melon thrips abundance and damage are increased by the application of some insecticides (Capinera, 2020). Natural enemies such as the predatory mite, *Amblyseius cucumeris* feeds on various thrips species. The lacewings, *Chrysopa carnea* is the most common species that feed on thrips (FAO, 2003). For eggplant lacebug, the use of synthetic insecticides have shown to be effective against this insect. Also neem products are effective against eggplant lace bug. The management of aphids in garden eggs production requires an integrated approach. This includes cultural control such as proper farm sanitation and intercropping. Plant debris left in the field after harvest may serve as breeding grounds for aphids. It is therefore important to remove all sources infestation as possible Intercropping rows of another crop or planting a barrier crop around garden egg field helps to reduce aphid infestation. Use of insecticides is another way of controlling aphid however its use should be regulated as it has effects on other natural or beneficial organisms. Some botanical extracts have also been reported to control aphids. These include neem kernel oil, lemon grass extracts among others. Use of resistant varieties is another method that forms an integral part of IPM. This method interacts with other control methods and has no effect on the environment. Even though, this is difficult to develop as resistant varieties are not resistant to all pests, this method is one of the best environmentally safe strategy



2.7. The use of host plant resistance in pest management

Over the years, many efforts have been channeled towards the development of insect resistant varieties. Using resistant varieties are compatible and can act synergistically with other control measures such as cultural, biological, mechanical control among others. Host plant resistance has been identified as one of the self-perpetuating and cost-effective methods used in integrated pest management programmes. This method has provided the basis on which most integrated pest management structure are built. Resistance in a crop cultivar is enhanced through the presence of biophysical or biochemical factors (Dent, 2003).

Use of resistant varieties have been found to be important part of insect control because in this control method, the benign environment is not harmed and it interacts well with biological control. Again, use of resistant varieties are very useful in countries where holdings are usually small and farmers may be able to afford other methods of pest control. Use of resistant varieties may also enhance the efficacy of insecticides

Since the 1800, many efforts have led to the development of insect resistant varieties. Early maturing varieties of wheat were developed to evade damage by the Hessian fly, *Mayetiola destructor* (Say) in 1788 (Selvanarayanan, 2019). The discovery of the wheat cultivar “Underhill” in New York as resistant to Hessian fly was also made. “Winter Majetin” and “Northern Spy” which apple varieties were identified to be resistant to woolly aphid *Eriosoma lanigerum* (Hausmann).

In rice production, the International Rice Research Institute (IRRI) in Philippines developed varieties that are resistant to the key insect pests and diseases of rice. Consequently, varieties such

as IR36 was identified to be resistant the brown planthopper, green leafhopper, stem borers, bacterial blight, tungro among many other pests and diseases (Selvanarayanan, 2019).



CHAPTER THREE

3.0 Materials and methods

3.1 Experimental site

The experiment was conducted at the Forest and Horticultural Crop Research Centre (FOHCREC) located within the forest agro-ecological zone in the eastern region of Ghana. FOHCREC is located at Okumaning-Kade, in the Denkyembour district in the Eastern of region of Ghana. The centre is located (06° 05'N; 0° 05'W; 90 km NW) in the semi-deciduous forest agro-ecological zone. It is characterized by a semi-equatorial climate with a bimodal rainfall ranging between 1200-1500 mm. The major rainy season starts from mid-March to July with a peak in June-July, with the minor rainy season from September to mid-December with a peak in September-October. However, the region experiences some rainfall every month of the year. The mean annual temperature range at this location is 25-38°C. The Relative Humidity is around 70-80% for most parts of the year.

3.2. Varieties used and source of seeds

The varieties of garden eggs used were local varieties which were obtained from the Forest and Horticultural Crop Research Centre. The varieties used for this study include

Aworoworo: this variety is elongated and has a tear-drop shape. It is commonly grown in the Ashanti, Central and Volta regions of Ghana (Horna *et al.*, 2007).

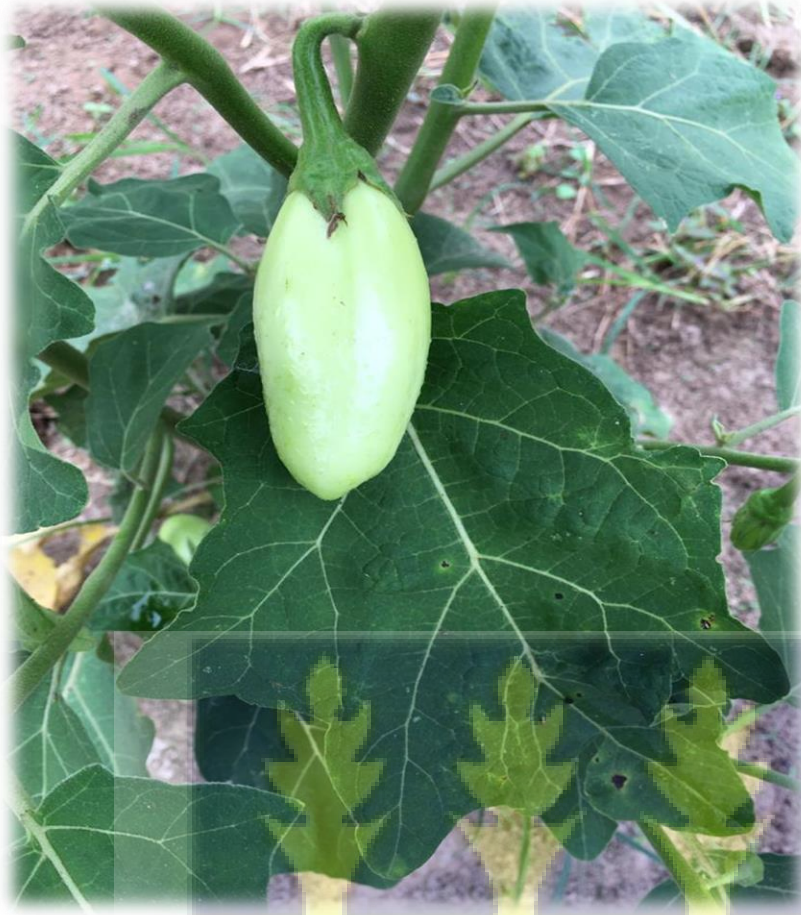


Plate 13: Aworoworo garden egg variety

Yorgbe: this variety look very similar to aworoworo but is bigger and assumes a more triangular shape. It is broader at the stem insertion and narrower at the other end (Horna *et al.*, 2007).





Plate 14: Yorgbe garden egg variety

Round garden egg: based on the area, the round garden egg can be called akutuku, tin toro, kukruwa, Techiman, Kwashie, or Kpando irrigated variety (Horna *et al.*, 2007).





Plate 15: Round garden egg variety.

Legon 1 variety: this is an advanced line bred at the University of Ghana, Legon, hence the name. It is one of the widely cultivated variety and it is an interspecific cross between the common eggplant and the African garden egg (Horna *et al.*, 2007)





Plate 16: Legon 1 variety of garden egg.

3.3. Nursing of garden eggs seedlings

Seed trays were used to nurse the seeds of all the varieties of the garden eggs. Watering was done manually with a watering can, twice daily to keep the soil moisture constant. Nursery practices were carried out until seedlings were transplanted onto the field.

3.4. Land preparation, field layout and experimental design

The experimental field was weeded and ploughed before lining and pegging was done.

The field was laid out in a randomized complete design (RCBD) with four treatments. Each plot measured 3.2m by 3m. Each plot had a total of 20 plants.

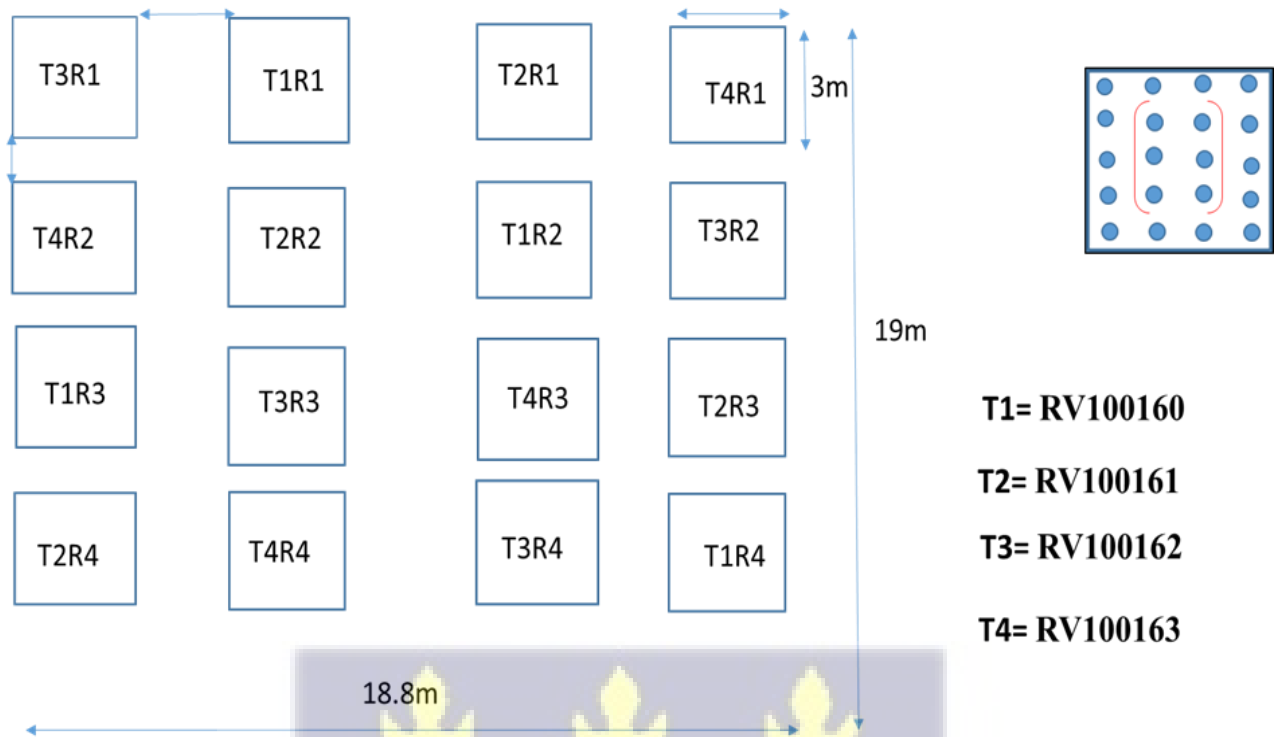


Figure 1: Experimental field layout

Normal agronomic practices including watering, fertilizer application, and weed control were carried out on the field. Weeding was done manually at two or three weeks interval. N-P-K 15-15-15 was applied to the plants at 4 weeks and 8 weeks after planting. No Insecticides were sprayed throughout the period of the study.

3.5 Data collection

3.5.1. The Assessment of population buildup of the major insect pests of garden eggs and the different growing stages of the garden eggs they attack i.e. vegetative, flowering and fruiting stage in the field.

Two weeks after transplanting, data on insect pests that visit the garden egg plants were taken. This was done by visual observation and setting of yellow pan traps for insect collection. A detergent was dissolved in the water to reduce the surface tension of the water and enhance the

arrestant effect of the trap. Visual observation was carried out in the morning between 6:00am and 8:00am on sampling days. The content of the trap from each plot were sieved separately through white nylon cloth. Data was collected until harvest, to see how the pest population build up per the various varieties. The major insect pest that attack the different developmental stages of garden eggs was surveyed. As a result, data from the vegetative stage through to the fruiting stage was surveyed.

3.5.2 The level damage caused by insect pests to different varieties of garden eggs.

Data was taken to assess the level of injuries done to the different varieties of garden egg. Damage caused to the leaves, shoots, flowers and fruits were taken throughout the period.

For the determination of damage caused to leaves, the number of new leaves produced by garden eggs every 14 days was taken and expressed over the number of damaged leaves. Leaves were considered damaged when about 75% of leaf was missing (Owusu-ansah *et al.*, 2001). Percentage leaf damage was calculated using the formula below

$$PLD = \frac{TLD}{TL_{14}} * 100 \text{ where PLD is the percentage of leaf damage,}$$

TLD is the total number of damaged leaves and TL_{14} is the total number leaves produced in 14 days.

Also, the average number of shoots and damaged shoots were recorded. Shoots here included the leaves and branches that were damaged as a result of the borer activities. Shoots were considered damaged based on the following;

- i. presence of frass

- ii. emergent holes on the shoots
- iii. Leaves and branches losing their freshness and drooping.

Percentage shoot damage was calculated using the using the formula below

$PSD = \frac{TSD}{TS_{14}} * 100$ TSD is the total number of damaged shoot, TS₁₄ is the total number shoot counted in 14 days and PSD is the percentage of shoot damage.

The flowers were also classified as damaged or undamaged when they could not develop into fruit and found either on the plant or fallen on to the ground (Owusu-ansah *et al.*, 2001).

To determine damage caused to fruits, fruits were collected and sorted into damaged and undamaged categories. A fruit was considered damaged based on

- i. The presence of feeding scar.
- ii. Frass.
- iii. Emergent hole in it.

The damaged fruit were dissected and examined for the presence of fruit borer larvae. In order to prevent cutting through larvae in fruits that showed no visible sign of infestation, fruits were kept for some time until larvae emerges to pupate.

Based on the damage caused to the fruit, the scale below was used for grading the level resistance as used by Selvanarayanan (2019)

Table 2: Susceptibility index table

Damage Level	Rating
No damage	Highly resistant
0 – 10.0	Resistant
10.1 – 20.0	Moderately resistant
20.1 – 30.0	Moderately susceptible
30.1 – 40.0	Susceptible
40.1 and above	Highly susceptible

3.5.3 Assessing the oviposition, larval development and adult emergence of the major fruit and shoot borers in the different varieties of garden eggs.

Fruits were harvested three times in each of the seasons. In order to prevent cutting through larvae in fruits that showed no visible sign of infestation, fruits were kept for some time until larvae emerged to pupate. Data on the number of exit holes on the fruits were taken for the different varieties of garden eggs. Also, Larvae were reared until they reached adult stage. Observation was made on the oviposition preference, larval development and adult emergence. Percentage adult emergence per the varieties was determined.

Percent fruit infestation was calculated using the formula (%) = $\frac{\text{Number of infested fruits}}{\text{Number of total fruits}} * 100$

3.5.3 Assessing the yield and growth parameters of the different varieties of garden eggs.

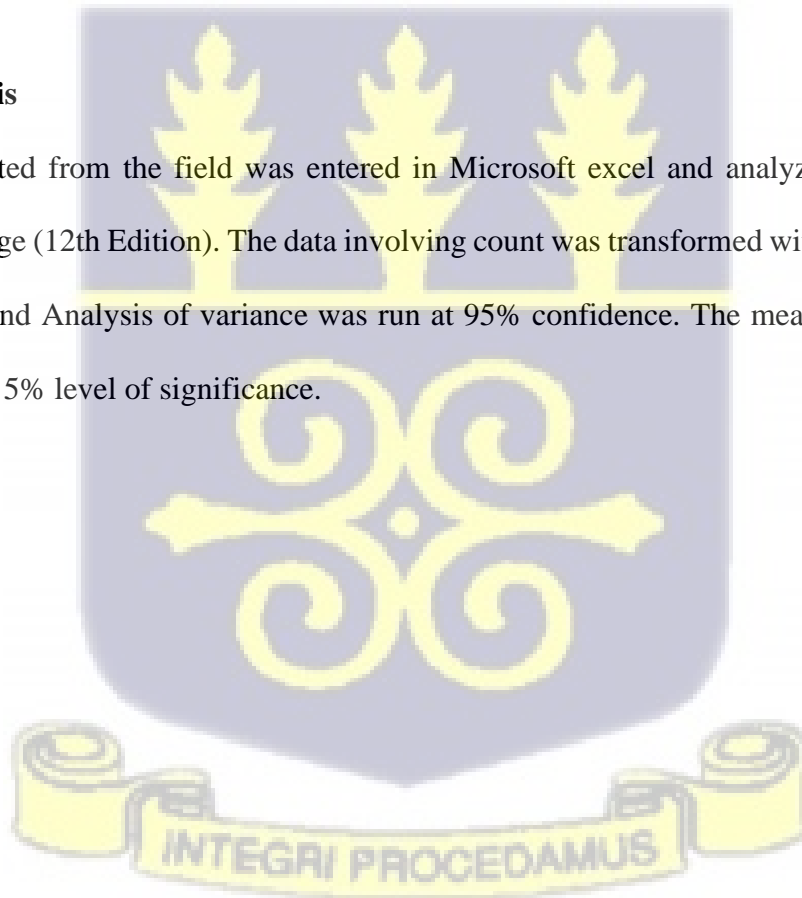
Data on yield of the different varieties of garden eggs were collected. Data for the yield that was taken included

- i. the number of fruits produced per plant
- ii. weight of fruits produced per plant
- iii. plant height

Yield was calculated using the formula $\text{Fruit yield/ha} = \frac{1000}{\text{Area harvested}} * \text{fruit yield/plot}$ (John & Aetiba, 2015).

3.5 Data analysis

The Data collected from the field was entered in Microsoft excel and analyzed with Gen Stat Statistical Package (12th Edition). The data involving count was transformed with square root data transformation and Analysis of variance was run at 95% confidence. The means were separated with LSD test at 5% level of significance.



CHAPTER FOUR

4.0 Results

4.1. The Assessment of the population build-up of the major insect pests of garden eggs on the field.

The study was carried out in three seasons, the minor raining season (October to December 2020), the dry season (February to April 2021) and then the major raining season (June to July 2021).

The major insect pests found during the study were Cotton aphid (*Aphis gossypii*), Black bean aphid (*Aphis craccivora*), thrips (*Thrips tabaci*), eggplant lacebug (*Urentius hystricellus*) and eggplant fruit and shoot borers (*Leucinodes orbonalis*).

The *Aphis gossypii*, *Aphis craccivora*, *Thrips tabaci*, *Leucinodes orbonalis* were found in all three seasons whilst the *Urentius hystricellus* was found only in the dry and major seasons (Table 4.1).

