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AGRO–INPUT USE IN PERI–URBAN OKRA PRODUCTIONIN THE GREATER ACCRA REGION

BY

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DECLARATION

I, DOTSE ELORM ABLA, author of this thesis, do hereby declare that except for references to other peoples' work, which have been duly recognized and cited, this is my original scientific research work. It was done in partial fulfillment of the requirements for Master of Philosophy Degree in Crop Science (Agronomy) and submitted to the Department of Crop Science, College of Basic and Applied Sciences of the University of Ghana.

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ABSTRACT

A series of studies were carried out in the Greater Accra region from October, 2012 to May, 2013 to ascertain agro-input usage in okra production and its effects on quality of production and the produce. Studies comprised a survey, two field studies (an on–farm trial and a field experiment) and one laboratory study. For the survey, data were collected through the administration of questionnaires and analyzed using Statistical Package for Social Sciences (SPSS) software (version 18). A randomized complete block design (RCBD) with three treatments as follows: combination of 25g/L permethrin + 475g/L pirimiphos–methyl insecticide + Propaquizafop–100g Herbicide; 25g/L permethrin + 475g/L pirimiphos–methyl + Imidacloprid insecticides + Propaquizafop–100g herbicide and the Control (no pesticide) for the on-farm experiment and 25g/L permethrin + 475g/L pirimiphos–methyl; Neem extract oil at a rate of 3.3mL/L in a knapsack sprayer and a Control (no pesticide) for the field experiment; was used for the field studies with four replicates, while a completely randomized design (CRD) with three replicates was used for the laboratory study. Data were collected on vegetative, reproductive and quality characteristics of okra. Data from field and laboratory studies were analyzed using Analysis of Variance (ANOVA), Genstat Statistical Package (11th edition). The results showed that the farmers in peri-urban okra production were predominantly male (70%) and used agrochemicals widely in their production. None had used certified okra seed for production. Most of these farmers had only basic education which significantly impacted negatively on their ability to read labels on agrochemicals. On–farm trial produced okra which performed significantly better in terms of plant height, stem girth, leaf production, fresh and dry weights of plants compared to that of the field experiment. The laboratory study showed a 10% rapid deterioration and reduced sliminess of okra from plots treated with a mixture of inorganic agrochemicals and botanicals although these fruits were aesthetically more appealing at harvest compared to the controls.

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DEDICATION

This work is dedicated to the Almighty God, my late father Mr. A. K. Dotse who did not live long enough to see the completion of my work and to a very good friend of mine Mr. Isaac Bedu for encouraging me to pursue this programme.

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TABLE OF CONTENTS

DECLARATION i

ABSTRACT ii

ACKNOWLEDGEMENT iv

TABLE OF CONTENTS vi

LIST OF TABLES xiii

LIST OF FIGURES xv

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background 1

1.2 Origin and economic importance of Okra 2

1.3 Problem Statement 3

1.4 Justification 4

1.5 Objectives 4

CHAPTER TWO 5

2.0 LITERATURE REVIEW 5

2.1 Growth and Development of okra 5

2.2 Susceptibility of Okra Growth Stages to Pests 5

2.3 Major Agronomic Practices 7

2.3.1. Climate and soil requirements of okra 7

University of Ghana http://ugspace.ug.edu.gh

2.3.2. Seeds and Varietal Selection 7

2.3.3. Seed treatment, spacing, rate and germination 8

2.3.4. Soil Characteristics 8

2.3.5. Fertilizer Management 9

2.3.6 Irrigation 9

2.3.7 Weed control. 10

2.3.8 Insect Pest control 10

2.3.9. Disease control 11

2.3.10 Harvesting 12

2.3.11. Postharvest Storage 12

2.3.12 Quality of okra 12

2.4. Effects of Agrochemicals on Plant Growth, Yield and Yield Components of okra. 13

2.4.1 Fertilizers 13

2.4.2 Pesticides 14

2.4.2.1 Herbicides 15

2.4.2.1.1 Agil 100 EC herbicides 15

2.4.2.2 Insecticides 16

2.4.2.2.1 Attack insecticide 17

2.4.2.2.2 Antie Attaa insecticide 18

2.4.2.2.3 Neem oil 19

2.5 Effect of Agrochemicals on Quality and Shelf life of some Vegetables. 20

University of Ghana http://ugspace.ug.edu.gh

CHAPTER THREE 21

3.0 MATERIALS AND METHODS.....21

3.1. Experiment one (1): Field Survey.....21

3.1.1 Experimental site 21

3.1.2 Questionnaire design and administration.....21

3.2. Experiment two (2): A. Experimental Field study; B. On–farm/ On–site farmers' field Study 22

3.2.1 Experimental site 22

3.2.2 Land Preparation.....23

3.2.3 Experimental design and field layout for Experiment IIa and IIb 23

3.2.4 Experiment IIa: Study of effects of two insecticides and a herbicide as commonly applied by farmers on performance of okra.....23