Table 3: Major insect pests of garden egg found during study

Insects	Present/Absent		
	Minor season	Dry season	Major season
<i>Aphis gossypii</i>	+	+	+
<i>Aphis craccivora</i>	+	+	+
<i>Thrips tabaci</i>	+	+	+
<i>Urentius hystricellus</i>	-	+	+
<i>Leucinodes orbonalis</i>	+	+	+

NB: + (Present) and (- absent)

4.1.1. *Aphis gossypii*

The population buildup of *Aphis gossypii* for the three seasons is shown in Fig 2 - 4. The population of *Aphis gossypii* was found to be fluctuating from the first week of sampling through to the seventh week. For the minor season, as shown in Fig 2, the Legon 1 had significantly higher infestation than the other varieties. The Legon 1 variety recorded the highest number (283.3) in the fourth week, but the numbers reduced in the subsequent weeks. On the other hand, the round garden egg variety showed the least infestation of aphid with the least number recorded in the sixth week (16.7). The Aworoworo variety and Yorge variety also recorded high numbers of 86.8 and 154.5 respectively.

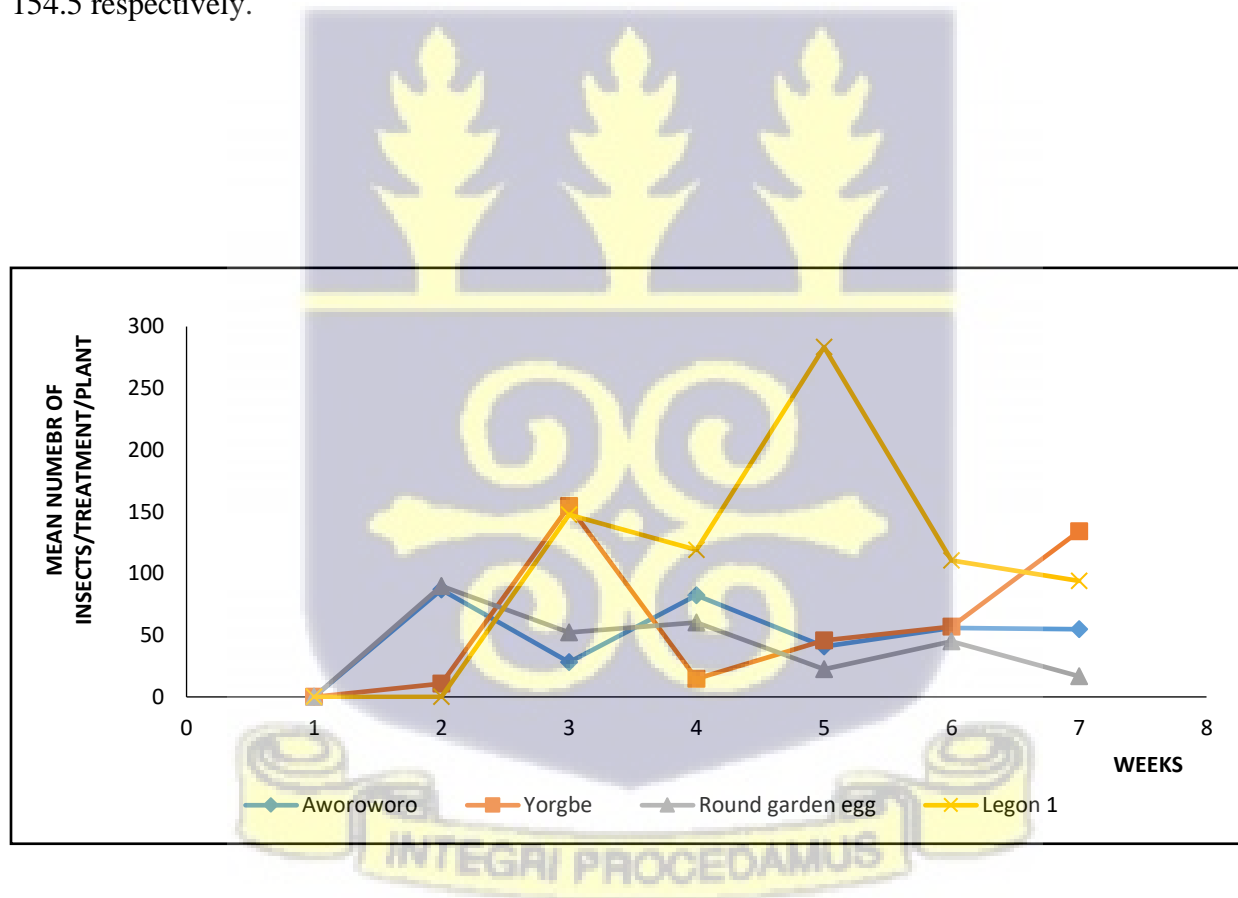


Figure 2: Mean number of *Aphis gossypii* during the minor season (October – December)

During the dry season, as shown in Figure 3, the Yorgbe variety recorded the highest mean number of the *Aphis gossypii* (535.5) with the highest being recorded in the third week (257.5). The round garden egg variety recorded the lowest number (364.2) of *Aphis gossypii* with lowest number recorded in the fifth week. The numbers of the *Aphis gossypii* was found to be fluctuating from the first week till the 7th week.

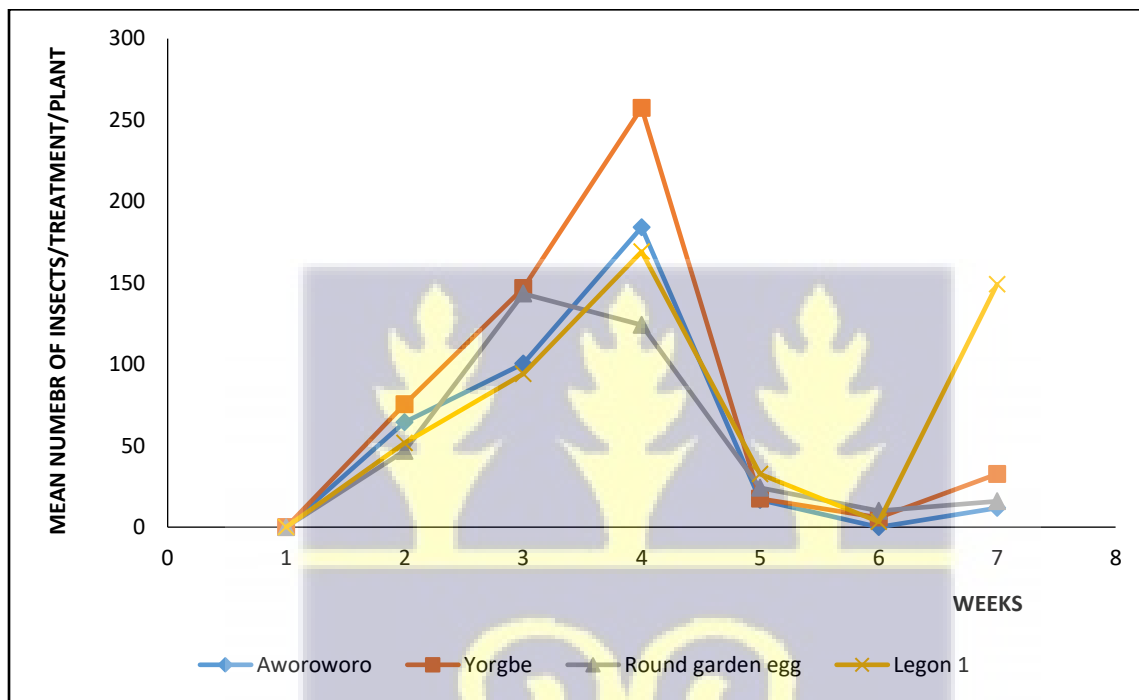


Figure 3: Mean number of *Aphis gossypii* recorded from February – April.

During the major season, as shown in Figure 4, the Legon 1 variety recorded the highest number of *Aphis gossypii* with an overall number of (201.6) and the highest number recorded in the fourth week (62.5). Also, the Yorgbe variety was the variety that recorded the least number of *Aphis gossypii* with an overall number of (90.8) and least number recorded in the third week (10).

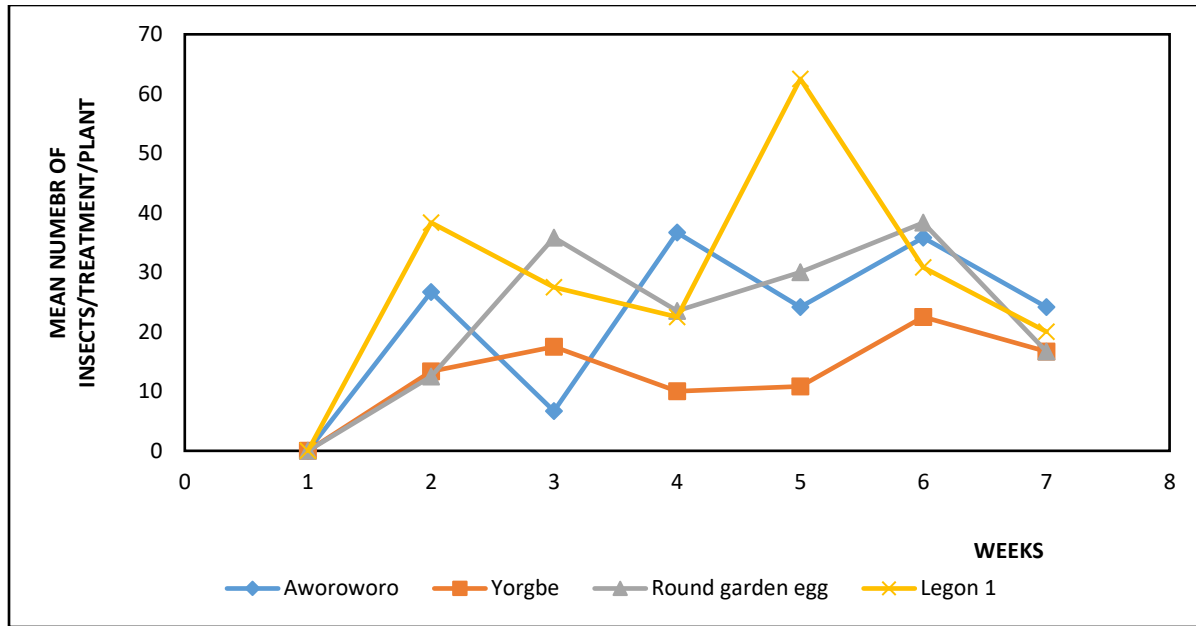


Figure 1: Mean number of *Aphis gossypii* recorded from June - July.

4.1.2 *Aphis craccivora*

The population buildup of *Aphis craccivora* for the three seasons is shown in Fig 5 - 7. *Aphis craccivora* was found in the minor season i.e. October – December. During the minor season, the population was found to be fluctuating from week one to the time of harvesting (Fig 5). Generally, the Legon 1 variety recorded the highest number of *Aphis craccivora* with an overall number of (1252.0) and the highest number recorded in the fourth week (455.0). Also, the Yorgbe variety was the variety that recorded the least number of *Aphis craccivora* with an overall number of (41.3) and least number recorded in the fifth week (Fig 5).

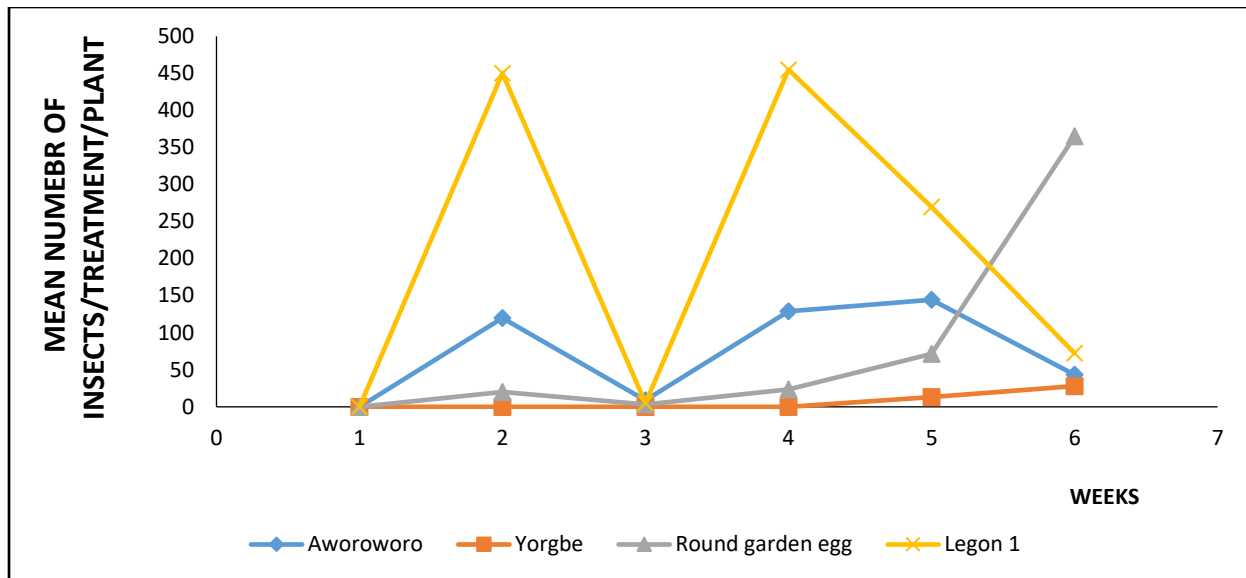
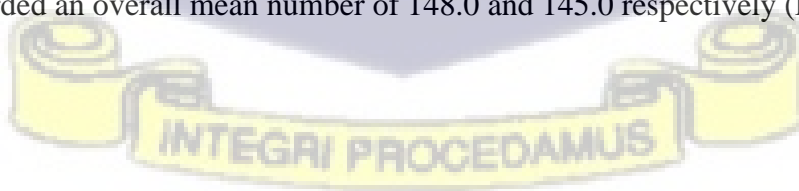


Figure 5: Mean number of *Aphis craccivora* recorded from October – December.

Aphis craccivora was found in the dry season i.e. February – April. The population recorded for six plants per treatment per week is shown in figure 6. Consequently, the number of *Aphis craccivora* was found to be fluctuating from the first week to the time of 7th week. The dry season, (i.e. February– April) also saw the Legon 1 variety recording the highest number of *Aphis craccivora* with an overall number of (337.7) and the highest number recorded in the sixth week (243.3). The Aworoworo variety was the variety that recorded the least number of *Aphis craccivora* with an overall number of (29.2). The other varieties i.e. the Yorgbe and round garden egg variety recorded an overall mean number of 148.0 and 145.0 respectively (Fig. 6).



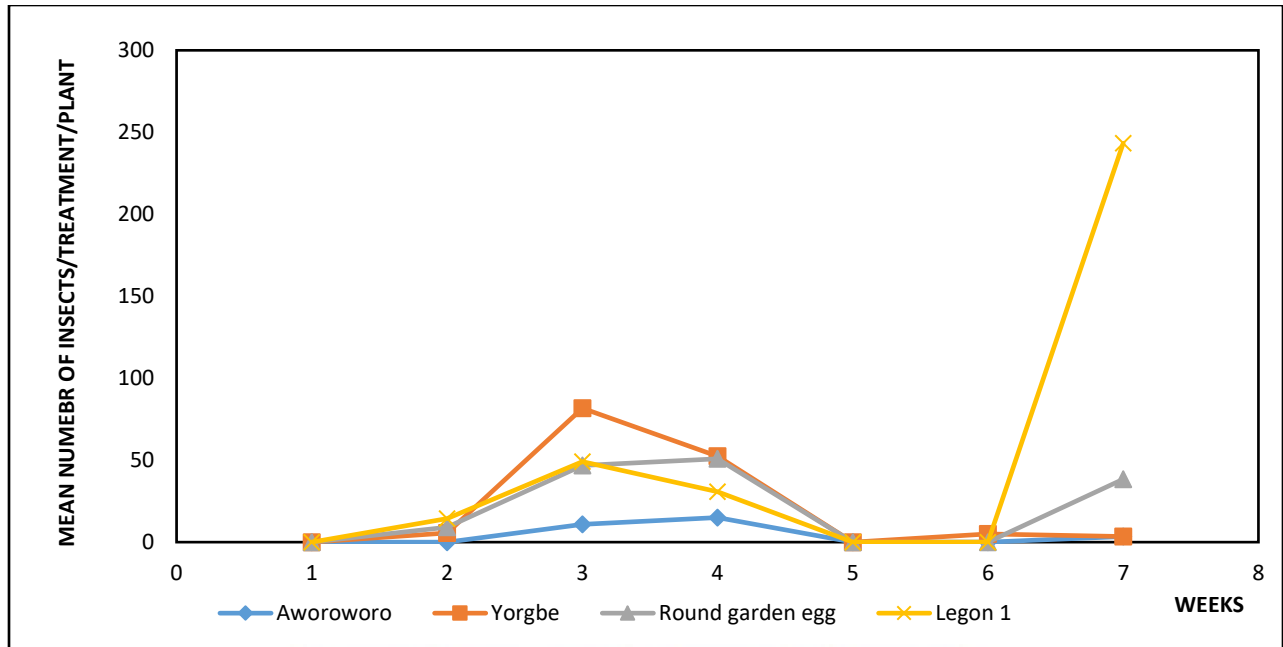


Figure 6: Mean number of *Aphis craccivora* recorded in the dry season from February – April.

During the major raining season (i.e. June – July), on the other hand, however, the round garden egg variety recorded the highest number of *Aphis craccivora* with an overall number of (234.2) and the highest number recorded in the sixth week (71.7). Also, the Legon 1 variety was the variety that recorded the least number of *Aphis craccivora* with an overall number of (35.3) and least number recorded in the second week (0.3).



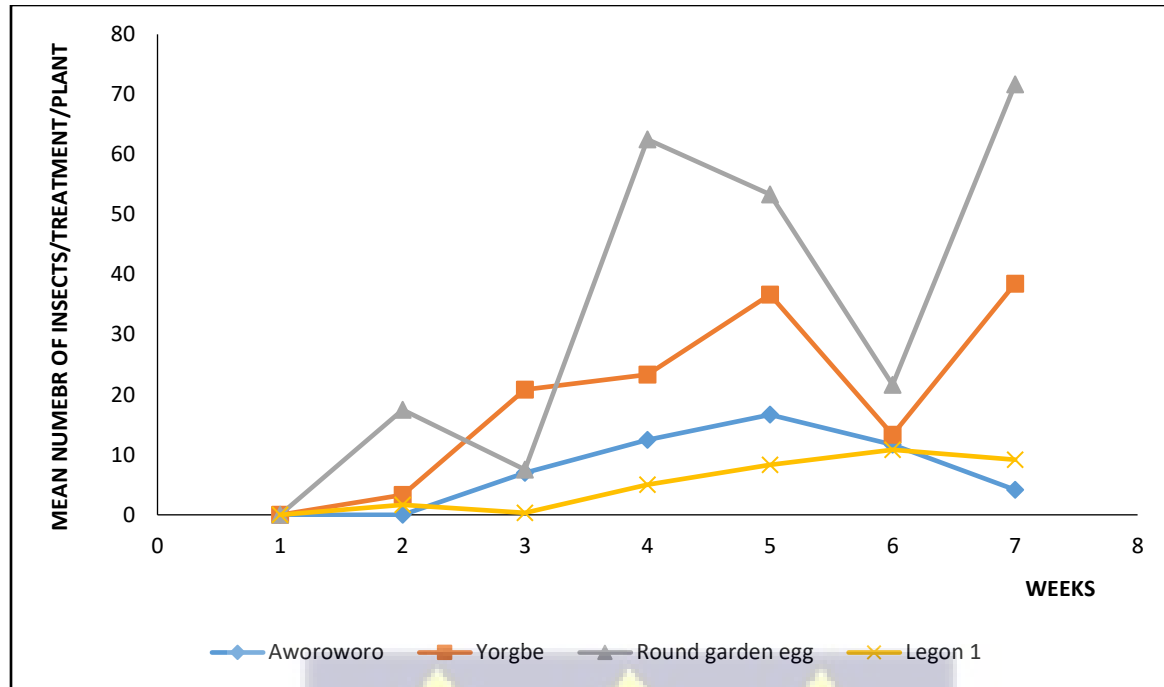


Figure 7: Mean number of *Aphis craccivora* recorded from June – July.

4.1.3 *Urentius hystricellus*

Urentius hystricellus is another pest that was found during the study however, this pest was not found in the minor season during which the study was conducted. It was found in both the dry (February – April) and major seasons (June - July).

During the dry season, the round garden egg variety recorded the highest mean number (1176.5). The Aworoworo variety recorded the lowest mean number (371.5) of *Urentius hystricellus* with lowest number recorded in the second week (8.9). The numbers of the *Urentius hystricellus* was found to be increasing from the first week until the 7th week.

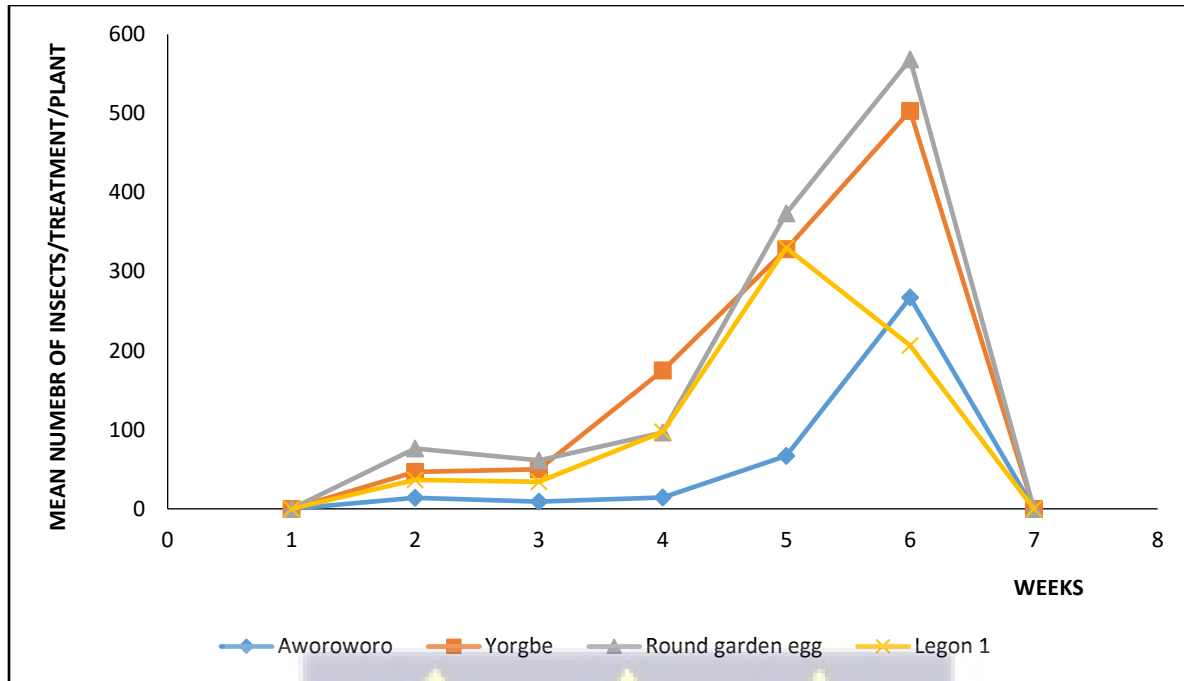


Figure 8: Mean number of *Urentius hystricellus* recorded from February – April.

In the major season generally, the numbers of the *Urentius hystricellus* were found to be increasing from the first week, but it was observed that their numbers reduced in the 7th week (Fig 9). The Aworoworo variety recorded the highest number (8.3). The round garden egg variety on the other hand recorded the lowest mean number (3.3) of *Urentius hystricellus*.



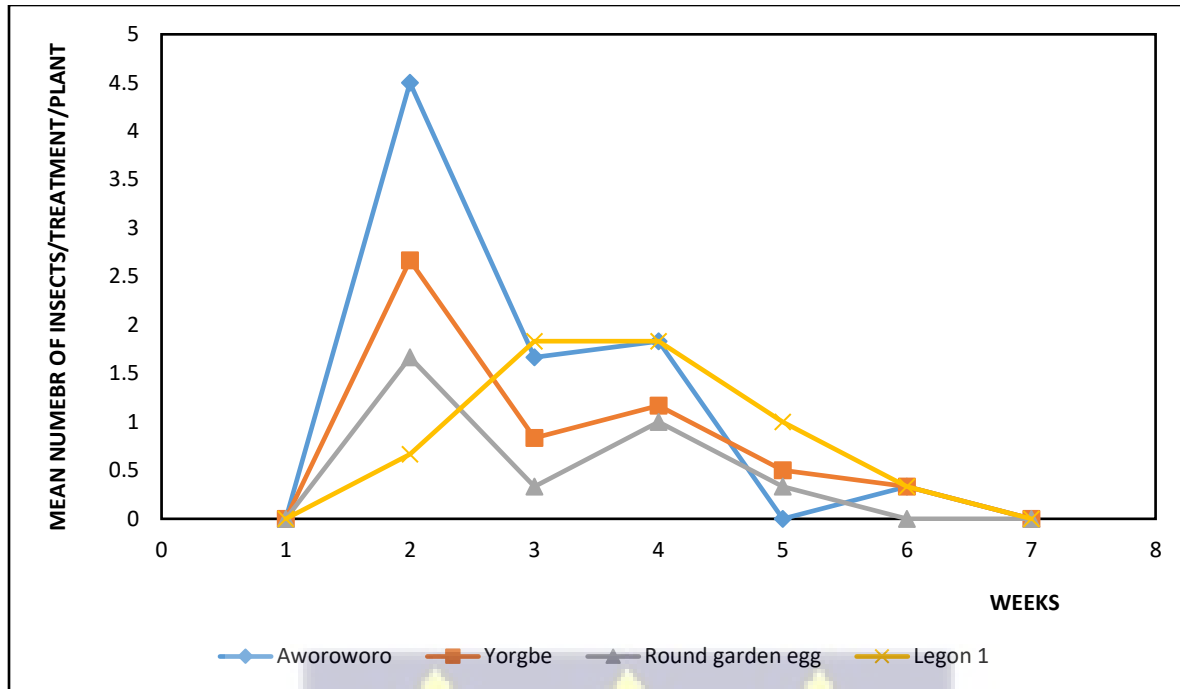
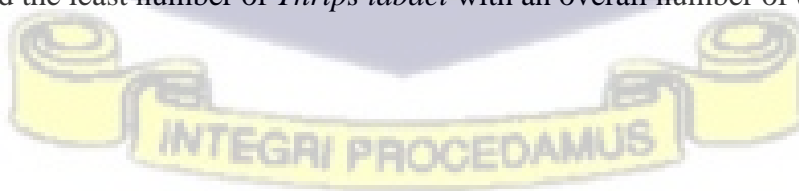


Figure 9: Mean number of *Urentius hystricellus* recorded from June – July.

4.1.4 *Thrips tabaci*

The population of thrips was found to be fluctuating for all the varieties over the weeks for the three seasons. Figures 10 - 12 show the number of *Thrips tabaci* recorded during the periods of study. During the minor season (Fig 10), the Aworoworo variety recorded the highest number of *Thrips tabaci* with highest being recorded in the sixth week (7.8). The round garden egg variety however recorded the least number of *Thrips tabaci* with an overall number of (8.2).



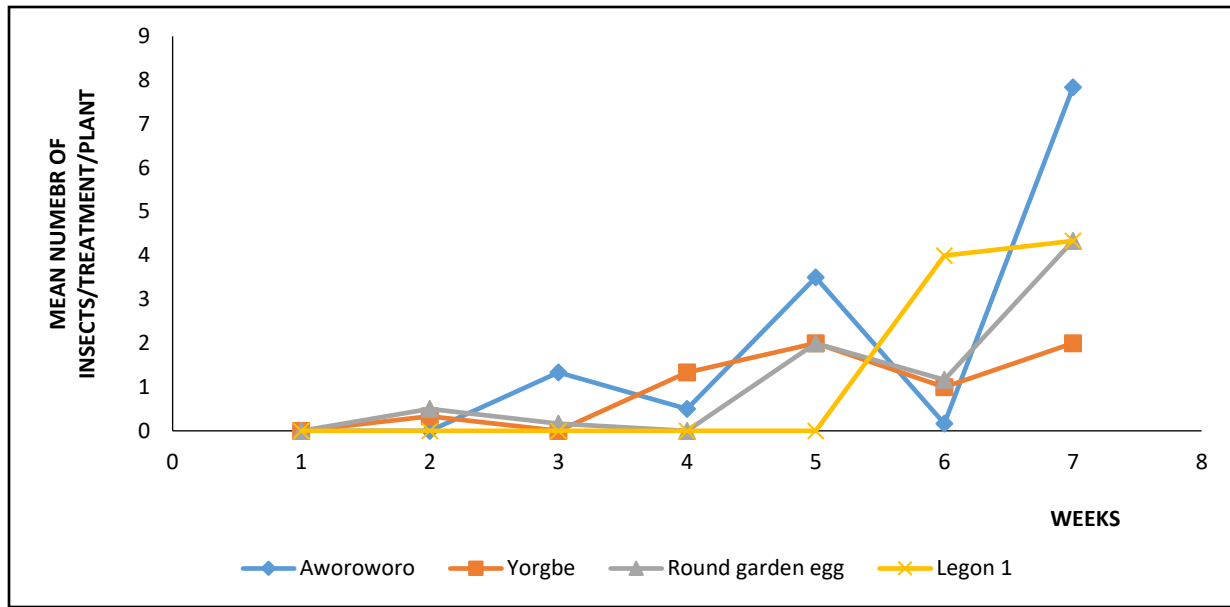
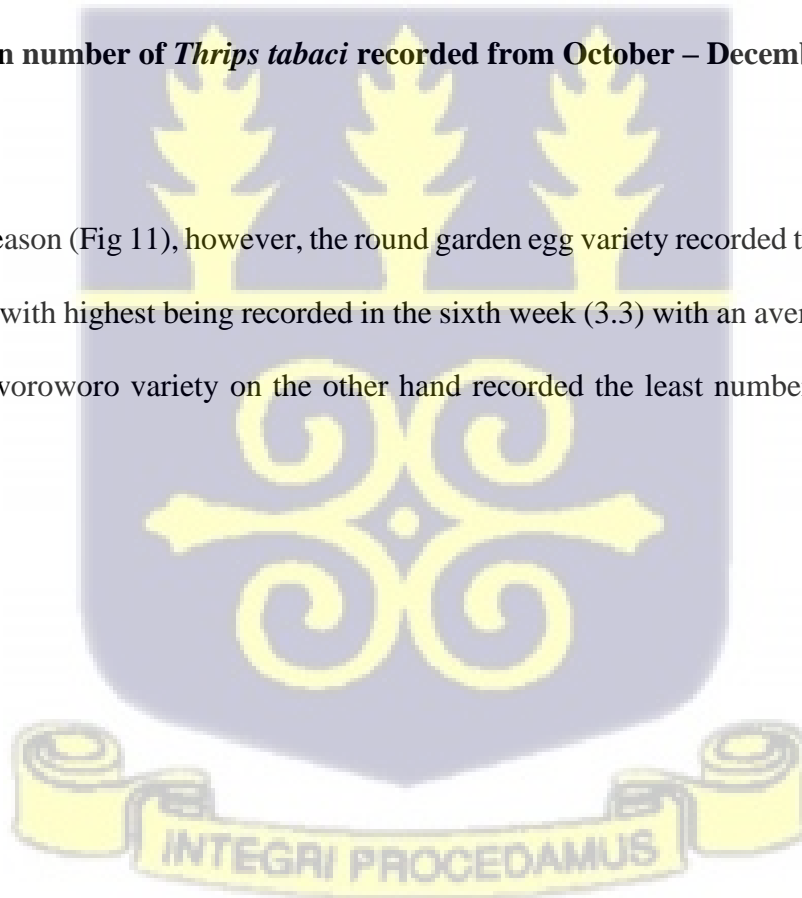


Figure 10: Mean number of *Thrips tabaci* recorded from October – December.

During the dry season (Fig 11), however, the round garden egg variety recorded the highest number of *Thrips tabaci* with highest being recorded in the sixth week (3.3) with an average mean number of (8.5). The Aworoworo variety on the other hand recorded the least number of *Thrips tabaci* (4.0).



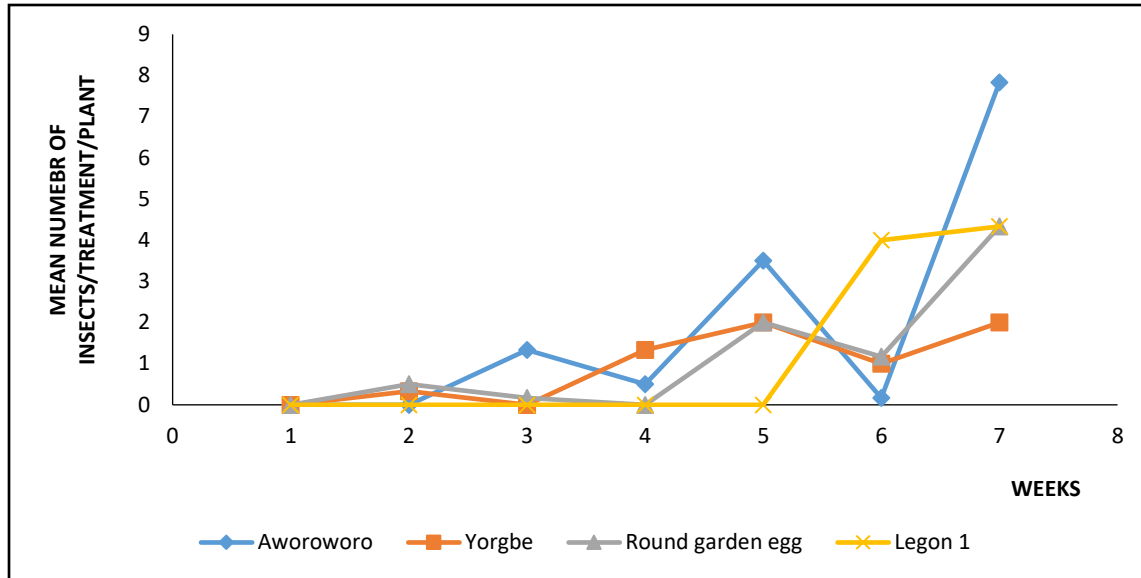


Figure 11: Mean number of *Thrips tabaci* recorded from February – April

In the major season, generally, the Aworoworo variety recorded the highest number of *Thrips tabaci* with average number of (13.3) (Fig 12). The lowest number (0.3) of *Thrips tabaci* was recorded in the first week. Also the Yorgbe variety recorded the least number of *Thrips tabaci* with an overall number of 11.7. However, the Legon 1 variety and the round garden variety recorded an average number of 12.2 and 13.0 respectively (Fig 12).



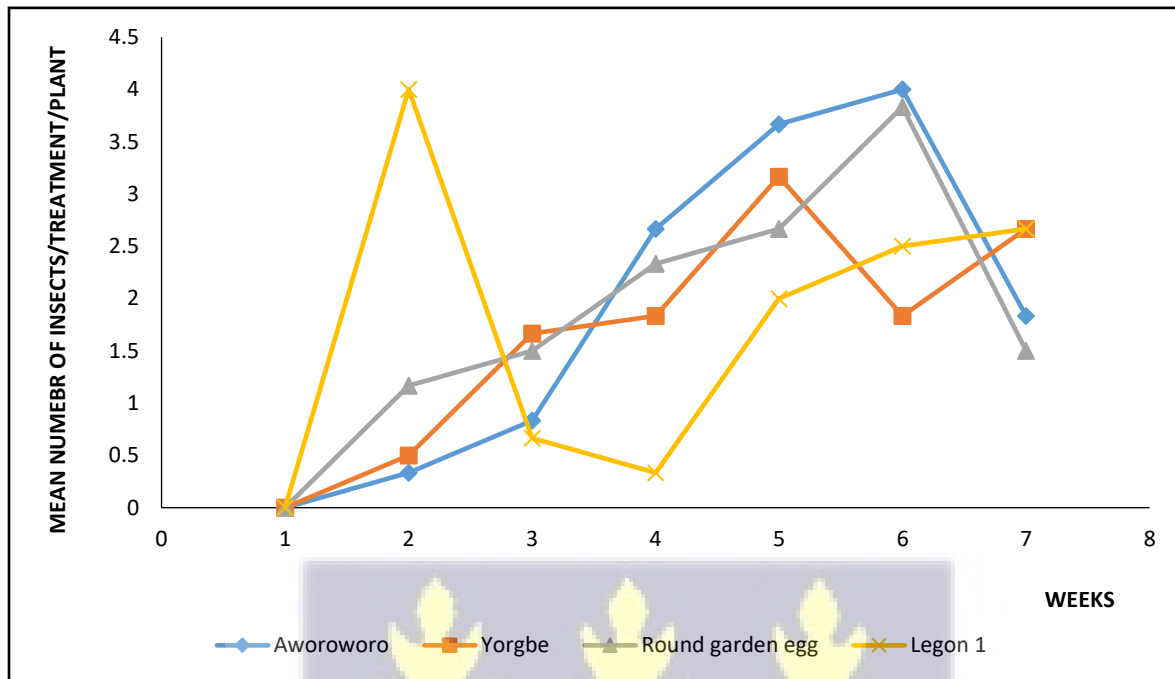


Figure 12: Mean number of *Thrips tabaci* recorded from June – July.