3.2.5 Experiment IIb: Effect of Attack and Neem oil insecticides on performance of okra 24

3.2.6 Planting materials.....24

3.2.7 Sowing 24

3.2.8 Cultural Practices.....25

3.2.9 Data collection 25

3.3. Experiment III: Study of effect of crop protection practices on shelf life and fruit quality of okra. 27

3.3.1 Experimental design and Methodology 27

3.3.2 Experimental Treatments.....27

University of Ghana http://ugspace.ug.edu.gh

3.3.4 Data Collection 28

3.4 Data analysis 29

CHAPTER FOUR 30

4.0 RESULTS 30

4.1 Field Survey 30

4.1.1 Sex distribution of okra farmers 30

4.1.2 Age distribution of farmers 30

4.1.3 Marital status of farmers 31

4.1.4 Educational background of farmers 32

4.1.5 Family size of farmers 32

4.1.6.1 Gender Distribution in Okra Production 33

4.1.7 Land size usually cropped by farmers 38

4.1.9 Farmers' experience and use of family labour in okra production 39

4.1.10 Water Source and Frequency and frequency of watering 40

4.1.12 Intercropping of Okra 42

4.1.13. Okra Varieties Used by Farmers and Days to 50% Flowering 43

4.1.15. Seed Source and Seed Treatments by Farmers 44

4.1.16. Insect Pest Problems encountered during Okra Production in Peri–Urban Greater Accra 46

4.1.17 Diseases of Okra 50

4.1.18. Weed problems in Okra Production 53

4.1.19 Agrochemicals used by peri–urban okra farmers. 56

University of Ghana http://ugspace.ug.edu.gh

4.1.19.1 Fertilizers use by farmers 56

4.1.19.2 Pesticides used by farmers 59

4.1.20Misuse of Insecticides among Farmers 61

4.1.21Important Constraints in Okra Production 62

4.1.22. Practice of Record Keeping in Okra Production 63

4.2. Field studies on Okra 64

4.2 Effects of pesticide application on the growth of Okra in On–farm Okra field studies 64

4.2.1 Plant Height 64

4.2.2 Mean Plant Girth 65

4.2.3 Mean Leaf Numbers 65

4.2.4 Mean Dry Weights 66

4.2.5 Mean Pod Length and Pod Diameter in On–farm experiment (IIa) 67

4.2.6 Mean Number of Seeds/Pod and Mean Number of Pods/Plant 67

4.2.7 Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra. 68

4.3 Effects of pesticide application on the growth of Okra in the experimental field. 69

4.3.1 Mean Plant Heights. 69

4.3.2 Mean Plant Stem Girth 70

4.3.3 Mean Leaf Numbers. 71

4.3.4 Mean Plant Dry Weight 72

4.3.5 Mean Pod Length and Pod Diameter. 73

4.3.6 Mean Number of Seeds/Pod and Mean Number of Pods/Plant 73

University of Ghana http://ugspace.ug.edu.gh

4.3.7 Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra. 74

4.4 Laboratory Studies on effect of agrochemical (pesticides) usage on okra storability and quality. 75

4.4.1. Sliminess of Okra 75

4.4.2 Mean Days to Shriveling, Blackening and Decay. 76

4.4.3. Weight loss of okra pods during storage 78

5.0 DISCUSSION 80

5.1 Field Survey 80

5.1.1 General Background of respondents 80

5.1.2 Gender distribution in okra production 80

5.1.3 Agronomic practices 81

5.1.4 The use of agrochemicals in peri-urban okra production. 82

5.1.5 Important constraints in okra production 84

5.2 Experiment two: Effects of agrochemical on growth and yield of okra 84

5.2.1 Effect of agrochemicals on Plant height and other growth parameters 84

5.2.2 The effect of agrochemicals on yield and yield components 86

5.3.1 Effect of agrochemicals on the quality of okra fruits 87

6.0 CONCLUSIONS AND RECOMMENDATIONS 88

5.1 CONCLUSIONS 88

5.2 RECOMMENDATIONS 89

REFERENCES 90

University of Ghana http://ugspace.ug.edu.gh

APPENDIX 98

University of Ghana http://ugspace.ug.edu.gh

LIST OF TABLES

Table 1: Climatic data of experimental area 22

Table 2: Experiment IIa (On–farm experiment at Haatso) 23

Table 3: Experiment IIb (Experimental field at the University Farm). 24

Table 4: Educational background of okra farmers. 32

Table 5: Family sizes of okra farmers. 33

Table 6: Land size used by Okra Farmers. 38

Table 7: Farmers production experience and use of family labour in okra production. 40

Table 8: Source of water for irrigation and frequency of watering for okra farms. 41

Table 10: System of Okra cultivation among Peri-Urban Greater and environs. 43

Table 11: Okra varieties used by okra farmers and days to 50% flowering. 44

Table 12: Seed source and pre-treatments by farmers. 46

Table 13: Insect problems in Okra Production. 49

Table 14: Percentage Damage caused by insect pests on okra fields in Peri–Urban Greater Accra. 50

Table 15: Disease problems of okra. 52

Table 16: Frequencies of different diseases on Okra farms and control measures adopted by farmers 53

Table 17: Weeds associated with Okra Production. 55

Table 18: Weed species encountered inPeri–Urbanokra farms in greater Accra region and methods of control. 56

Table 19: Fertilizer combinations and fertilizer types used by farmers. 58

Table 20: Pesticides used in Okra production in Peri–Urban Greater Accra. 60

Table 21: Degree of misapplication of insecticide among Peri-Urban okra farmers. 61

Table 22: Frequency of pesticide spraying. 62

University of Ghana http://ugspace.ug.edu.gh

Table 23: The practice of record keeping in Okra Production.....64

Table 24: Fresh Weight of Plant, Root and Shoot Dry Weights (On–farm experiment).....67

Table 25: Mean Pod Length and Pod Diameter (On–farm experiment).....67

Table 26: Mean Number of Seeds/Pod and Mean Number of Pods/Plant (On–farm experiment). 68

Table 27: Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra (Experiment IIa).....69

Figure 9: Mean Plant Height of Okra 3–9 WAE (Experimental field).....70

Table 28: Dry Weight of Plant Root and Shoot (Experimental field). 72

Table 29: Mean Pod Length and Pod Diameter (Experimental field trial).....73

Table 30: Mean Number Seeds/Pod and Mean Number of Pods/Plant (Experimental field trial).....74

Table 31: Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra (Experimental field trial). 74

Table 32: Sliminess of okra pods (Laboratory experiment). 76

Table 33: Mean Days to Shriveling, Blackening and Decay 77

University of Ghana http://ugspace.ug.edu.gh

LIST OF FIGURES

Figure 1: Sex distribution of peri-urban okra farmers in the greater Accra region. 30

Figure 2: Age distribution of okra farmers. 31

Figure 3: Marital status of okra farmers. 31

Figure 4: Gender distribution of peri-urban okra producers in greater Accra region.....38

Figure 5: Percentage of farmers acknowledging each of the four identified major constraints in Okra Production. 63

Figure 6: Mean Plant Heights of Okra from 3–9 WAE (on–farm experiment).....65

Figure 7: Mean Plant Girth 3–9 WAE (on–farm experiment). 65

Figure 8: Mean Leaf Numbers 3–9 WAE (On–farm experiment).....66

Figure 9: Mean Plant Height of Okra 3–9 WAE (Experimental field).....70

Figure 10: Mean Plant Girth 3–9 WAE (Experimental field trial). 71

Figure 11: Mean Leaf Numbers 3–9 WAE (Experimental Field trial).....72

Figure 12: Weight loss of okra under storage (Laboratory studies). 79

University of Ghana http://ugspace.ug.edu.gh

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

In general, agro–inputs use in agriculture include; agrochemicals and high quality seeds. Agrochemicals refer to substances used in the management of agricultural ecosystems. They include fertilizers, pH–adjusting agents, soil conditioners, crop–growth regulators and pesticides which comprise insecticides, herbicides, fungicides, rodenticides and nematicides.

In Ghana, the predominantly used agrochemicals include insecticides, herbicides, fumigants, fertilizers and growth regulators (Ntow, 2004; Laary, 2012).