4.1.5 *Zonocerus variegatus*

In the minor season, the Legon 1 variety recorded the highest number of *Zonocerus variegatus* with mean number of 3.3 whilst the Aworoworo variety recorded the least number of *Zonocerus variegatus* with average number of 0.8. During the period, the number of *Zonocerus variegatus* was found to be fluctuating from the 1st week to the 7th week. The highest peak was recorded by Legon 1 variety in the 5th week. The Figure 13 below shows the population trend of *Zonocerus variegatus* in the minor raining season.

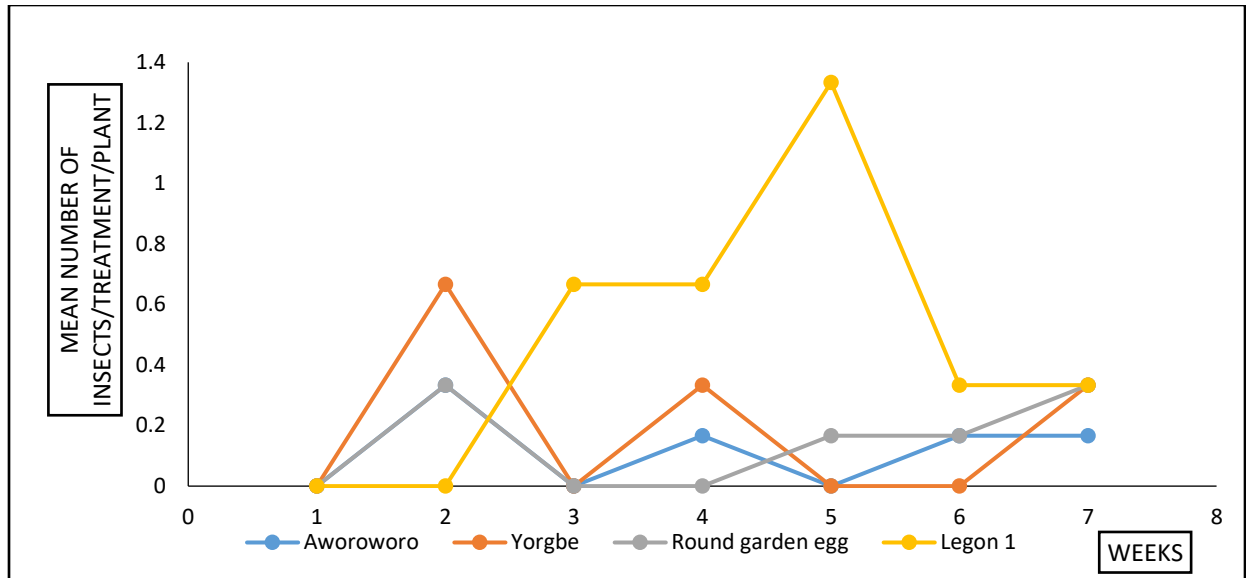


Figure 13: Mean number of *Zonocerus variegatus* recorded from October - December.

In the dry season, the number of insects recorded was observed to be fluctuating from the 1st week to until 6th week. The Round garden egg had the highest number of *Zonocerus variegatus* with mean number of 4.00 and peak recorded in the 4th week. The Legon 1 and Aworoworo varieties recorded the least number of *Zonocerus variegatus* with average numbers of 1.5 respectively. The Fig 14 below shows the population trend of *Zonocerus variegatus* in the dry season.



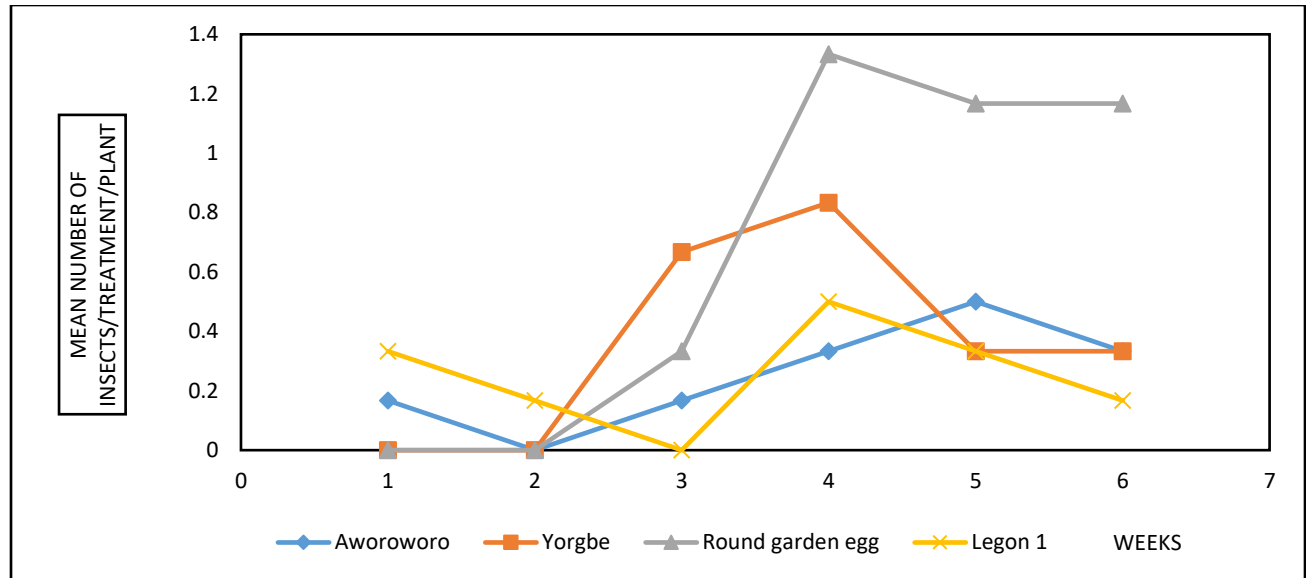


Figure 14: Mean number of *Zonocerus variegatus* recorded from February - April.

In the major season, generally, the Round garden egg variety recorded the highest number of *Zonocerus variegatus* with average number of (3.3). The number of *Zonocerus variegatus* found to be increasing from the 2nd and reached its peak during the 4th week from where the number of *Zonocerus variegatus* began to reduce. In general, the Legon 1 variety recorded the least number of insects with mean value of 0.8.



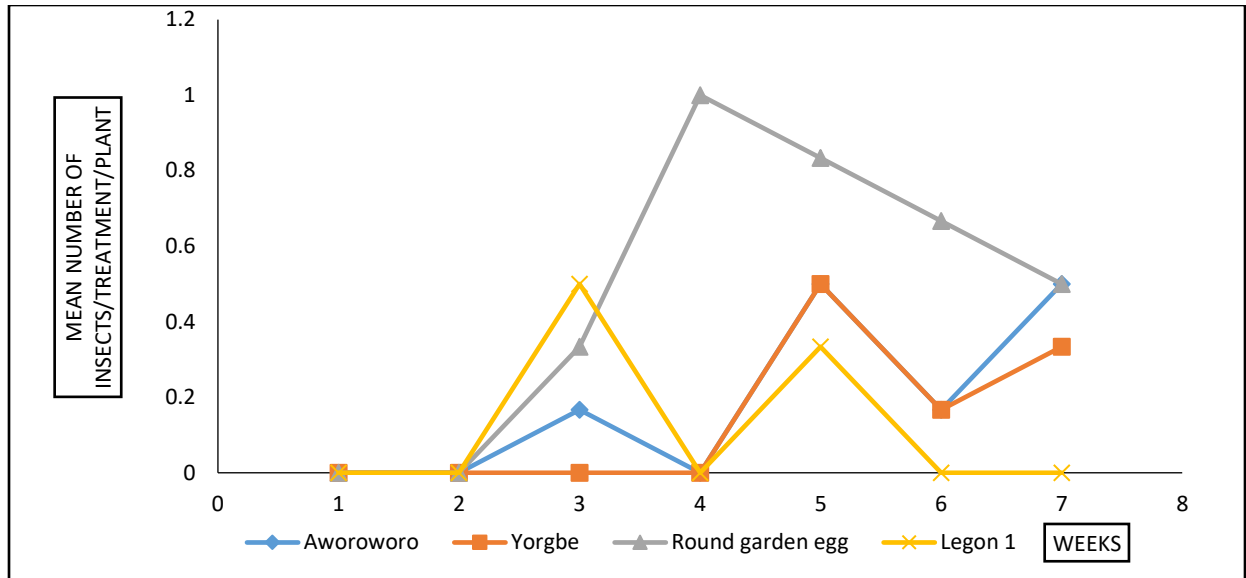


Figure 15: Mean number of *Zonocerus variegatus* recorded from June – July.

4.1.6 *Leucinodes orbonalis*.

Leucinodes orbonalis was found in the major season i.e. October -December. Consequently, the number of *Leucinodes orbonalis* was found to be fluctuating from the first week to the time of sixth week. The Legon 1 variety recorded the highest number of *Leucinodes orbonalis* with an overall number of (24.2) highest whilst the Yorgbe variety recorded the least number of *Leucinodes orbonalis* with mean number of (3.9). The highest peak was recorded by the Legon 1 variety in the 5th week. The Figure 16 below shows the population trend of the *Leucinodes orbonalis* in the minor season.



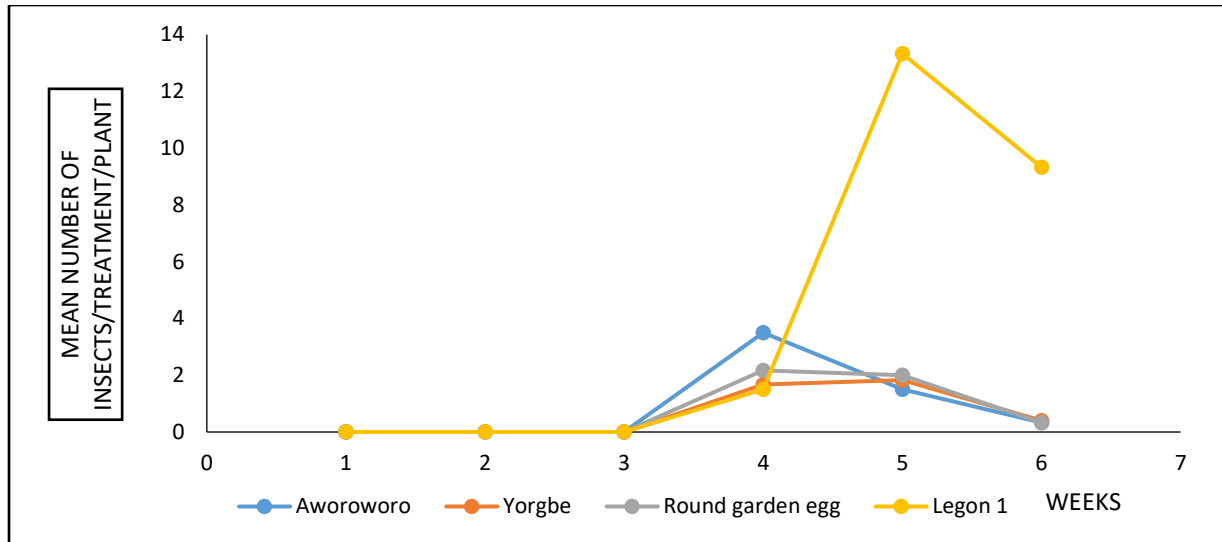
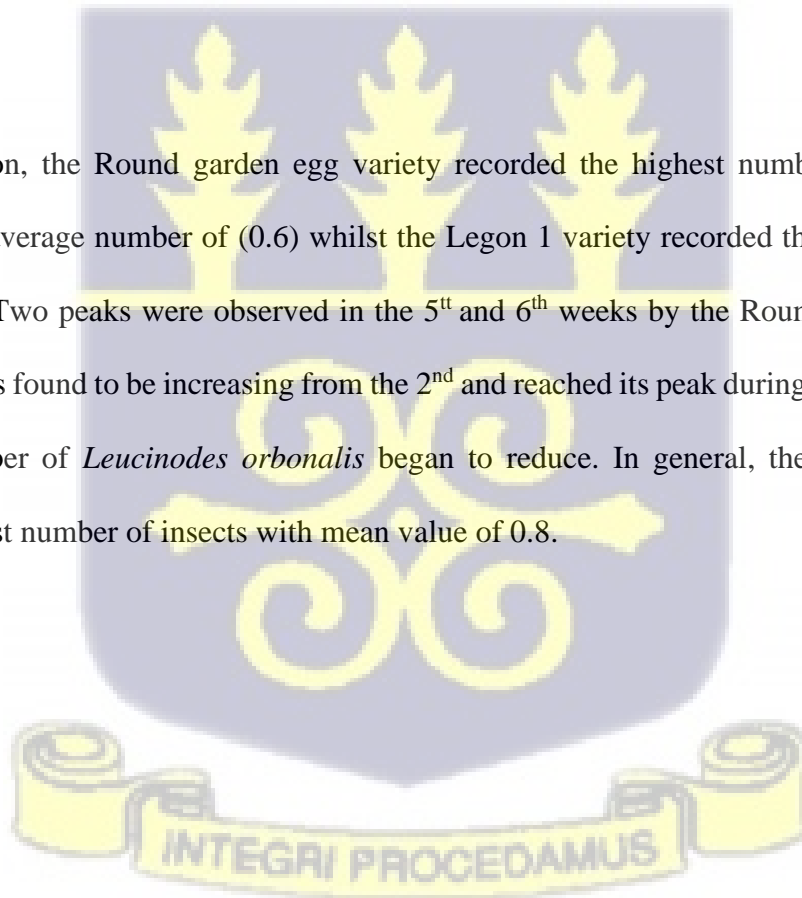


Figure 16: Mean number of *Leucinodes orbonalis* recorded from October – December.

In the dry season, the Round garden egg variety recorded the highest number of *Leucinodes orbonalis* with average number of (0.6) whilst the Legon 1 variety recorded the least with mean number of 0.3. Two peaks were observed in the 5th and 6th weeks by the Round garden egg and Legon 1 varieties found to be increasing from the 2nd and reached its peak during the 4th week from where the number of *Leucinodes orbonalis* began to reduce. In general, the Legon 1 variety recorded the least number of insects with mean value of 0.8.



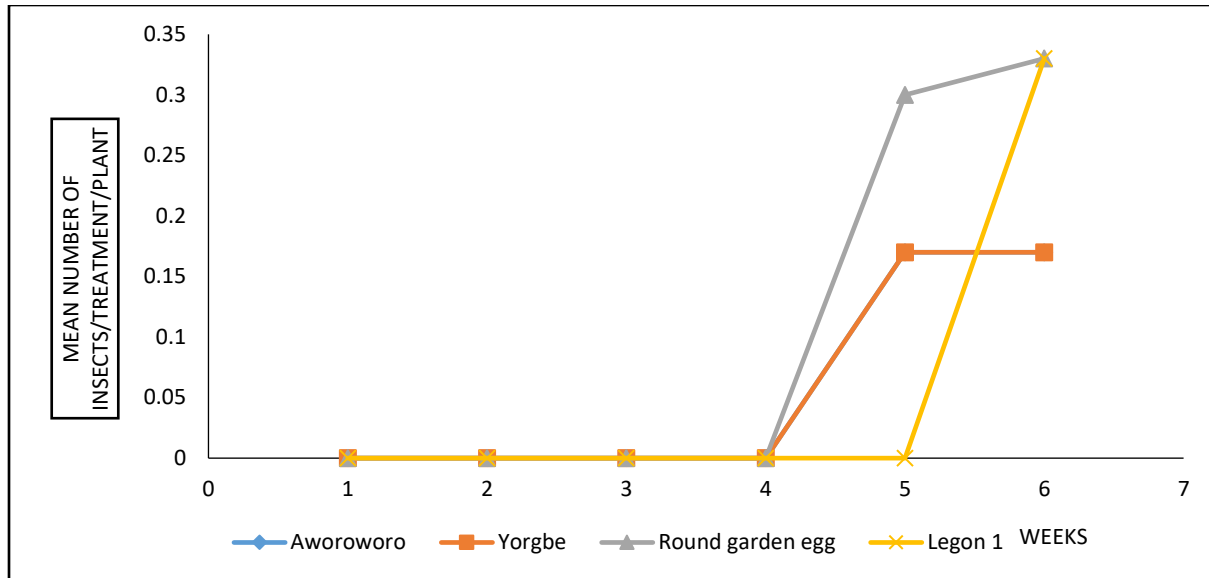
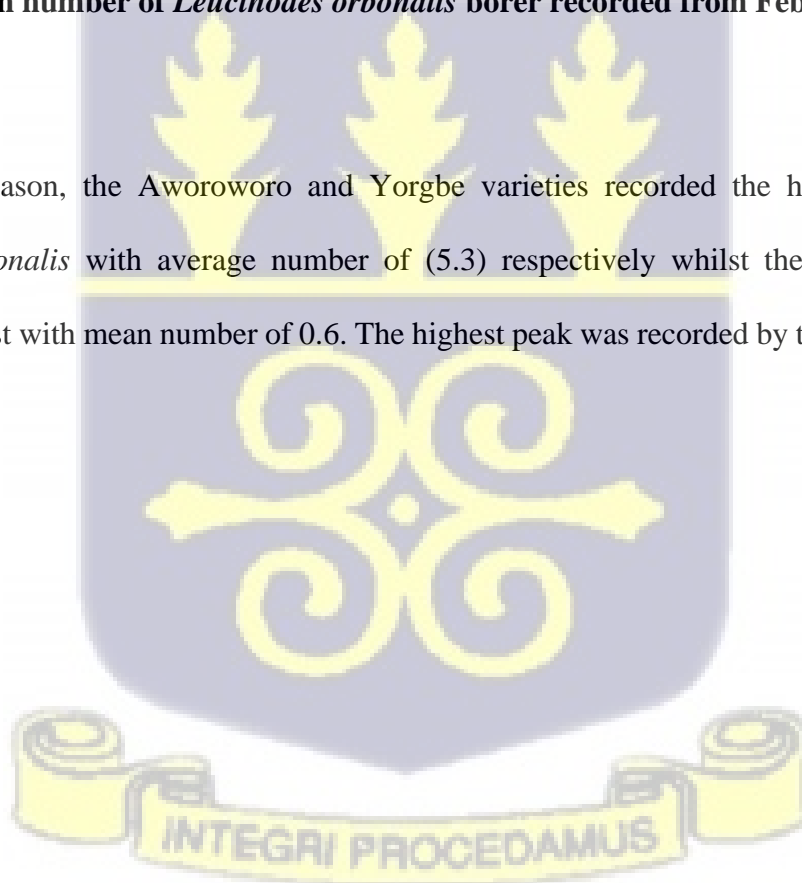


Figure 17: Mean number of *Leucinodes orbonalis* borer recorded from February – April.