The numerous benefits achieved by the use of agrochemicals can never be under rated. These benefits are largely associated with increased yields of crops with less spoilage during storage. In combination with genetically improved varieties of crop species with pest and drought resistance, agrochemicals have made tremendous contributions to the successes of the "green revolution." This has helped to increase the food supply for the rapidly increasing population of humans on earth and by so doing ensuring food security.

Agrochemicals act fast when applied on crops and give better crop yields when properly applied. Their use also reduces the time spent on labour and cost of carrying out some of the tedious farm operations such as weeding and controlling insect pests. Agrochemicals also protect the health of humans and animals against vectors and diseases ensuring that farmers get high returns from their investments (Kasimo & Mndeme, 2002).

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Farmers in a bid to increase yield and marketing potentials of their produce engage in the use of agrochemicals often in an indiscriminate manner. The chemical residues left in the produce can result in adverse health effects when consumed.

Agrochemicals, in recent times, have played an increased and significant role in vegetable production in peri–urban areas in Ghana owing to the practice of year round vegetable production. The continuous application of agro–chemicals is seriously hampering the ecosystem (Laary, 2012). The incessant use of, herbicides especially, reduces biodiversity, causes death of micro–organisms and the loss of plant and animal life. The health and lives of vegetable farmers may also be at risk.

Peri–urban vegetable production is fast gaining importance as well as an increasing role in the economy of Ghana by providing employment, income, foreign exchange and above all contributing to poverty reduction in the country. Tomatoes, garden eggs, onion and okra are among the important vegetable crops grown in Ghana.

1.2 Origin and economic importance of Okra

Okra (*Abelmoschus esculentus)* is an annual vegetable crop with an erect growth habit belonging to the Family *Malvaceae.* Okra is a heat–loving crop whose history can be traced to the Nile basin in Egypt where Egyptians have cultivated it for centuries, according to accounts of the crop in the thirteenth century (Gulsen *et al*., 2007). Okra spread through North Africa from the Nile basin and on to the eastern Mediterranean, Asia Minor, and India, spreading to the New World from Brazil and Dutch Guiana. By 1781, the crop was known as far north as Philadelphia (Oppong–Sekyere, 2011).

Currently, India is the largest producer of okra followed by Nigeria, Sudan, Iraq, Ivory Coast with Ghana being the seventh largest producer of okra in the world (Benchasri, 2012).

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Okra is mainly grown for its young immature fruits and consumed as a vegetable, raw, cooked or fried. It is a common ingredient in soups and sauces. The fruits can be preserved by drying or pickling. The leaves are sometimes used as spinach or as cattle feed, the fibers from the stem for cord, the mucilage for medical and industrial purposes, and the seeds as a substitute for coffee (NARP, 1993). Okra seeds also contain a considerable amount of good quality oil and protein. The immature green pods and fresh leaves are used as pot herbs. The pods also contain a glutinous substance which thickens soups and stews. The fruits may also be preserved for later consumption when there is a shortage of fresh produce (DeLannoy, 2001).

Okra is grown in all the ten regions of Ghana, but the bulk of the produce comes from Brong–Ahafo, Northern, Volta, Ashanti and Greater Accra regions with production levels ranging between 20.2 metric tonnes and 25.2 metric tonnes from 1974 to 1983 (NARP,1993). Some exotic varieties grown in Ghana include Lady's Finger, Clemson Spineless, Perkin's Dwarf and Perkins Long Pod. Some local varieties also include "Labadi Dwarf", "Nkrumah afuogya" and "Putsele". They are mostly cultivated as annuals in West Africa but biennial and semi–perennial types may also occur.

1.3 Problem Statement

With good agronomic practices and irrigation, okra yield could exceed 3,300 kg/ha (Messian, 1992; Sinnadurai, 1992; Ofosu–Budu *et al*., 1999). However, under erratic rainfall, yield as low as 500kg have been reported although the crop can tolerate temporary drought conditions (Messian, 1992; Sinnadurai, 1992; Ofosu–Budu *et al*., 1999).

Okra production in Ghana is also constrained by many factors including attack from weeds and insect pests, diseases, nematodes and declining soil fertility, necessitating the use of high rates of pesticides and artificial fertilizers to boost production (Obeng–Ofori, 2008). High levels of deterioration of fresh produce also affect production levels. About 25–40% of all

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vegetables and other respiring fresh commodities produced worldwide each year have been estimated to deteriorate beyond usable qualities (Lioutas, 1988).

Okra pods have a short shelf life. The pods lose quality usually through blackening, shriveling and decaying within two days after harvesting under room temperature conditions. The indiscriminate applications of agrochemicals have been reported to contribute to increased postharvest losses (Ngure *et al.*, 2009).Although the farmers at this level of production make their maximum profit from sales of their produce at the farm–gate, retailers and final consumers are those who incur postharvest losses and deterioration of the commodity.

1.4 Justification

Indiscriminate agrochemical use in peri–urban vegetable production in Ghana has been documented over several years (Ntow, 2004; Laary, 2012). However, the practice is still a challenge as farmers are keener on their economic gains from production than on effects of agrochemicals used on environment, consumer, health, storage and shelf life of the commodity.

1.5 Objectives

The objectives of this study were to:

a) ascertain the current level of use of agro–input in peri–urban okra production
b) Compare on–farm okra production in relation to experimental field production.
c) Compare quality of on–farm produced okra pods in relation to okra pods from the experimental field production.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Growth and Development of okra

Okra is a stout, erect annual herb that grows up to 4.0m height with spirally–arranged leaves with leaf blades of up to 50 cm diameter and more or less deeply 3–5- and 7–lobed. The seeds are numerous, gray to black in colour and about 3–6 mm in diameter. Seeds germinate in about 5–7 days after sowing. One to two weeks from seed germination, seedlings have at least 3–4 leaves with a height approximately 12–18 cm. By 3–4 weeks from seed germination, the plant has over 8 leaves. Plants start to flower at 5–9 weeks (40–90 days) from seed germination. Yellow solitary flowers form in the leaf axils and flower opening is in the mornings. Fruits or pods are green, cylindrical to pyramidal capsules 5–35 cm long and 1–5 cm in diameter. It takes about 4 to 6 days from anthesis to edible fruit maturity. Mature green pods turn fibrous and dry when pods are not harvested (Justo, 2012).

2.2 Susceptibility of Okra Growth Stages to Pests

Okra is attacked by several species of insect pests and infected by a few diseases from seedling to harvesting. Economic losses depend on the degree of damage, pest density, environmental conditions, stage of growth and the plant part damaged by the pest (Siemonsma, 1991; Justo, 2012).

Damping off at seedling stage can be reduced by treating the seeds with fungicides prior to sowing (Justo, 2012).

Leafhoppers, aphids and whiteflies attack seedlings at the early vegetative stage. These insects transmit yellow vein mosaic virus in okra. Infected plants produce poor quality pods. If there is no source of yellow vein mosaic virus in the neighboring fields, the rapid increase

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in leafhopper population during the dry season may cause hopper burn in okra where the plant leaves curl, turn red and eventually become dry due to the feeding by high population density of plant sucking insects at vegetative stage (Benchasri, 2012).

Cercospora leaf spot and powdery mildew are two fungal diseases that attack okra at late vegetative to reproductive stage. Fungal infection can spread rapidly in the field due to crowded and overlapping broad leaves of the plants. Besides wind spreading the fungal spores to plants, people harvesting daily and passing along the okra rows are also responsible for the widespread infection in the field (Siemonsma, 1991). Improper sanitation by farmers removing the old yellow leaves with *Cercospora* leaf spots and dropping on the site in an attempt to reduce infection rather increases the sources of infection in the field (Siemonsma, 1991).

Stem borers at early vegetative stage damage the shoots. The plants then develop branches to compensate for the damage by stem borers (Justo, 2012). Unlike other crops such as eggplant, where the development of more branches is advantageous, branching in okra is disadvantageous. Pods from branches are fewer and smaller. Fruit worms, stem and pod borers feed on flowers and bore inside the pods. If flowers are damaged, no fruits or pods will be developed and damaged pods are not marketable (Justo, 2012).

Cutworms usually feed on the leaves and pods when their population is high and may cause enormous damage to both the leaves and pods. However damage by cutworm does not greatly affect the photosynthetic ability of the whole plant because okra at vegetative stage has many big and broad leaves.

Pest infestation occurs in succession in okra. The critical stages when these pests are seen serve as basis in designing a pest management strategy to reduce damage and obtain high

quality produce. Pest incidence in okra can be determined by regular monitoring of the plants (Siemonsma, 1991; Justo, 2012).

2.3 Major Agronomic Practices

High yield of okra can be obtained if proper agronomic practices are followed. Sowing high quality seeds, good land preparation, effective application of the recommended rates of fertilizer, irrigation and removal of weeds when necessary are recommended. Agronomic practices also include the cultural management practices from seed selection, land preparation to post-harvest handling practices to obtain maximum yield and best quality okra pods.

2.3.1. Climate and soil requirements of okra

Okra is usually grown in many kinds of soils but it thrives well in well–drained sandy and clay loam soils. The plant is well adapted to a climate with a long, warm growing season. It grows well on a maximum average temperature of 35ºC with a minimum average above 18ºC. It may be grown at elevations from sea level up to 30 meters above sea level. Okra is usually planted twice a year, from April to June and October to January in Ghana and also in other parts of Africa (MOFA, 2008).

2.3.2. Seeds and Varietal Selection

In Ghana, most of the varietal names of okra are in vernacular and consists of languages like Twi, Ewe, Dagbani and Krobo and are also based on other criteria such as morphology, fruit characters, names of persons or locality, maturity periods and culinary properties (Essilfie *et al.*, 2010).

Aikins (2007) reported on the consumer preference of ten local varieties of edible matured okra fruits in some selected markets. The names of the local varieties he investigated

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included: ‘Tafo’, Janga full ridged’, ‘Janga smooth ridge’, ‘Legon spineless’, ‘Legon fingers’, ‘Green Jade’, ‘AOA98/060’, ‘AOA96/0/6’, ‘TOO60’ and ‘Legon market’.

Nkansah (2007) also reported on the growth and yield of some four exported okra varieties namely: Najuka', 'Saloni' OH–152 and OH–016 in different ecological zones in Ghana.

2.3.3. Seed treatment, spacing, rate and germination

Farmers usually use floatation for testing for okra seed viability. Percentage seed germination is important in estimating desirable number of seedlings per hill. Seeds should have at least 70% germination. For packed certified seeds, usually the percentage germination is indicated on the labels (Justo, 2012).

Locally produced seeds are not always treated. Also farmers’ seed may not be treated to enhance germination. Seed treatments such as soaking seeds in hot water (50ºC) for 30 minutes or coating seeds with fungicides, or use of botanical repellants, *Trichoderma* or *Bacillus subtillis* are usually done to kill fungal spores.

Okra seeds are planted to produce stands with plants spaced 0.3m to 0.4m apart within the row (spacing can be closer when using semi–dwarf varieties) and 0.6m to 0.9m between rows. Seeds are planted at a depth of 1–2.5cm.Maximum stand is achieved by planting three to four seeds per square meters and thinning to desired spacing. Seeding at this rate requires 3 to 11.12 kg of seed per hectare (Justo, 2012).

2.3.4. Soil Characteristics

Okra grows best in well–drained sandy loam soils with high levels of organic matter (pH 5.8 to 6.5). It is difficult to achieve good stands when seeds are directly sown in heavy clays. A well–drained soil is best used, since poorly drained soils may result in drowning of the plants (Justo, 2012).

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2.3.5. Fertilizer Management

Omotoso & Shittu (2007) investigated the effect of NPK fertilizer rates and method of application on growth and yield of okra. The methods of application they used were the band and ring methods. They suggested that the ring method was appropriate for okra production and that 150kgNh^{-1}a was the most appropriate fertilizer rate for okra production.

Most farmers do not usually use organic fertilizers in okra production since it acts slowly and does not give high yields compared to inorganic fertilizers although usually expensive. Roijuben (2011) investigated the effect of organic and synthetic fertilizers on okra and reported that the synthetic fertilizer was better than organic fertilizer because it provides faster growth of the plant but was dangerous and harmful to the health of the farmers because of the chemical composition.

Akanbi *et al*. (2005) also reported on the effects of split application of organo–minerals fertilizers on okra growth, nutrient uptake and fruit yield. They discovered that the efficiency of the applied fertilizers could be improved by split application.

2.3.6 Irrigation

Optimum irrigation is very essential for the growth and development for okra. Findings from Owusu–Sekyere and Annan (2010) and Gunawardhana and de Silva (2010) observed that okra plants, frequently irrigated, obtained higher yields compared to plants that were water stressed. They suggested that for higher returns in okra production, 80% application of the estimated amount of water lost from the soil and the crop through evapotranspiration should be adopted.