In the major season, the Aworoworo and Yorgbe varieties recorded the highest number of *Leucinodes orbonalis* with average number of (5.3) respectively whilst the Legon 1 variety recorded the least with mean number of 0.6. The highest peak was recorded by the Yorgbe variety in the 6th week.



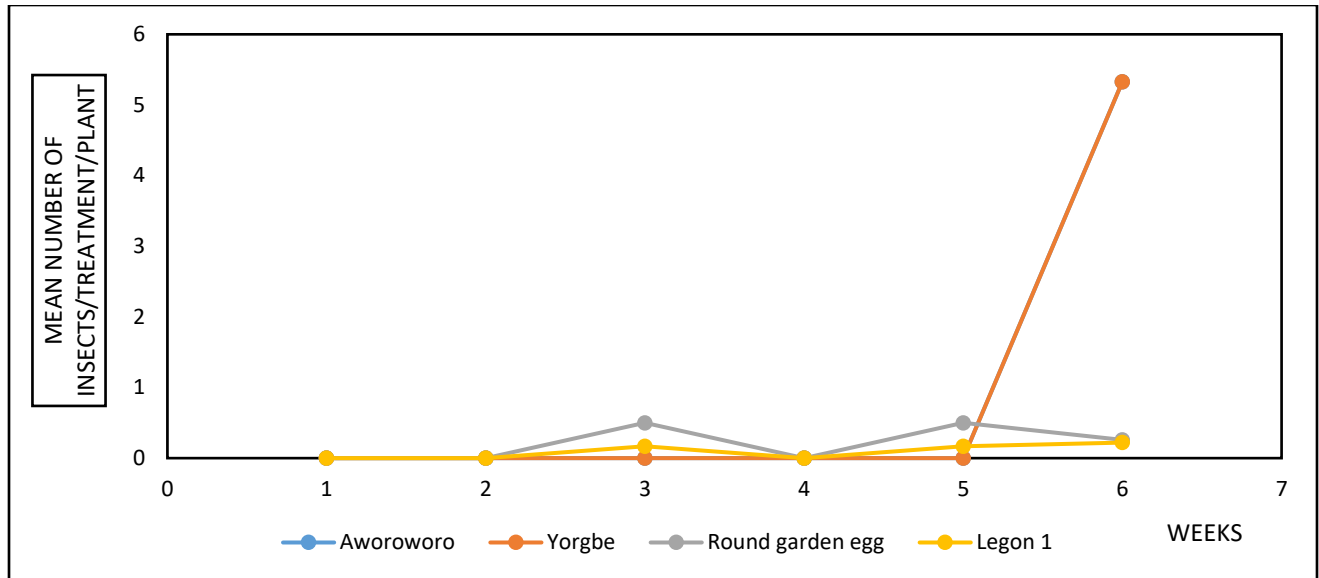


Figure 18: Mean number of *Leucinodes orbonalis* recorded from June – July.

Survey of the major pests that attack the different growing stages of garden eggs.

Aphis gossypii

Table 4 - 6 shows the various insects that attack the different growing stages of the varieties. In the minor raining season, the Yorgbe variety recorded the highest number of *Aphis gossypii* attacking the different varieties (165.2 ± 31.5) whilst the Aworoworo variety recorded the least number (114.8 ± 14.9) at the vegetative stage in the minor season. At the flowering and fruiting stages, the Legon 1 variety was found to be the variety with the highest numbers of (119.00 ± 13.5) and (487.83 ± 56.7) respectively. However, the Yorgbe variety (14.7) and the round garden egg (84.2) varieties recorded the least number of *Aphis gossypii* at the flowering and fruiting stages. There were no significant differences in the number of *Aphis gossypii* that attacked the different growing stages.

Aphis craccivora

At the vegetative stage, the Legon 1 variety recorded the highest number of *Aphis craccivora* (450.0 ± 23.9) whilst the Yorgbe variety recorded the least number (0.00 ± 0.00). Again, the Legon 1 variety also recorded the highest number at both the flowering stage (460 ± 12.42) whilst the round garden egg variety recorded the highest at fruiting stage (435.66 ± 10.29). Yorgbe variety recorded the least number at flowering stage (0.00 ± 0.00) whilst the Legon 1 variety had the least number of black bean aphid (41.3 ± 3.7). There were significant differences in the number of *Aphis craccivora* that attacked the different growing stages at ($P < 0.05$).

Thrips tabaci

For *Thrips tabaci*, the Legon 1 variety recorded the least number at both the vegetative and flowering stages however, towards the fruiting stage, the number of thrips increased (8.3 ± 0.3). The Aworoworo variety recorded the highest number at the vegetative stage (1.3 ± 0.1) and flowering stage (4.0) whilst Yorgbe variety recorded the least number of thrips at the fruiting stage (4.0 ± 0.9). There were no significant differences in the number of thrips that attack the different growing stages of the varieties in the minor season.

Zonocerus variegatus

In the minor season, *Zonocerus variegatus* was found to attack the different stages of the garden egg. At the vegetative stage, the Yorgbe and Legon 1 varieties recorded the highest respectively whilst the Aworoworo and Round garden egg varieties recorded the least. There were no significant differences in the number of insects that attacked the different stages at the vegetative stage. The Legon 1 variety recorded the highest number of insects at both the flowering (2.0 ± 0.0) and fruiting stages (0.7 ± 0.1) respectively. However, the Aworoworo and Round garden egg

varieties recorded the least at the flowering stage with mean number of (0.2 ± 0.04) whereas the Yorgbe and Aworoworo varieties recorded the least at the fruiting stage. There were significant differences in the number of *Zonocerus variegatus* that attacked the different varieties at the flowering stage at $(P < 0.05)$ but at the fruiting stage there were no significant differences.

Leucinodes orbonalis

At the vegetative stage, *Leucinodes orbonalis* was not recorded however, their numbers began to increase toward the flowering and fruiting stages. At the flowering stage, the Aworoworo variety recorded the highest (3.5 ± 0.4) whilst the Legon 1 variety recorded the least (1.5 ± 0.2) . At the fruiting stage, the number of insects that attacked the Legon 1 variety increased with a mean value of (22.7 ± 1.1) whilst the Aworoworo variety recorded the least (1.8 ± 0.2) . There were no significant differences in the number of *Leucinodes orbonalis* that attacked the different varieties at the flowering stage however, significant difference was observed in the fruiting stage at $(P > 0.05)$.

Table 4 - 6 shows the number of insects that attacked the different growing stages in the minor season.



Table 4: Insects that attack the garden eggs at the vegetative stage in the minor season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	114.8 ± 14.9a	120.0 ± 7.4b	1.3 ± 0.1b	0 ± 0.0	0.3 ± 0.1a	0 ± 0.0a
Yorgbe	165.1 ± 31.5a	0.0 ± 0.0a	0.3 ± 0.1a	0 ± 0.0	0.7 ± 0.1a	0 ± 0.0a
Round garden egg	142.0 ± 16.5a	20.0 ± 0.41a	0.7 ± 0.1ab	0 ± 0.0	0.3 ± 0.1a	0 ± 0.0a
Legon 1	147.5 ± 25.0a	450.0 ± 23.9c	0 ± 0.0a	0 ± 0.0	0.7 ± 0.1a	0 ± 0.0a
Fpr	0.90	0.001	0.037	0.00	0.30	0.00

Table 5: Insects that attack the garden eggs at the flowering stage in the minor season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	82.3 ± 12.2ab	138.0 ± 6.01c	4.0 ± 0.9a	0.0 ± 0.0a	0.2 ± 0.04a	3.5 ± 0.4a
Yorgbe	14.7 ± 2.6a	0.0 ± 0.0a	3.3 ± 0.5a	0.0 ± 0.0a	0.3 ± 0.1a	1.7 ± 0.2a
Round garden egg	60.2 ± 8.3ab	26.7 ± 4.1b	2.0 ± 0.3a	0.0 ± 0.0a	0.2 ± 0.04a	2.2 ± 0.3a
Legon 1	119 ± 13.5b	460.0 ± 12.4d	0.0 ± 0.0a	0.0 ± 0.0a	2 ± 0.0b	1.5 ± 0.2a
Fpr	0.20	0.001	0.44	0.00	0.004	0.69

Table 6: Insects that attack the garden eggs at the fruiting stage in the minor season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	151.5 ± 18.9ab	187.8 ± 6.7b	8 ± 1.1a	0 ± 0.0	0.3 ± 0.1a	1.8 ± 0.2a
Yorgbe	236.8 ± 32.2ab	41.3 ± 3.7a	3 ± 0.5a	0 ± 0.0	0.3 ± 0.1a	2.2 ± 0.2a
Round garden egg	84.2 ± 6.0a	435.7 ± 10.3c	5.5 ± 0.5a	0 ± 0.0	0.5 ± 0.04a	2.3 ± 0.3a
Legon 1	460.0 ± 12.4d	0 ± 0.0a	0 ± 0.0a	2 ± 0.0b	119.0 ± 13.5b	22.7 ± 1.1a
Fpr	0.13	0.001	0.43	0.00	0.94	0.001

Aphis gossypii

Table 7 - 9 shows the various insects that attacked the different growing stages of the varieties. In the dry season, the Yorgbe variety recorded highest mean numbers both at the vegetative stage (222.2 ± 15.04) and flowering stage (257.5 ± 25.8), however, their numbers reduced at fruiting stage (55.8 ± 5.5). Although there was a decline in the mean number of *Aphis gossypii* at fruiting stage for Yorgbe variety, the variety that recorded the least number of insects at the fruiting stage is the Aworoworo variety (28.3 ± 5.5). At the vegetative stage, the Legon 1 variety recorded the least number of *Aphis gossypii* (145.8 ± 12.4) whilst at the flowering stage, the Round garden egg variety recorded the least number of *Aphis gossypii* (124.2 ± 7.9). There were no significant differences in the number of *Aphis gossypii* that attacked the different growing stages of the varieties.

Aphis craccivora

The mean number of *Aphis craccivora* increased from the vegetative stage through to the fruiting stage. As a result, it was the Legon 1 variety that recorded the highest number at both the vegetative stage (14.3 ± 3.5) and fruiting stage (243.0 ± 35.3). Also the Aworoworo variety recorded the least number at the vegetative stage (0.00 ± 0.00) and flowering stage (25.8 ± 1.4) whilst the Yorgbe variety recorded the highest mean number at the flowering stage (134.2 ± 8.7). There were no significant differences in the number of *Aphis craccivora* that attacked both the vegetative and flowering stages however there were significant differences in the number that attacked the varieties in the fruiting stage.

Thrips tabaci

In the dry season, the Yorgbe variety recorded the highest number of *Thrips tabaci* (1.5 ± 0.2) whilst the Aworoworo variety (0.7 ± 0.1) recorded the least at the vegetative stage. During the flowering stage, the Legon 1 variety recorded the highest number (3.5 ± 0.4) whilst the Yorgbe variety recorded the least (1.5 ± 0.2) whilst at the fruiting stage, the round garden egg variety recorded the highest number (5.0 ± 0.6) whilst the Yorgbe variety recorded the least (1.3 ± 0.1). Throughout the different growing stages of the garden eggs, there were no significant differences in the number of *Thrips tabaci* that attacked the different stages of the varieties.

Urentius hystricellus

The highest number of *Urentius hystricellus* was found in the dry season. As a result, high numbers of eggplant lacebug was recorded for the different varieties. The variety that recorded the highest number of *Urentius hystricellus* at the vegetative stage was the round garden egg variety ($76.2 \pm$

11.1) whilst the Legon 1 variety recorded the least (36.7 ± 3.5). At the flowering stage, the Yorgbe variety recorded the highest number (535.0) whilst the Aworoworo variety recorded the least number (90.4). At the fruiting stage, the Round garden egg variety was to be the variety that recorded the highest number (568.3) whereas the Legon 1 variety recorded the least (206.7). There were no significant differences in the number of *Urentius hystricellus* that attacked the different varieties.

Zonocerus variegatus.

In the dry season, the *Zonocerus variegatus* was found to attack the different stages of the garden egg. At the vegetative stage, the Legon 1 varieties recorded the highest (0.5 ± 0.8) whilst the Aworoworo and Yorgbe varieties recorded the least (0.0 ± 0.0). There were no significant differences in the number that attacked the different stages at the vegetative stage. The number of variegated grasshopper that attacked the Yorgbe variety at the flowering stage (1.5 ± 0.2) at the flowering stage. However, the Round garden egg variety recorded the least at the flowering stage with mean number of (0.2 ± 0.2) but at the fruiting stage, their numbers increased Yorgbe and Aworoworo varieties recorded the least at the fruiting stage. There were no significant differences in the number that attacked the different varieties at the flowering and fruiting stage.

Leucinodes orbonalis

At the vegetative stage, *Leucinodes orbonalis* was not recorded however, their numbers began to increase toward the flowering and fruiting stages. At the flowering stage, the Round garden egg variety recorded the highest (0.3 ± 0.1) whilst the Legon 1 variety recorded the least (0.0 ± 0.0). At the fruiting stage, the number of insects that attacked the Legon 1 increased with a mean value of (0.3 ± 0.1) whilst the number of insects that attacked the Round garden egg increased ($0.3 \pm$

0.1). The Aworoworo and the Yorgbe varieties recorded the least number of *Leucinodes orbonalis*. There were no significant differences in the number that attack the different varieties at the flowering and fruiting stages respectively.

Table 7: Insects that attack the garden eggs at the vegetative stage in the dry season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	164.8 ± 15.3a	0 ± 0.0a	0.7 ± 0.11a	56.2 ± 12.61a	0.2 ± 0.04a	0 ± 0.0a
Yorgbe	222.2 ± 15.04a	5.5 ± 0.98a	1.5 ± 0.20a	46.8 ± 7.20a	0 ± 0.0a	0 ± 0.0a
Round garden egg	190 ± 20.84a	9.2 ± 2.29a	0.8 ± 0.14a	76.2 ± 11.05a	0 ± 0.0a	0 ± 0.0a
Legon 1	145.8 ± 12.38a	14.3 ± 3.53a	1.2 ± 0.13a	36.7 ± 3.51a	0.5 ± 0.8a	0 ± 0.0a
Fpr	0.89	0.55	0.85	0.87	0.20	0.00

Table 8: Insects that attack the garden eggs at the flowering stage in the dry season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	184.2 ± 15.3a	25.8 ± 1.4a	1.7 ± 0.2a	93.3 ± 18.2a	0.5 ± 0.1a	0.2 ± 0.4a
Yorgbe	257.5 ± 25.8a	134.2 ± 8.7a	1.5 ± 0.2a	224.8 ± 28.1a	1.5 ± 0.2a	0.2 ± 0.4a
Round garden egg	124.2 ± 7.9a	97.5 ± 17.5a	2.7 ± 0.3a	158.2 ± 22.4a	0.2 ± 0.2a	0.3 ± 0.1a
Legon 1	169.2 ± 23.2a	80 ± 12.7a	3.5 ± 0.4a	131.8 ± 13.2a	0.5 ± 0.1a	0 ± 0.0a
Fpr	0.87	0.35	0.74	0.97	0.55	0.76

Table 9: Insects that attack the garden eggs at the fruiting stage in the dry season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	28.3±5.5a	3.3 ± 0.5a	1.7 ± 0.3a	268.3±23.3a	0.8 ± 0.01a	0.17±0.4a
Yorgbe	55.8 ± 5.5ab	8.3 ± 1.3a	1.3 ± 0.2a	328.3 ±44.3a	0.67 ± 0.1a	0.17 ± 0.4a
Round garden egg	50.0 ± 3.2ab	38.3 ± 8.0a	5.0 ± 0.6a	373.8±52.4a	2.3 ± 0.2a	0.33 ± 0.1a
Legon 1	185.0 ± 23.2b	243 ± 35.3b	3.2 ± 0.5a	330.0±41.3a	0.5 ± 0.1a	0.3 ± 0.1a
Fpr	0.13	0.05	0.71	0.72	0.36	0.89

Aphis gossypii

The *Aphis gossypii* was found to attack the developmental stages of the different garden egg varieties in the major season as shown in Table 10. The Legon variety recorded the highest at the vegetative stage (65.8 ± 5.9) whilst the Yorgbe variety recorded the least number ($30.8 \pm 2.1bc$). Although the Legon 1 variety recorded the highest mean number at fruiting stage (113.3), the mean number recorded at the flowering stage reduced (22.5). At the flowering stage, the Yorgbe variety recorded the least number (10.0) whilst the Aworoworo variety recorded the highest (36.7). Finally, at the fruiting stage, the Yorgbe variety recorded the least number of *Aphis gossypii* (50.0). There were no significant differences in the number that attacked the different varieties.

Aphis craccivora

At the vegetative as shown in Table 10 – 12, the Round garden egg variety recorded the highest number of *Aphis craccivora* (87.5) whilst the Legon 1 variety recorded the least number (7.0). Again, the Round garden egg variety also recorded the highest number at both the flowering stage (53.3) whilst the Legon 1 variety recorded the least at flowering stage (8.3). It was also found that the round garden egg variety recorded the highest number at fruiting stage (93.3) whilst the Aworoworo variety had the least number of *Aphis craccivora* (15.8) at the fruiting stage. At the vegetative stage, there were significant ($P < 0.05$) differences in the number of *Aphis craccivora* that attacked the different varieties at however, no significant differences was observed at both the flowering and fruiting stages.

Thrips tabaci

In the major season, not very high numbers were recorded for the different varieties however, the Legon 1 variety and the Round garden egg variety recorded the highest numbers (5.00) whilst Aworoworo variety recorded the least number of thrips (3.83) at the vegetative stage. During the flowering stage, the Legon 1 variety recorded the least number (2.00) whilst the Aworoworo variety recorded the highest (3.67) whilst at the fruiting stage, the round garden egg variety recorded the highest number (5.33) and the Yorgbe variety recorded the least (4.50). There were no significant differences in the number of thrips that attacked the different varieties in the different seasons.