2.3.7 Weed control.

Rao (1983) observed that integrated weed control method was more effective in controlling weeds than isolated applications; while Jarwar *et al*. (1999) and Usman *et al*. (2005) observed that combining chemical weed control method with cultural method of weed control was very effective and reduced weed populations and decreased their dry matter. Few herbicides are however registered for weed control in okra production in Ghana. They include Glyphosate, Gramoxone, Sarosate, Gramoquat (non–selective) and Chemostom, Amin salt, Propanil (selective) (Amoah *et al*., 2005). Their indiscriminate application however can result in several adverse effects on the environment. Fianko *et al*. (2011) identified the use of Glyphosate, fluazifop–butyl, ametryne, diuron or bromacil as the main herbicides normally employed in weed control on vegetables fields in Ghana.

Aside the use of herbicides to control weeds, Opata (2007) studying the influence of mulching on the growth and yield of okra reported that mulching was very effective in controlling weeds on okra fields and contributed to increased growth and yields of okra. Agbeko (2011) also investigated the effects of organic and inorganic mulches on the growth and yield of okra and obtained similar results. He further added that weeds are controlled better in their early stages of growth. Hand hoeing is also used in the absence of mechanized system of farming.

2.3.8 Insect Pest control

Chemical control of insect pests of okra can be a problem because few insecticides are registered for use on this crop. Frequent pest scouting and use of cultural controls are advised to best solve pest problems early and make the crop less suitable for insect pest infestations. Insect pests of okra fall into two categories namely; foliage feeders and pod feeders.

A study conducted by Obeng–Ofori (1982), at the University of Ghana farm revealed that insect pest of okra caused economic damage by destroying the quality of leaves through boring large holes in them which serve as portal for the entry of other pathogens in addition to causing reduction in effective photosynthesis.

Ameho (2006) and Asantewaa (2010) also reported on some insects that affect okra economically. These included Aphids (*Aphids gossypii*), cotton flea beetle (*Podagrica puncticollis Weise*), swollen thighed beetle (*Oedemera nobilis*), cotton stainer (*Dysdercus spp*.), ladybird beetle (*Coccinella septempunctata*), variegated grasshopper (*Zonocerus variagatus*), okra leaf roller (*Sylepta derogata*), okra leaf miner *(Trachys herilla*) and whiteflies (*Bermisia tabaci*).

2.3.9. Disease control

Diseases of okra are widespread with the common ones being blossom blight, okra mosaic virus, okra leaf curl, and okra leaf spot among others. In Ghana, okra mosaic virus and okra leaf curl diseases are prevalent (Siemonsma, 1991). The work of Siemonsma (1991),revealed susceptibility of okra to the okra mosaic virus disease transmitted by flea beetle (*Podagrica sp.)* which is widespread in West Africa although the damage caused was less important compared to that caused by okra leaf curl disease which is transmitted by whitefly (*Bermisia tabaci*). According to Oppong–Sekyere, (2011), some local varieties such as "Atuogya–Asante", "Wunmana" and a few other okra cultivars exhibit high resistance to the mosaic and leaf curl viral diseases.

Tiendrébéogo *et al*.(2008) reporting on the effect of leaf curl disease on four local varieties and four exotic varieties of okra in Burkina Faso, noted that local varieties of okra were more susceptible to the leaf curl disease than the exotic varieties. Also yield loss was more profound among the local varieties compared to the commercial varieties.

2.3.10 Harvesting

Most varieties of okra are ready for picking 55 to 60 days after planting. Pods should be harvested when they are 6–9 cm long. Generally, pods should be picked 4 to 6 days after flower opening. In Ghana, the annual production of okra is estimated to be 1,548–4,507 metric tonnes (SRID–MOFA, 2007)

2.3.11. Postharvest Storage

Okra deteriorates rapidly and may be normally stored briefly to hold for marketing or for processing. Large quantities of okra may be canned, frozen, or brined (Aguiar *et al*., 2011). Deteriorations rapid because okra has a very high respiration rate at warm temperatures and needs to be promptly cooled to reduce field heat and after harvesting. Okra that is in good condition may be stored satisfactorily for 7 to 10 days at 7^0C–10^0C. At higher temperatures toughening, yellowing, and decaying are rapid. A relative humidity of 90 to 95% is desirable to prevent shriveling (Norman, 1992). At temperatures below 7^0C okra is subject to chilling injury, which is manifested by surface discoloration, pitting, and decay. Holding okra for 3 days at 0^0C may cause severe pitting. Okra should never be stored in large bins or hampers for any length of time as pods are likely to bleach due to improper ventilation and excessive heating (Aguiar *et al*., 2011).

Ngure*et al*.(2009) reported that, packaging of okra in perforated polyfilm bags and storing of the pods at temperatures of 15–20^0C was the best in maintaining okra fruit quality as it enhanced aesthetic value, while resulting in low decay, low off odour, no chilling injury and limited weight loss to the fruits.

2.3.12 Quality of okra

Okra pods should be well formed and straight, should not be fibrous but tender, have fresh appearance and a bright green colour which is typical of the cultivar with no signs of

dehydration. Packaged okra pods should be free of defects such as leaves, stems, broken pods, insect damage, and mechanical injury. The tender pods are easily damaged during harvest, especially on the ridges and this leads to unsightly brown or black discoloration. Quality losses that occur during marketing are often associated with mechanical damage, water loss, chilling injury, and decay (Cantwell & Suslow, 2001).

2.4. Effects of Agrochemicals on Plant Growth, Yield and Yield Components of okra.

Agrochemicals are used in boosting yields and controlling insect pests, diseases and weeds in agriculture. They are known to increase agricultural production and boost yields tremendously as these chemicals act on pests that destroy agricultural produce (Laary, 2012). The behaviour of agrochemicals in the environment depends on their stability, physio–chemical properties, the nature of the medium into which they are applied, the organisms present in the soil, and the prevailing climatic conditions (Graham–Bryce, 1981). It has been established that agrochemicals could become a nuisance if they are misused. Some of the negative effects of agrochemicals misuse include low crop yield, destruction of soil micro–fauna and flora, and undesirable residue accumulation in food crops (Edwards, 1986).

2.4.1 Fertilizers

Before planting, soil test needs to be done on each field to determine the correct fertility level. The recommendations based on the analysis must also be followed to prevent excessive plant vigour and poor yield. If no soil test is done, a general recommendation is to apply 35 kg of nitrogen, 70 to 90kg of phosphorus (P_2O_5), and 70 to 90kg of potassium (K_2O) per hectare. Side dressing is done with 11 kg of nitrogen when plants are 15 to 20 cm in height and again 2 to 3 weeks later (Briggs & Courtney, 1989).

Inorganic fertilizers have been widely adopted by farmers because of their wide range of benefits including cheapness, cleanliness, ease of handling, ease of storage and

transportation. In addition the guaranteed composition of inorganic fertilizers makes it easier for users to determine their rates of application and to predict their effect on yield (Briggs & Courtney, 1989). It must be noted that there has been a growth in the use of chemical fertilizers during the 20th century, especially during the last 50 years. From 1960, liquid fertilizers became more popular because of their effect on increased crop production without taking consideration of the possible dangers to the environment (Muyunda, 2003).

Singaravel *et al*. (2008) investigatingthe effect of liquid bio fertilizer symbiont N (*Azospirillum*) and symbiont P (*Phosphobacter*) on the growth and yield of okra, discovered that both treatments, applied in the soil were significantly superior in increasing the growth and yield of okra up to 6.28 metric tonnes ha^{-1}.

2.4.2 Pesticides

Pests may damage an estimated 30% of crops produced on the farm. Pests are natural enemies affecting crops and may include weeds, insects, slugs, snails, rats and mice. Pesticides are chemicals, which are used to kill or control these pests (Muray, 2002). The pesticides used in okra production in Ghana are mainly herbicides and insecticides (MOFA, 2008).Bio–control agents and neem extracts have been reported to beeco–friendly options for management of insect pests of okra (Bindu *et al.*, 2003). Neem oil produced non-toxic effects after spraying and acted as antifeedant, growth inhibitor and oviposition deterrent against insect pests of okra and cotton (Ahmed *et al.*, 1995). Indiscriminate use of insecticides has resulted in killing of natural enemies and environmental pollution problems on a large scale. Adoption of IPM strategies however ensures safety of the environment. Botanical pesticides (Neem oil, garlic bulb extract orpapaya leaves extract), microbial control (*Bacillus thuringiensis*) and biological control agents (spider, ant, lady bird beetle, myrid bug, etc) should be integrated for economic management of insect pests (Abro *et al.*, 2004).

2.4.2.1 Herbicides

Herbicides are agrochemicals, which kill or control weeds. These herbicides are either selective or non–selective. Selective herbicides kill the weed without affecting the crop. Non-selective herbicides will kill every plant that comes into contact with it. Indiscriminate use of herbicide causes more harm than good by destroying agricultural crops of high economic importance (Muray, 2002; Muyunda, 2003).Few herbicides are however registered for weed control, some of which are Glyphosate, Gramoxone, Sarosate, Gramoquat (non–selective) and Chemostom, Amin salt, Propanil (selective) (Amoah *et al*.,2005). Their indiscriminate application however can result in several adverse effects on the environment. Fianko *et al*. (2011) identified the use of Glyphosate, fluazifop–butyl, ametryne, diuron or bromacil as the main herbicides normally employed in weed control on vegetables fields in Ghana.

2.4.2.1.1 Agil 100 EC herbicides

Agil 100 EC is an emulsifiable concentrate herbicide for the selective post-emergence control of annual grasses in crops. It contains the active ingredient aryloxyphenoxy propionate (100 g/ℓ). It may be applied at any time during the growing season, independent of crop development. AGIL 100 EC must be applied on young, actively growing grasses under warm and humid conditions to obtain optimum results. Follow-up treatments may be advantageous in cases of irregular grass emergence. The first application should be made at the recommended time of application and the second when new emergence is observed. Some grasses propagate and distribute by means of seed and rhizomes (e.g. Johnson grass).

Grasses that germinate from seed are well controlled by the recommended rate 100g/L. Plants that grow from rhizomes are more difficult to control. Higher application rates and/or follow-up applications may be necessary under these circumstances. Weeds that are overshadowed at the time of application will not be sufficiently controlled. AGIL 100 EC is rain fast one hour

after application. Treated grasses cease to grow within 1–2 days after application. The entire plant decays within 10–20 days, depending upon climatic conditions.

2.4.2.2 Insecticides

Insecticides are used to kill or control insect pests. They are particularly more useful in tropical areas where insect pests pose a great threat to crops. Some types of insecticides can kill pests by contact. Meanwhile, other insecticides are absorbed by the plants and kill the insects when they feed on the treated plants (Briggs & Courtney, 1989).

Horna *et al*. (2008) in their survey to investigate the pesticide use in vegetable production in Ghana discovered that very few farmers were able to understand and interpret symbols and instructions on the label with about 51% of the farmers using the recommended levels of insecticides while about 30% of the farmers over applied insecticides. They also cited the finding of Owusu–Ansah *et al.* (2001b), on the use of synthetic insecticides which stated that "vegetable farmers in Ghana use a weekly calendar to spray the crop with "cocktails" of synthetic insecticides with active ingredients such as cyhalothrin, pirimiphos, and dimethoate" with about 90% of farmers applying doses above the recommended rates in single applications but considerably lower doses than recommended in terms of total amounts for control of specific insect. Ameho (2006) recommended the use of Acetamiprid at rate 3.0mL/L of water for the management of insect pests of okra.

Senjobi *et al*. (2013) investigated the performance of okra under various applications of pesticides and fertilizers in an Oxic Paleustalf soil. They discovered that the combination of 50% neem, 350 mL/ha cypermethrin, 6000kg ha^{-1} poultry manure and 112kg ha^{-1} NPK fertilizer resulted in the production of the best yields in terms of number and weight of okra fruits.

For seed production, Hassan (2010) reported that the use of dimethoate resulted in high seed yields followed by lambda–cyhalothrin. Multineem recorded the lowest seed yield. He also

reported that all the insecticides used were significantly effective in controlling spotted bollworm of okra.

2.4.2.2.1 Attack insecticide

Attack is the first insecticide registered for use in forage brassicas that controls all the main insect pests – aphids, Nysius (wheat bug), leaf miner, springtails and caterpillars of white butterfly and diamond back moth (Addison, 2015). Up until now at least two or more sprays were needed to control all these common pests in forage brassica crops. Paul Addison says the introduction of Attack means they'll spend less time and money keeping pests at bay, and achieve better results. Attack is not a new insecticide – it has been registered for vegetable brassicas, as well as other crops, for several years. With two active ingredients – permethrin (25 g/L) and pirimiphos-methyl (475g/L) – it is effectively two insecticides in one.

Another key to Attack's performance is it works in five different ways to control pests - contact, ingestion, fumigation, translaminar and repellent. That means pests die when they come into contact with and/or eat sprayed foliage; they are poisoned by the vapours and the chemical also moves through plant tissue, killing pests inside and on the underside of leaves. Attack has a seven day grazing withholding period. Rates vary according to the type of pest being targeted and crop maturity. Crops treated with Attack in replicated field trials produced 500 to 2,300kg DM/ha more than those left untreated. That makes this insecticide the weapon of choice in optimizing brassica performance (Addison, 2015).