Urentius hystricellus

In table 10 - 12, the number of *Urentius hystricellus* recorded in the major season was not as high as the one recorded in the dry season. As a result, the Aworoworo variety recorded the highest

number of *Urentius hystricellus* (6.17) whilst the Round garden egg variety recorded the least (2.00) at the vegetative stage. At the flowering stage, the Legon 1 variety recorded the highest number (2.83) whilst the Round garden egg variety recorded the least number (1.33). At the fruiting stage, the Round garden egg variety was to be the variety that recorded the least number (0.00) whereas the other three varieties recorded the same numbers (0.33). There were no significant differences in the number that attacked the different varieties in the different seasons.

Zonocerus variegatus.

In the major raining season, the *Zonocerus variegatus* was found to attack the different stages of the garden egg. At the vegetative stage, the Legon 1 and Yorgbe varieties recorded the highest with mean values of (0.7 ± 0.07) respectively whilst the Aworoworo variety recorded the least (0.2 ± 0.04) . There were no significant differences in the number of *Zonocerus variegatus* that attacked the different stages at the vegetative stage. The Round garden egg variety recorded the highest at the flowering stage (1.0 ± 0.2) . At the fruiting stage, the number that attacked the different varieties increased. The Round garden egg variety recorded the highest at the fruiting stage with mean number of (2.0 ± 0.2) with the Legon 1 variety recording the least (0.3 ± 0.1) . There were no significant differences in the number of variegated grasshopper that attacked the different varieties in the different seasons.

Leucinodes orbonalis

At the vegetative stage, the Round garden egg variety recorded the highest number (0.5 ± 0.04) . Numbers began to increase at the flowering stage with Legon 1 variety recorded the highest (1.5

± 0.2) whilst the Yorgbe variety recorded the least (0.3 ± 0.1). At the fruiting stage, same number of *Leucinodes orbonalis* attacked the Aworoworo and Yorgbe varieties with mean values of (5.3 ± 0.4) and (5.3 ± 0.3) respectively whilst the Round garden egg and Legon 1 varieties recorded the least number of *Leucinodes orbonalis* ($2.7 \pm 0.3a$) and ($2.7 \pm 0.2a$) respectively. There were no significant differences in the number of *Leucinodes orbonalis* that attack the different varieties at the vegetative stage, flowering and fruiting stage respectively.

Table 10: Insects that attack the garden eggs at the vegetative stage in the major season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	$33.3 \pm 2.9ab$	$19.5 \pm 3.4a$	$1.2 \pm 0.1a$	$1.2 \pm 0.13a$	$0.2 \pm 0.4a$	$0 \pm 0.0a$
Yorgbe	$30.8 \pm 2.1bc$	$47.5 \pm 4.2a$	$2.2 \pm 0.04a$	$2.2 \pm 0.04a$	$0.7 \pm 0.1a$	$0 \pm 0.0a$
Round garden egg	$48.3 \pm 5.4c$	$87.5 \pm 9.9a$	$2.7 \pm 0.23a$	$2.7 \pm 0.23a$	$0.3 \pm 0.1a$	$0 \pm 0.0a$
Legon 1	$65.8 \pm 5.9a$	$7 \pm 1.14a$	$4.7 \pm 0.49a$	$4.7 \pm 0.49a$	$0.7 \pm 0.1a$	$0 \pm 0.0a$
Fpr	0.60	0.02	0.30	0.22	0.40	0.03



Table 11: Insects that attack the garden eggs at the flowering stage in the major season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	36.7 ± 5.9a	16.7 ± 2.5a	6.3 ± 0.4a	1.8 ± 0.4a	0 ± 0.0a	0.7 ± 0.1a
Yorgbe	10 ± 1.3a	36.7 ± 7.8a	5 ± 0.4a	1.7 ± 0.4a	0 ± 0.0a	0.3 ± 0.1a
Round garden egg	23.5 ± 1.92a	53.3 ± 6.85a	5.0 ± 0.05a	1.33 ± 0.24a	1.0 ± 0.2b	0.5 ± 0.1a
Legon 1	22.5 ± 3.03a	8.3 ± 2.08a	2.3 ± 0.14a	2.83 ± 0.5a	0.0 ± 0.0a	1.5 ± 0.2a
	0.75	0.34	0.14	0.88	0.10	0.55

Table 12: Insects that attack the of garden eggs at the fruiting stage in the major season

Treatment	<i>Aphis gossypii</i>	<i>Aphis craccivora</i>	<i>Thrips tabaci</i>	<i>Urentius hystricellus</i>	<i>Zonocerus variegatus</i>	<i>Leucinodes orbonalis</i>
Aworoworo	84.2 ± 4.1a	15.8 ± 1.7a	5.8 ± 0.2b	0.3 ± 0.1a	1.2 ± 0.2ab	5.3 ± 0.4a
Yorgbe	50.0 ± 2.5a	51.8 ± 7.9a	4.5 ± 0.2ab	0.3 ± 0.1a	1.0 ± 0.2ab	5.3 ± 0.3a
Round garden egg	85.0 ± 7.7a	93.3 ± 17.7a	5.3 ± 0.3ab	0.0 ± 0.0a	2.0 ± 0.2b	2.7 ± 0.3a
Legon 1	113.3 ± 9.7a	20.0 ± 5.0a	5.2 ± 0.1a	0.3 ± 0.1a	0.3 ± 0.1a	2.7 ± 0.2a
Fpr	0.49	3.15	0.65	0.42	0.06	0.29

4.3.0 The level of damage caused by insect pests in the different varieties of garden eggs

4.3.1. Minor season

The mean number of damaged leaves at the developmental stages of the different varieties of garden eggs for all the seasons is shown in Fig 19 – 21. During the minor season, Legon 1 variety recorded the highest number of damaged leaves ($86.1 \pm 34.7a$) at the vegetative stage whilst round garden egg variety recorded the least number of damaged leaves ($26.72 \pm 9.31a$). At the flowering stage, Aworoworo variety had the highest mean number of damaged leaves ($47.76 \pm 23.17b$) while Yorgbe recorded the least number of damaged leaves ($7.02 \pm 4.05a$). At fruiting stage, Aworoworo recorded the highest number of damaged leaves ($17.82 \pm 4.85a$) with the round garden egg recording the least ($8.47 \pm 3.43a$).

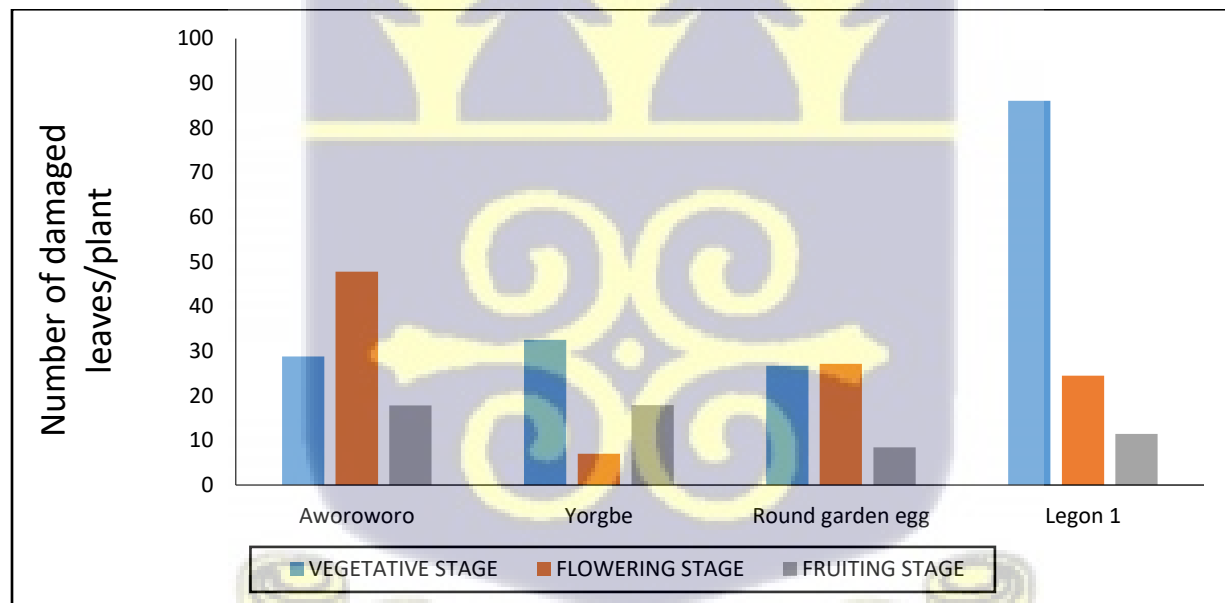


Figure 19: Mean number of damaged leaves in the minor raining season.

4.3.2. Dry season

The mean number of damage caused to leaves at the developmental stages of the different varieties of garden eggs were recorded during the minor season is shown in Fig 20 below, the Aworoworo variety recorded the highest number of damaged leaves ($40 \pm 3.39a$) at the vegetative stage whilst Yorgbe variety recorded the least number of damaged leaves ($14 \pm 2.36a$). At the flowering stage, the Legon 1 variety had the highest number of damaged leaves with mean number of 20 ± 2.86 damaged leaves. The round garden egg variety recorded the least number of damaged leaves ($10 \pm 2.19a$). At fruiting stage, the Legon 1 variety recorded the highest number of damaged leaves ($67 \pm 15.24a$) while the Yorgbe variety recording the least ($34 \pm 3.20a$).

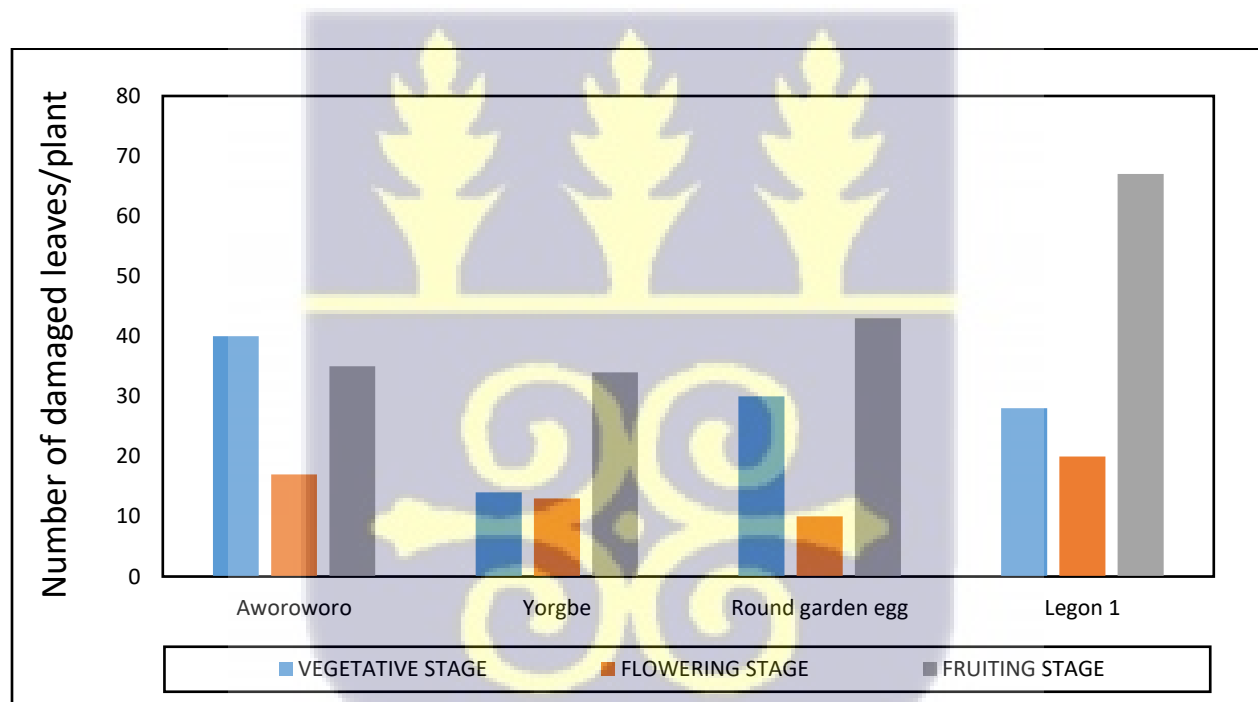
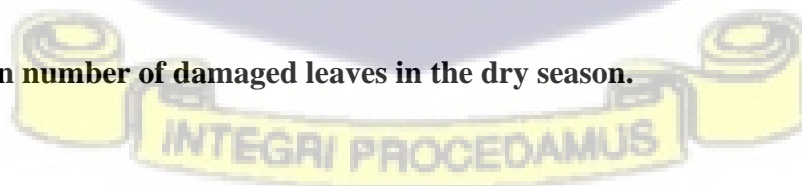


Figure 20: Mean number of damaged leaves in the dry season.



4.3.3 Major season

During the minor season as shown in Fig 21, at the vegetative stage the Aworoworo variety recorded the highest number of damaged leaves (40 ± 3.39) whilst the Yorgbe variety recorded the least number of damaged leaves (14 ± 2.36). At the flowering stage however, the Legon 1 variety had the highest number of damaged leaves with mean number of 20 ± 2.86 damaged leaves whilst the round garden egg variety recorded the least number of damaged leaves (10 ± 2.19). At fruiting stage, the Legon 1 variety recorded the highest number of damaged leaves (67 ± 15.24) whilst the Yorgbe variety recording the least (34 ± 3.20).

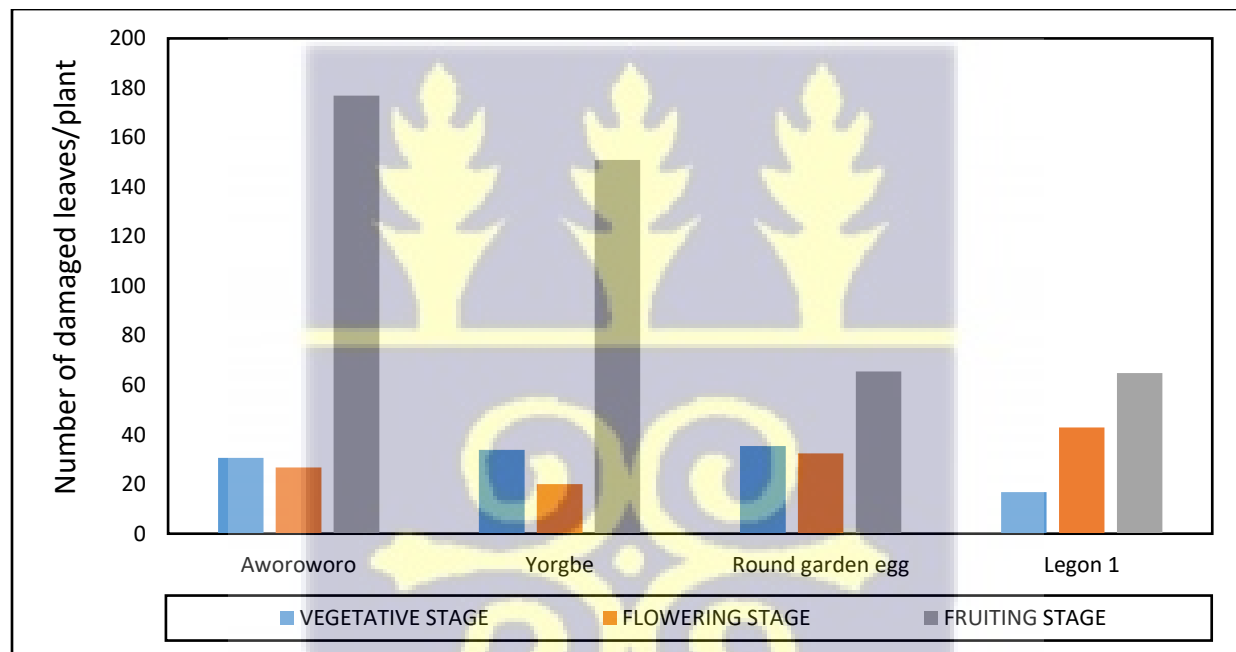


Figure 21: Mean number of damaged leaves in the major raining season.

4.4. Number of shoot and percent shoot damage

The mean number of shoots and percent shoot damage was recorded for the three seasons as shown in table 13. The Legon 1 variety recorded the highest number of shoots (78.0 ± 1.2) whilst the

Yorgbe variety recorded the least in the minor season. There was no significant differences in the number of shoot produced in the minor season. In the dry season, Legon 1 variety recorded the highest number of shoots (30.0 ± 0.7). In the dry season, the Legon 1 variety recorded the highest number of shoot (30.0 ± 0.7) whereas the Aworoworo variety recorded the least (20.0 ± 1.0). The round garden egg variety recorded the highest number of shoot in the major season (40.8 ± 0.6) whilst the Legon 1 variety recorded the least (31.7 ± 1.2). There was no significant differences in the number of shoot produced in the 3 seasons.

Table 13: Mean number of shoot and percentage number of shoot

Treatment	Minor season		Dry season		Major season	
	No of shoot	Percent shoot damage	No of shoot	Percent shoot damage	No of shoot	Percentage shoot damage
Aworoworo	42.0 ± 3.0 ab	2.7	20.0 ± 1.0 a	0.2	32.2 ± 0.6 a	10.0
Yorgbe	31.0 ± 2.3 a	2.0	28.0 ± 0.8 a	0.2	32.5 ± 0.7 a	10.0
Round garden egg	46.0 ± 2.9 abc	2.3	26.0 ± 0.6 a	0.3	40.8 ± 0.6 b	5.0
Legon 1	78.0 ± 1.2 c	12.3	30.0 ± 0.7 a	0.2	31.7 ± 1.1 a	5.0
Fpr	0.06		0.76		0.08	

4.4.4. Number of flowers and percent flower damage.

The mean number of flowers and number of damaged flowers were recorded for the period the study was conducted. The Legon 1 variety recorded the highest number of shoot (28.0 ± 0.7) whilst

Yorgbe recorded the least number of flowers (18.0 ± 2.9) and was also the variety that recorded the least number of damaged flowers (1.0 ± 0.2).