Four Nufarm trials comparing the DM response of turnips to repeat applications of Attack, compared with herbicide-only treatments, showed just what difference pests can make to the outcome of a crop. The yield benefit of one Attack application (0.5L per ha) tank mixed with herbicides was an extra 535 kg DM per ha. The tank mix plus one further Attack application of 1 litre per ha three to four weeks later resulted in a yield gain of 1226 kg at an average cost

of 8c per kg DM. Adding a third Attack treatment resulted in a yield gain of 2367 kg DM per ha more than turnips treated with herbicide alone, for a cost of just 7c kg DM per ha. That's not a lot of money for quality feed at that time of the year (Addison, 2015).

2.4.2.2.2 Antie Attaa insecticide

The production of vegetable can be badly affected due to damage caused by fruit borer, *Leuci-nodes orbonalis* (Guenee) (Sharma *et al.* 2001) and some important sucking pests like jassid (*Cestius phycitis*), whitefly (*Bemisia tabaci*) etc (Regupathy *et al.* 1997). Among the various strategies adopted by farmers, insecticides form most popular defense in spite of many drawbacks like pest resurgence, resistance, and harmful effects on natural enemies, pollinators, wildlifes and hazards to human beings. Chloronicoti-nyls or neonicotinoids (imidacloprid as active ingredient), the new group of insecticides which acts on receptor protein of insect nervous system are highly effective against sucking pests. Their selectivity, lower dose and relative safety to non-target organ-ism make this group an ideal component in Integrated Pest Management (IPM) resulting in less insecticidal load in the environment.

Ghsal and Chartterjee performed field experiments in two crop seasons to evaluate the efficacy of chloro-neonicotinoid as foliar application against whitefly, *Bemisia tabaci* (Gennadius). Imidacloprid 17.8 SL @ 50 g a.i./ha, was found superior against whiteflies among other treatments, received low-est number of whitefly population (1.55/plant) and offered maximum reduction of whiteflies (83.15%) as well as highest marketable fruit yield (146.50 q/ha). However, imidacloprid at lower doses showed nearly similar results. The other neonicotinoid, thiamethoxam also provided similar levels of protection as that of imidacloprid. The con-ventional insecticide, methyl demeton (125 g a.i./ha) was less effective.

2.4.2.2.3 Neem oil

Neem oil is a naturally occurring insecticide found in seeds from the neem tree. It has been used for hundreds of years to control pests and diseases. It can be used throughout the growing season on all types of plants. Components of neem oil can be found in many products like toothpaste, cosmetics, soaps, and pet shampoos. Azadirachtin is the most active component for repelling and killing pests. It reduces insect feeding and acts as a repellent. It also interferes with insect hormone systems, making it harder for insects to grow and lay eggs. It also inhibits growth which prevents larvae from moulting and eggs from hatching. Other components of neem oil kill insects by hindering their ability to feed (Jilani and Saxena, 1990).

The great thing about neem seed oil is that it mainly affects plant-feeding insects that suck or chew on leaves, so beneficial insects including bees, butterflies and other pollinators that feed on nectar aren't much affected. Because azadirachtin acts on the hormonal system, insects don't develop resistance in future generations, thereby making it a sustainable solution. Neem oil helps control nearly 200 species of insects and 15 of fungi, without causing much harm to beneficials such as bees, butterflies and earthworms.

Jilani and Saxena (1990) evaluated the repellency of some botanicals such as oils of turmeric, *Curcuma longa* (L.), sweetflag, *Acorus calamus* (L.), neem, *Azadirachta indica* A. Juss, or a neem-based insecticide (Margosan-O, Vikwood Botanicals, Sheboygan, Wis.) against the lesser grain borer insect, *Rhyzopertha dominica* (F.), for eight weeks. In a choice test, filter paper strips treated with the test materials at 200,400, or 800 $\mu g/em^2$ repelled the insect. Turmeric oil and sweetflag oil were significantly more repellent during the first 2 week than neem oil and Margosan-O, but thereafter, their repellency decreased more rapidly than that of neem oil or Margosan-O. *R. Dominica* adults made significantly fewer and smaller feeding punctures in filter paper disks (7 em diameter) treated with the test materials at 100, 500, or

1,000 μg/em^2 than in control disks. Because of greater persistence, neem oil and Margosan-O deserve to be evaluated in field trials against storage pests.

2.5 Effect of Agrochemicals on Quality and Shelf life of some Vegetables.

IbeandMadukwe (2010) reported on the effects of NPK fertilizer on the viscosity and reproductive performance of okra (*Abelmoschus esculentus* (L) (Moench) in a degraded isohyperthermic ArenicKandiudult soil in Nigeria. They discovered that higher rate of NPK (above the recommended rate) applied to the okra plants resulted in increase in high coefficient of viscosity among the different okra cultivars used. Their results however contradicted the common notion that high rates of fertilizers applied to okra plants results in low viscosity of okra.

Kodithuwakku and Kirthisinghe (2009) reported on the effect of different rates of nitrogen fertilizer application on the growth, yield and postharvest life of cauliflower. They reported that, higher doses of 125% nitrogen improved yield of cauliflower. However, postharvest quality attributes and shelf life of cauliflower curds increased to about 6–9 days at lower rates of 50% nitrogen fertilizer.

A similar report was made by Hoque *et al*. (2010) in their work on yield and postharvest quality of lettuce in response to nitrogen, phosphorus and potassium fertilizers. They observed that the increased doses of fertilizer contributed to high yields. However, in terms of quality, the lower doses were very beneficial in enhancing glossiness, colour, salt burn and reduction in decay of lettuce.

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CHAPTER THREE

3.0 MATERIALS AND METHODS

The study comprised three experiments involving a field survey in selected okra production farms in Accra and two field experiments (one on–farm and the other on the University of Ghana experimental site) followed by Laboratory analysis.

3.1. Experiment one (1): Field Survey

3.1.1 Experimental site

A survey was conducted between September and November, 2012 on okra farmers in peri-urban production areas which included Ashiaman district specifically the Ashiaman Irrigation Project site, okra farms along the Tema Motorway extension, okra farms on the Ghana Atomic Energy Commission lands at Haatso and some selected farms in Kwabenya and Larbadi.

3.1.2 Questionnaire design and administration

Stratified questionnaires were administered to fifty (50) farmers to obtain information on agrochemicals used in okra production. Questionnaires comprised both open and closed ended questions.

Prior to the exercise the questionnaires were pre-tested to ensure that they were applicable and relevant. Languages that were understood by the farmers were used. Questions asked included household demographics, farm sizes, agronomic practices, harvesting period, irrigation regimes, agrochemical use, mode and rate of agrochemical applications, pest and disease infestation and record keeping.