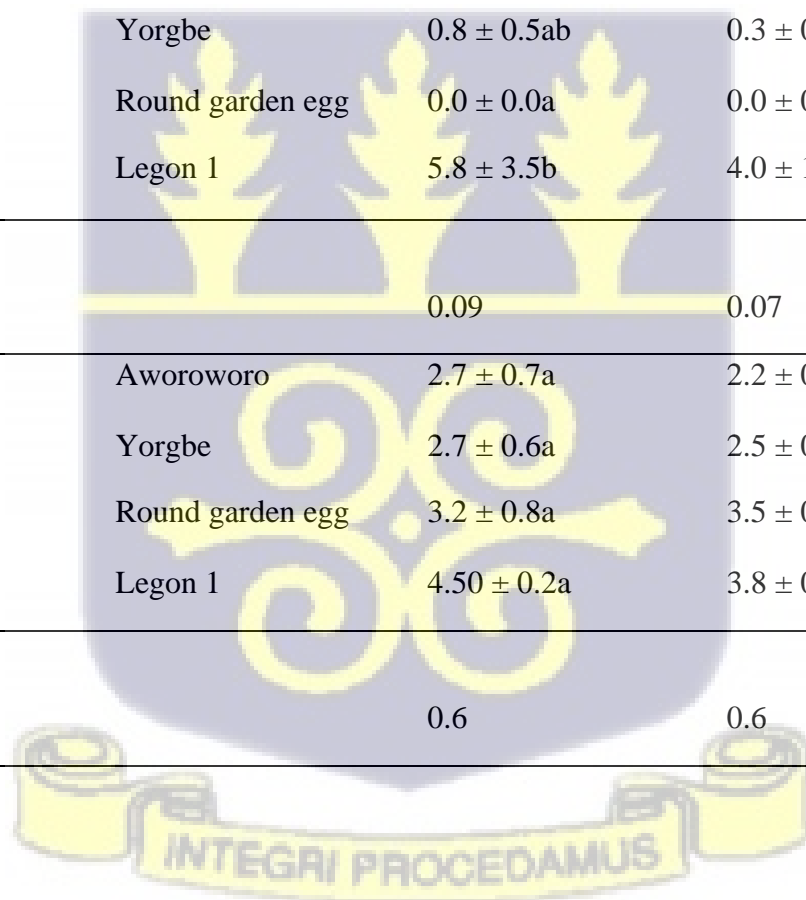
Table 14: Mean number of flowers and percentage number of damaged flowers

Treatment	Minor season		Dry season		Major season	
	No of flowers	Percent flower damage	No of flowers	Percent flower damage	No of flowers	Percent flower damage
Aworoworo	$24.0 \pm 2.1a$	6.0	$4.0 \pm 0.5a$	2.0	$8.8 \pm 0.4a$	3.1
Yorgbe	$18.0 \pm 2.9a$	1.2	$7.0 \pm 0.8a$	4.8	$8.5 \pm 0.6a$	5.1
Round garden egg	$24.0 \pm 1.8a$	4.8	$7.0 \pm 1.1a$	2.7	$20.2 \pm 0.8b$	9.7
Legon 1	$28.0 \pm 0.7a$	2.3	$10.0 \pm 0.8a$	1.8	$13.8 \pm 1.3b$	4.1
Fpr	0.91		0.81		0.11	

In assessing the ovipositional, larval development and adult emergence *Leucinodes orbonalis*, the number of pupa and adult were recorded for the different seasons. The Legon 1 variety recorded the highest number of pupa (23.0 ± 4.03) and consequently had the highest number of adults (16.00 ± 4.03) whilst the round garden egg variety recorded the least number of pupa and adult with mean value of (0.00 ± 0.00) at both the minor and dry seasons. There were no significant differences in the number of pupa and adults in the minor season. In the dry season, the Legon 1 variety recorded the highest number of pupa (5.75 ± 3.52) and also the highest number of adults (4.00 ± 1.87). In the major raining season, the Legon 1 variety recorded the highest number of pupa (4.50 ± 0.23) and also the highest number of adult (3.83 ± 0.21). There were no significant differences in the number of pupa and adults recorded in the dry and major season.

Table 15: Number of Pupae and adult recorded for the different seasons

Season	Treatment	No. of pupa	<i>L. orbonalis</i>
Minor	Aworoworo	3.0 ± 0.5ab	3.00 ± 1.0ab
	Yorgbe	3.0 ± 0.5ab	1.0 ± 1.0a
	Round garden egg	0.0 ± 0.0a	0.0 ± 0.0a
	Legon 1	23.0 ± 4.03b	16.0 ± 4.03b
Fpr		0.02	0.15
Dry	Aworoworo	0.8 ± 0.5ab	1.5 ± 0.5ab
	Yorgbe	0.8 ± 0.5ab	0.3 ± 0.3a
	Round garden egg	0.0 ± 0.0a	0.0 ± 0.0a
	Legon 1	5.8 ± 3.5b	4.0 ± 1.9b
Fpr		0.09	0.07
Major	Aworoworo	2.7 ± 0.7a	2.2 ± 0.3a
	Yorgbe	2.7 ± 0.6a	2.5 ± 0.4a
	Round garden egg	3.2 ± 0.8a	3.5 ± 0.5a
	Legon 1	4.50 ± 0.2a	3.8 ± 0.2a
Fpr		0.6	0.6



4.5.0 Assessing the growth and yield parameters of the different varieties of garden eggs.

The mean number of fruits, weight of fruit and number of damaged fruits were recorded in the minor season (October – December). The Legon 1 variety recorded the highest number of fruits (35.0 ± 7.0), highest number of damaged fruits (11.0 ± 4.9) and highest weight (1.5 ± 0.4). Also, the Yorgbe variety recorded the least number of fruits (10.0 ± 4.2), least number of damaged fruits (3.0 ± 1.2) and least weight (0.2 ± 0.1).

In the dry season (February – April), the mean number of fruits, weight of fruit and number of damaged fruits were recorded. The Legon 1 variety recorded the highest number of fruits (64.0 ± 7.7), highest number of damaged fruits (27.0 ± 4.03) and highest weight (1.7 ± 0.2). Also, the round garden egg variety recorded the least number of fruits (32.0 ± 4.3), least number of damaged fruits (5.0 ± 1.0) and least weight (0.9 ± 0.1).

The mean number of fruits, weight of fruit and number of damaged fruits were recorded from June to July. The Legon 1 variety recorded the highest number of fruits (16.0 ± 4.5), highest number of damaged fruits (7.0 ± 0.9) and highest weight (0.5 ± 0.1). Also, the Aworoworo variety recorded the least number of fruits (1.0 ± 0.9), least number of damaged fruits (0.5 ± 0.5) and least weight (0.02 ± 0.02).

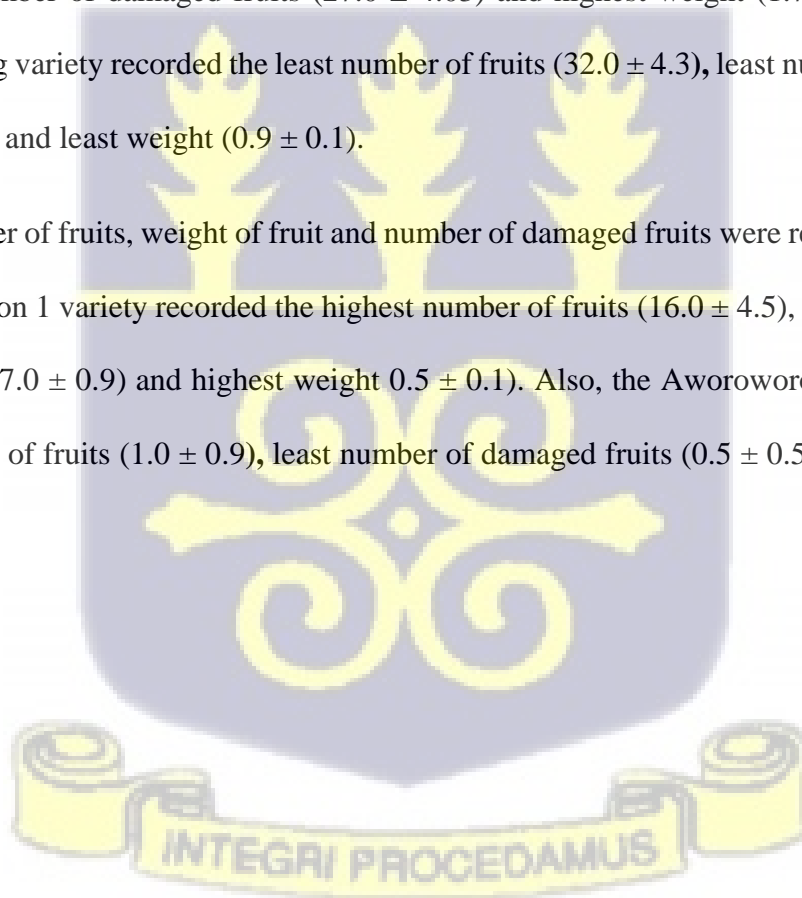


Table 16: Mean number of fruit, weight and number of damaged fruits

Minor season	No. of fruit	Weight of fruit	No. of damaged fruit	Percent fruit damage	Fruit/ha
Aworoworo	23.3 ± 8.2ab	0.6 ± 0.1a	9.0 ± 4.6a	38.71	2,395
Yorgbe	10.3 ± 4.3a	0.2 ± 0.1a	2.5 ± 1.2a	24.39	1,042
Round garden egg	21.0 ± 9.3ab	0.7 ± 0.3a	8.5 ± 4.7a	40.48	2,188
Legon 1	34.8 ± 7.0b	1.5 ± 0.4b	11.3 ± 4.9a	32.37	3,646
Fpr	0.001	0.001	0.001		
Dry season	No. of fruit	Weight of fruit	No. of damaged fruit	Percent fruit damage	Fruit/ha
Aworoworo	10.5 ± 7.5a	0.3 ± 0.2a	2.8 ± 2.1a	26.19	1094
Yorgbe	13.8 ± 6.06a	0.3 ± 0.2a	2.3 ± 1.4a	16.36	1432
Round garden egg	8.0 ± 4.3a	0.2 ± 0.1a	1.3 ± 1.0a	15.63	833
Legon 1	16.0 ± 7.7a	0.4 ± 0.2a	6.8 ± 4.03a	42.19	1667
Fpr	0.90	0.94	0.55		
Major season	No. of fruit	Weight of fruit	No. of damaged fruit	Percent fruit damage	Fruit/ha
Aworoworo	1.5 ± 0.9a	0.8 ± 0.5a	0.04 ± 0.02a	2.7	104.00
Yorgbe	2.8 ± 1.3a	1.5 ± 0.7a	0.1 ± 0.04ab	3.3	191.00
Round garden egg	5.3 ± 1.4a	3.3 ± 1.7a	0.2 ± 0.04b	3.4	365
Legon 1	24.5 ± 5.0b	10.8 ± 0.9b	0.8 ± 0.1c	43.9	1701
fpr	0.001	0.001	0.001		

As shown in the table 17, the Legon 1 variety had the highest yield for the three seasons with a mean value of 2,338 whilst the Yorgbe variety recorded the lowest yield with a mean value of 888.33.

Table 17: Mean yield for the different seasons.

Treatment	Minor season	Dry season	Major season	Mean
Aworoworo	2,395	1094	104	1197.67
Yorgbe	1,042	1432	191	888.33
Round garden egg	2,188	833	365	1128.67
Legon 1	3,646	1667	1701	2338.00

Susceptibility index

The Table 18 shows the susceptibility of the different varieties based on the index. In grading for resistance, the susceptibility index used showed that none of the varieties was resistant. It was found that the Legon 1 variety recorded the highest for the minor season and dry season with mean values of 32.4 and 67.5, however in the major season, it reduced to 3.1. On the average, mean value of 34.3 was recorded for Legon 1 variety and from the index, it was found to be susceptible. The Aworoworo variety had the second highest based on the rating with mean value of 22.5. In the minor season, an average of 38.7 was recorded whilst 26.2 was recorded during the dry season. In major season it reduced to 2.7 and consequently was found to moderately susceptible based on the index. The Yorgbe variety recorded the least and was graded as being moderately resistant. The Aworoworo variety and the Round garden egg variety was found to be moderately susceptible and moderately resistant respectively. However, in the minor season and dry seasons respectively,

average values of 40.5 and 15.6 were recorded whilst in the major season, a value of 3.4 was recorded for the round garden egg variety with an overall mean of 19.9. For Yorgbe variety, mean values of 24.4 and 16.4 were recorded for the minor and dry seasons respectively whilst a value of 3.3 was recorded for the major season. Consequently, an overall mean value of 14.7 was recorded

Table 18: Susceptibility level of different garden egg varieties.

Treatment	Minor season	Dry season	Major season	Mean	Grading for resistance
Aworoworo	38.7	26.2	2.7	22.5	Moderately susceptible
Yorgbe	24.4	16.4	3.3	14.7	Moderately resistant
Round garden egg	40.5	15.6	3.4	19.9	Moderately resistant
Legon 1	32.4	67.5	3.1	34.3	Susceptible

4.5.1 PLANT HEIGHT

Data on plant height was taken for the different treatments for the seasons the study was conducted. In the minor season, the Legon 1 variety recorded the highest ($184.9 \pm 5.3a$) whilst the Yorgbe variety recorded the least ($110.9 \pm 26.5a$). There was no significant differences in the plant height in the minor season. In the dry season, the Yorgbe variety recorded the highest with mean value of ($203.8 \pm 14.5b$) whilst the Aworoworo variety recorded the least with mean value of ($142.7 \pm 23.9a$). In the major season, the Round garden egg variety recorded the highest $226.5 \pm 9.3a$ whilst the Aworoworo variety recorded the least with value of ($209.5 \pm 7.1a$). It was found out that there were no significant differences in the plant height recorded in the dry and major seasons.

Table 19: Mean height (cm) of the different varieties

Treatment	Minor season	Dry season	Major season
Aworoworo	143.2 ± 34.1a	142.7 ± 23.9a	209.5 ± 7.1a
Yorgbe	110.9 ± 26.5a	203.8 ± 14.5b	218.3 ± 16.0a
Round garden egg	128.5 ± 22.6a	179.7 ± 19.5ab	226.5 ± 9.3a
Legon 1	184.9 ± 5.3a	182.8 ± 11.0ab	213.4 ± 15.1a
Fpr	0.32	0.22	0.77



CHAPTER FIVE

Discussion

In general, the major pests of garden eggs were found to exhibit seasonal variation, with a higher population presence recorded for each season. Two weeks after transplanting, *Urentius hystricellus*, *Leucinodes orbonalis*, *Thrips tabaci*, *Aphis gossypii* and *Aphis craccivora* were discovered on the various varieties of garden eggs. During the different seasons, two aphid species were most abundant i.e. the *Aphis gossypii* and *Aphis craccivora*. Owusu (2012) confirm the presence of cotton aphid as an eggplant pest in the studies that were conducted. These insects were most commonly found on the undersides of leaves, where they were shielded from direct sunlight. Infestation by this pest resulted in leaf deformation. Due to the fact that no insecticides were sprayed during the study period, the number of aphids was extremely high. The low number of records indicates that the various varieties were not preferred for *Thrips tabaci*. In the case of *Urentius hystricellus*, no insects were recorded during the minor season, but the numbers were extremely high during the dry season. The seasonal variation in the number of *Urentius hystricellus* suggests that the pest is a seasonal pest, with the highest population density during the dry season. The number of *Zonocerus variegatus* was observed to fluctuate across all seasons and varieties. They are serious defoliators that feed on the leaves, reducing the amount of surface area exposed to sunlight for photosynthesis (Baidoo *et al.*, 2017). *Leucinodes orbonalis* were found in small numbers during the vegetative phase, but their numbers began to rise during the flowering and fruiting stages. Similar observation was noted by Adagba *et al.* (2015) where they observed that few number of the insect was recorded at 35, 41 and 49 days after transplanting. At the flowering and fruiting stages, the number of insects increased progressively. This could be due to the presence of fruits during the period as confirmed by Owusu-ansah *et al.* (2001).

The major pests that attack the different growing stages of garden eggs.

Throughout the experiment, various insect pest species were observed attacking the various growth stages of garden eggs for all of the varieties studied. This is largely due to differences in the phenology of the crop at various stages (Rice & Pedigo, 2014). The study also revealed that none of the varieties were resistant to these pests. *Aphis gossypii* and *Aphis craccivora* were observed attacking all stages of growth in garden egg varieties. This implies that aphids should be controlled at all stages of development in garden eggs. However, according to Owusu (1997), the *A. gossypii* population in Ghana is becoming resistant to the insecticides used on eggplant. According to Dent (2003), sucking insects like aphids imbibe plant sap by piercing and probing within the plant tissue with their mouthparts until they find a phloem vessel from which they take the sap, redirecting a large portion of it away from the tissue for which it was intended and into the insect gut. Ants were also seen in the vicinity of the aphid colonies. Aphids and ants appear to have a mutualistic relationship. According to Zhou *et al.* (2015), honey dew produced by hemipterans such as aphids attracts a large number of ants, which tend to kill parasites or predators that would otherwise control honeydew-producing insects. *Thrips tabaci* causes damage to the underside of leaves, which appears brown and dried up. Thrips feed on the sap of leaves and, in heavy infestations, can cause stunted growth of the leaves, wilted shoots, reduced fruit size, and possibly plant death (FAO, 2003). Thrips typically feed on foliage, but scars, deformities, and abortion have been reported in fruits (Capinera, 2020). According to Kotey *et al.* (2013), aphid and thrips feeding activity reduces yield and causes economic loss. Thrips were found on the leaves more than the flowers in the study. Toapanta *et al.* (1996) discovered that thrips aggregate and feed on leaves early in plant growth but migrate to flowers once blooming begins. Thrips, in general, prefer succulent and more succulent plant parts. *Urentius hystricellus* appears to be a seasonal pest,

appearing only during the dry season. The nymphs are typically found on the underside of leaves, whereas the adults are typically found on the upper surface of leaves. They feed on the sap of the leaves, resulting in yellowish mottled patches on the leaves. The feces of the bugs are speckled with small black shiny spots on the attacked leaves. In severe infestations, the leaves turn completely yellow and drop off, eventually killing the plant (Eziah, 1999). *L. orbonalis* was not observed at the vegetative stage of the garden eggs during any of the seasons. This may be attributed to the absence of egg laying sites for adults and nutrient source for the larvae. According to Robert (1986), females of insects whose larvae are less mobile including those of *L. orbonalis* prefer egg laying sites that are favorable and where food is readily available. Usually at the vegetative stage, the plants secrete kairomones that tend to attract a small number of females to lay eggs. This can be related also to the presence of natural enemies notably the predator *Cheilomenes sulphuræ* (ladybird) (Coleoptera: Coccinellidae) that was observed on the field (Kadam *et al.*, 2006). At the flowering stage, the number of insects began to increase. Similar observation was recorded by Adagba *et al.* (2015), who attributes this phenomenon to the fact that the plants at this stage produce tender shoots and emit kairomones that attract adults for mating. At fruiting stage, the number of insects recorded was high because plants at this point have reached their maximum size and have many branches that have enough tender shoots, leaves, floral buds, flowers and fruits which offer the females egg laying sites and food source for the larvae. *Zonocerus variegatus* was also observed attacking the various stages of growth of the varieties. The occurrence of a higher percentage of foliar damage recorded during different seasons could be due to a variegated grasshopper outbreak. This finding is consistent with the findings of Owusu-ansah *et al.* (2001). The use of biobit (biopesticide with *B. thuringiensis* as active ingredient) did not control this pest

in the study, but the application of karate (pyrethroid insecticide) and aqueous neem seed extract at the pre-flowering, fruiting, and post-fruiting stages reduced foliar damage by 50%.

5.2 The level of damage caused by insect pests to different varieties of garden eggs.

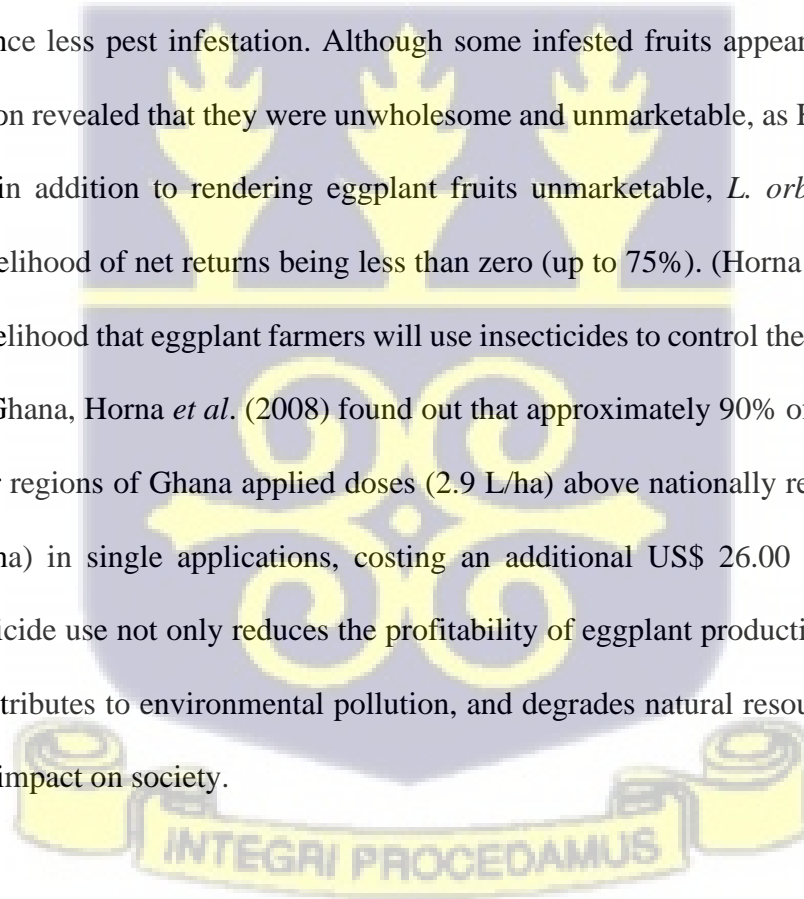
Insect pests on crops are typically associated with a specific type of damage. Damage caused by feeding, the presence of frass, which reduces the quality of the harvestable product, or indirect damage caused by insects acting as vectors to transmit diseases are all examples of damage (Dent, 2003). By chewing, sucking, or boring, insects consume plant tissue or sap. Insects that chew on leaf tissue reduce the amount of photosynthetic material available to the plant. Orthoptera species, such as *Zonocerus variegatus*, were among the insects observed in this study causing economic damage to the leaves, but their infestation was very low in comparison to the varieties studied. According to Dent (2003), although chewing insects reduce the photosynthetic material available to the plant, the loss of leaf area does not necessarily lead to loss in plant yield as the plant can compensate for damaged tissue by enhanced growth. Insects that bore into tissue, such as those that bore into stems or fruits, cause direct yield loss due to crop consumption, whereas others may reduce the value of the product by causing a decrease in quality. *Leucinodes orbonalis* was the most damaging insect pest observed, with the larvae boring into the shoots causing the most damage to the leaves. As a result, the shoot lost its freshness or began to droop, causing the leaves to fall off. Although the variegated grasshopper, aphids, eggplant lacebug, and thrips caused sap sucking damage to the leaves, eggplant shoot and fruit borers caused significant damage. Observations on the field revealed that *L. orbonalis* was responsible for the shoot's injuries. *Leucinodes orbonalis* was not found during the vegetative stage of the varieties, but their numbers increased during the flowering and fruiting stages, a finding similar to that of Taiwo *et al.* (2020).

Infestation begins with the shoots and progresses to the fruits, where damage continues until the infestation is reduced after harvesting. The withered or dropped stem indicated the start of a shoot infestation. This observation backs up the findings of Zakka *et al.* (2018). *L. orbonalis* infested, damaged, and developed in all of the varieties studied, indicating that none of them were resistant. Hossain *et al.* (2002) discovered that none of the 20 accessions tested against *L. orbonalis* were resistant to the pest in a similar study. In this study, no or very few plant shoots were infested during the vegetative stage, but injuries and infestation increased as the plant began to flower and produce fruits. This discovery is similar to that of Taiwo *et al.* (2021). The percent fruit infestation ranged from 2.72 to 12.33 during the minor season, 0.16 to 0.32 in the dry season and lastly, 5.01 to 9.99 in the major season. *Leucinodes orbonalis* has been identified as a serious pest of garden egg and brinjal, causing approximately 70% yield loss (Netam *et al.*, 2016). The larvae of *Leucinodes orbonalis* prefer to bore into flower buds, according to Netam *et al.* (2016). Taiwo *et al.* (2020) found that larvae of *Leucinodes orbonalis* and *Spodoptera litoralis* attacked the flowers and fruits in large numbers. This could be one of the reasons for the flower damage. Fruit examination revealed that the *L. orbonalis* caused the most damage to the fruits. This is consistent with the findings of Taiwo *et al.* (2020), who found out that *L. orbonalis* causes more damage to the fruits than the flowers.

5.3 Assessing the yield and growth parameters of the different varieties of garden eggs.

In terms of marketable fruit, the yields obtained in this study were low when compared to the average eggplant yield of 8000kg/ha produced in Ghana (MOFA, 2010). The highest yield obtained was 2,395kg/ha in the minor season in 2020, 1667 kg/ha in the dry season in 2021, and 1701 kg/ha in the major season in 2021. (Legon 1 variety). The relatively low yield could be attributed to the fact that the materials used in the study were mostly landraces with little or no

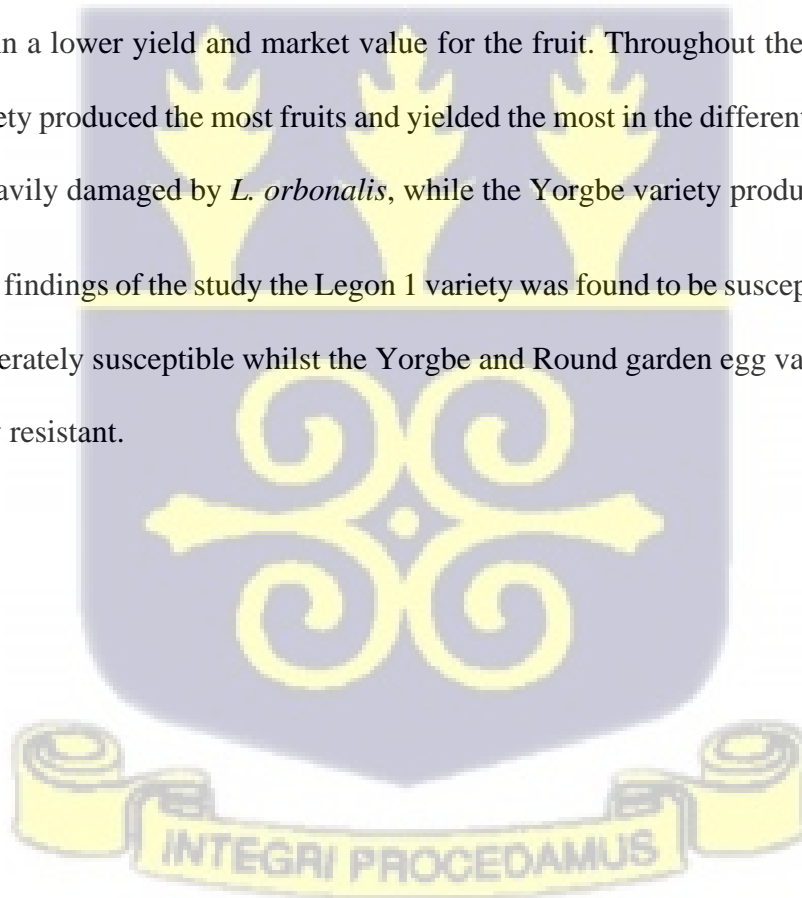
crop improvement. Improved cultivars grown under favorable conditions, according to Kotey *et al.* (2013), may yield between 50 and 80 tonnes/ha (50,000 and 80,000 kg/ha). The Legon 1 variety, which produced the most fruits and yielded the most in the different growing seasons in 2020 and 2021, was heavily damaged by larvae of *L. orbonalis*, whereas the other varieties with low yields were less susceptible to *L. orbonalis*. While susceptible varieties such as Aworoworo and Yorgbe were discovered, the Round garden egg was found to be moderately tolerant. Despite the fact that the reasons for this variety's tolerance are unknown, Prabhu *et al.* (2009) stated that eggplant accessions with a high or moderate level of various biochemical components such as glycoalkaloid, solasodine, total phenol content, and enzymes such as peroxidase and polyphenol oxidase experience less pest infestation. Although some infested fruits appeared healthy on the outside, dissection revealed that they were unwholesome and unmarketable, as Kotey *et al.* (2013) claimed. Thus, in addition to rendering eggplant fruits unmarketable, *L. orbonalis* infestation increases the likelihood of net returns being less than zero (up to 75%). (Horna *et al.*, 2007). This increases the likelihood that eggplant farmers will use insecticides to control the eggplant fruit and shoot borer. In Ghana, Horna *et al.* (2008) found out that approximately 90% of eggplant farmers surveyed in four regions of Ghana applied doses (2.9 L/ha) above nationally recommended rates (200 - 800 ml/ha) in single applications, costing an additional US\$ 26.00 on average. Such widespread pesticide use not only reduces the profitability of eggplant production, but also poses health risks, contributes to environmental pollution, and degrades natural resources, all of which have a negative impact on society.



6.0 CONCLUSION

The study demonstrated the field susceptibility of various garden egg varieties to the major field insect pests, including Yorgbe, Aworoworo, Round garden egg, and Legon 1 variety. *Aphis gossypii*, *Aphis craccivora*, *Zonocerus variegatus*, *Urentius hystericellus*, and *Leucinodes orbonalis* have all been identified as important garden egg pests. The incidence and abundance of these pests varied according to season; *Aphis gossypii* and *Aphis craccivora* populations were high, *Urentius hystericellus* populations were high only during the dry season, but other insects were recorded in low numbers. Whilst other insects were observed to be attacking other plant parts such as the leaves it was observed that *Leucinodes orbonalis* caused the most damage to the shoots and fruits, resulting in a lower yield and market value for the fruit. Throughout the growing seasons, the Legon 1 variety produced the most fruits and yielded the most in the different growing seasons, despite being heavily damaged by *L. orbonalis*, while the Yorgbe variety produced the least.

According to the findings of the study the Legon 1 variety was found to be susceptible, Aworoworo variety was moderately susceptible whilst the Yorgbe and Round garden egg varieties were found to be moderately resistant.



6.2 RECOMMENDATION

Based on the findings of this study, the following recommendations can be made:

- A study should be conducted to assess the susceptibility level of the individual pests on the different varieties.
- The antibiosis, tolerance and antixenosis studies can be carried out on the different varieties to determine the most preferred variety by the insects.
- The moderately resistant varieties which were the least preferred by the adults and therefore biochemical studies should be conducted to understand this phenomenon.



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APPENDICES

Analysis of variance for Black bean aphid

Variate: VEGETATIVE1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_B_APHID stratum	3	3.594	1.198	0.55	

REP_B_APHID.*Units* stratum

TREATMENT	3	243.266	81.089	36.94	<.001
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Residual	9	19.756	2.195		
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Total	15	266.616			
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Analysis of variance

Variate: FLOWERING1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
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REP_B_APHID stratum	3	9.224	3.075	2.49	
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REP_B_APHID.*Units* stratum

TREATMENT	3	269.362	89.787	72.60	<.001
Residual	9	11.131	1.237		
Total	15	289.717			

Analysis of variance

Variate: FRUITING1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_B_APHID stratum	3	6.898	2.299	1.40	
REP_B_APHID.*Units* stratum					
TREATMENT	3	123.258	41.086	24.93	<.001
Residual	9	14.833	1.648		
Total	15	144.989			

Analysis of variance for Cotton aphid

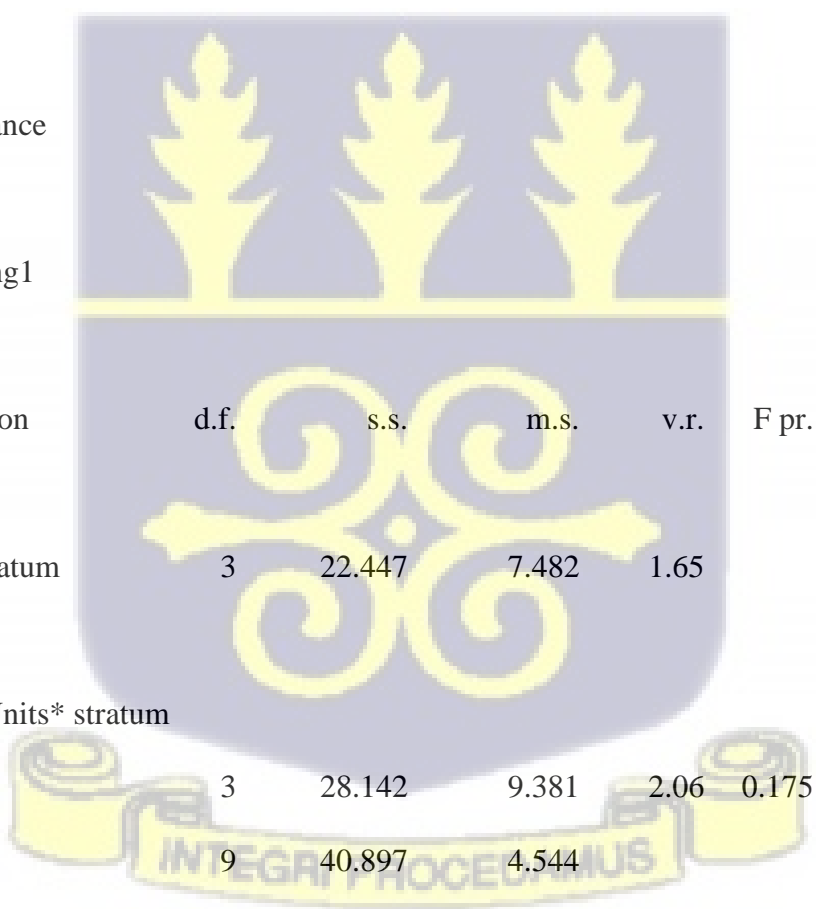
Variate: vegetative1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_APHID stratum	3	55.00	18.33	1.54	
REP_APHID.*Units* stratum					
TREATMENT	3	0.81	0.27	0.02	0.995
Residual	9	107.01	11.89		
Total	15	162.83			

Analysis of variance

Variate: flowering1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_APHID stratum	3	22.447	7.482	1.65	
REP_APHID.*Units* stratum					
TREATMENT	3	28.142	9.381	2.06	0.175
Residual	9	40.897	4.544		
Total	15	91.486			



Analysis of variance

Variate: fruiting1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_APHID stratum	3	98.582	32.861	3.68	

REP_APHID.*Units* stratum

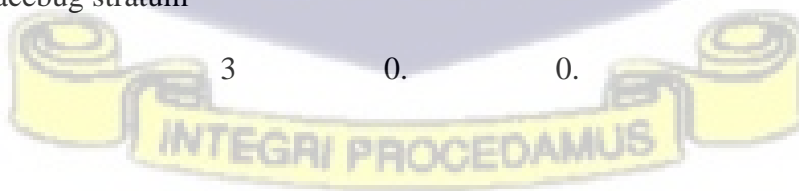
TREATMENT	3	66.243	22.081	2.47	0.128
Residual	9	80.468	8.941		

Analysis of variance for eggplant lacebug

Variate: vegetative1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
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REP_eggplant_lacebug stratum



REP_eggplant_lacebug.*Units* stratum

TREATMENT	3	0.	0.		
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Residual 9 0. 0.

Total 15 0.

Analysis of variance for Variegated grasshopper

Variate: VEGETATIVE1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
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REP stratum	3	0.51070	0.17023	5.72	
REP.*Units* stratum					
TREATMENT	3	0.12858	0.04286	1.44	0.295
Residual	9	0.26789	0.02977		

Total 15 0.90718

Analysis of variance

Variate: FLOWERING1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
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REP stratum	3	0.08333	0.02778	0.75	
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REP.*Units* stratum

TREATMENT	3	1.00606	0.33535	9.05	0.004
Residual	9	0.33333	0.03704		

Total 15 1.42273

Analysis of variance

Variate: FRUITING1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.03275	0.01092	0.13	
REP.*Units* stratum					
TREATMENT	3	0.03275	0.01092	0.13	0.942
Residual	9	0.78125	0.08681		
Total	15	0.84674			

Analysis of variance for Thrips

Variate: fruiting1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_THRIPS stratum	3	0.2123	0.0708	0.15	
REP_THRIPS.*Units* stratum					
TREATMENT	3	1.4942	0.4981	1.03	0.426
Residual	9	4.3670	0.4852		
Total	15	6.0736			

Analysis of variance

Variate: vegetative1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_THRIPS stratum	3	0.23191	0.07730	1.50	
REP_THRIPS.*Units* stratum					
TREATMENT	3	0.67628	0.22543	4.38	0.037
Residual	9	0.46307	0.05145		
Total	15	1.37126			

Analysis of variance

Variate: flowering1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP_THRIPS stratum	3	0.7338	0.2446	0.58	
REP_THRIPS.*Units* stratum					
TREATMENT	3	1.2247	0.4082	0.97	0.448
Residual	9	3.7837	0.4204		
Total	15	5.7422			