In addition to the questionnaire, data were also collected through observation in farmers' field activities.

3.2. Experiment two (2): A. Experimental Field study; B. On–farm/ On–site farmers' field Study

3.2.1 Experimental site

Two field experiments were carried out; one at the University of Ghana, Legon farm and the other on Ghana Atomic Energy Commission, Haatso farm from January to May, 2013. The soils at the experimental sites belong to the Adenta series which is well drained, light in texture and easy to work on. The vegetation of the experimental sites is coastal savannah.

The rainfall pattern of the area is bimodal. The major season starts from the month of March and ends in July, with a peak rainfall in June whilst the minor rains occur between September and November with a peak rainfall in October. The climatic data for the experimental period are shown in Table 1.

Table 1: Climatic data of experimental area

Month	Total Rainfall (mm)	Relative Humidity (%)		Temperature (^{o}C)	
		At 06:00 h GMT	At 15:00 h GMT	Minimum	Maximum
Dec.'12	41.9	91	66	24.9	32.6
Jan.'13	34.0	90	88	25.5	33.4
Feb.'13	0.0	93	66	25.4	33.7
Mar.'13	19.2	91	54	25.7	34.3
Apr.'13	58.5	88	51	25.0	33.8
May'13	62.8	85	68	24.6	32.9

Source: Ghana Metrological Services Agency, Mempeasem,Legon

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3.2.2 Land Preparation

The land was ploughed and harrowed in December, 2012 prior to planting. The land was lined, pegged, leveled and demarcated into plots after the debris had been removed.

3.2.3 Experimental design and field layout for Experiment IIa and IIb

The randomized complete block design was used with three treatments and four replications for both experiments. The planting distances used were 70 cm between rows and 40 cm within rows. Each experimental unit contained ten rows and three plants within each row with eight record plants

3.2.4 Experiment IIa: Study of effects of two insecticides and a herbicide as commonly applied by farmers on performance of okra

This study involved an on–farm experiment at Haatso using the agrochemicals supplied by the farmer for okra production. The three treatments were made up of the recommended rates of two pesticides used by the farmer. The second treatment was made up of a mixture of two insecticides as prepared by the farmer and the use of herbicide. While the third treatment served as a control (Table 2).

Table 2: Experiment IIa (On–farm experiment at Haatso)

Treatment	Agrochemical Used
T1a	Attack insecticide + Agil 100 EC Herbicide at recommended rate frequency of spraying
T2a	Mixture of Attack and Auntie Atta insecticides + Agil 100 EC herbicide
T0a	No Agrochemical

3.2.5 Experiment IIb: Effect of Attack and Neem oil insecticides on performance of okra

This experiment was conducted at the University of Ghana farm. It comprised three treatments involving two insecticides commonly used for okra production at the University of Ghana farm. Treatment one (T1b) involved the use of 'Attack' insecticide(containing 25g/L permethrin + 475g/L pirimiphos-methyl as active ingredient) at the recommended rate of 3.3mL/L in a knapsack sprayer every two weeks. Treatment two (T2b) involved Neem oil (organic insecticide) at the recommended rate of 3.3 mL/L knapsack sprayer and the third treatment, Control, where no pesticide was applied (Table 3). No other crop protection was used in this experiment?

Table 3: Experiment IIb (Experimental field at the University Farm).

Treatment	Agrochemicals used
T1b	Attack insecticide at recommended rate only
T2b	Neem oil insecticide at recommended rate only
T0b	No agrochemical (control)

3.2.6 Planting materials

Farmer saved seeds (Variety Legon finger) obtained from a farmer at Ghana Atomic Energy Commission, Haatso was used for the study.

3.2.7 Sowing

Four seeds were sown per hill manually at a depth of 2cm. Seedlings were thinned to two per hill and replacement of non–geminated seeds was done one week after emergence. Two weeks after emergence, the seedlings were thinned to one plant per hill.

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3.2.8 Cultural Practices

Hoeing and hand picking of weeds were done twice during the experimental periods at three weeks after sowing and seven weeks after sowing. 15:15:15 NPK fertilizer was applied to the crop two weeks after planting at a rate of 250kg/ha (6g/plant) and urea was applied at 60kg/ha (1.4 g/plant) at flowering. Watering was done regularly throughout the period of the study.

3.2.9 Data collection

Data collection started two weeks after seedling emergence and continued every two weeks thereafter to the end of the experiments. Records were taken on eight non–border record plants. The following data were collected:

3.2.9.1 Number of leaves per plant

The total number of leaves per plant was counted fortnightly for each of the record plants starting two weeks after seedling emergence and the mean computed.

3.2.9.2 Plant height

The heights of the record plants were measured with the aid of a meter rule by measuring each plant from the ground level of the soil to the tip of the apical leaves and the mean plant height computed.

3.2.9.3 Stem girth

Stem girth of each record plant was measured at about 5 cm above the soil level using vernier calipers and the mean stem girth computed.

3.2.9.4. Number of days to 50% flowering

The number of days to 50% flowering is defined as the number of days to anthesis from sowing of seeds until half of the record plants flowered. The number of days to 50% flowering per treatment was counted for the record plants and the mean computed.

3.2.9.5. Plant fresh weight

Three plants selected at random eight weeks after sowing were uprooted and cut into pieces and then weighed using an electronic scale after the soil had been washed off from the roots. The mean plant weight was then computed.

3.2.9.6. Root and Shoot Dry Weights

The roots of three freshly harvested plants were put in paper bags after the roots had been thoroughly washed and oven–dried at 80 ^{o}C until a constant weight was attained. The mean weight of root dry matter per plant was determined. Similarly, the shoots of three freshly harvested plants were cut into pieces, put into paper bags and oven–dried at 80 ^{o}C until a constant weight was attained. The mean shoot dry weight was then computed.

3.2.9.7. Number of Productive Branches

Productive branches refer to the branches that produced pods (fruits). The number of productive branches was counted and the mean computed.

3.2.9.8. Number of Pods per Plant

The total number of pods at edible maturity was counted after each harvest and the total calculated at the end of the harvesting period.

3.2.9.9. Length and Diameter of Pods

The length of edible mature pods/plot was measured from the pedicel end of pod (where the sepals are formed) to the tip using a rule and the mean length computed. Similarly the diameter of edible mature pods/plot was measured at the middle portion of the fruit using a pair of vernier calipers and the mean computed.

3.2.9.10. Weight of Pod

The total weight of harvested pods (at edible maturity) mature pods was weighed at each harvest and the mean computed.

3.2.9.11. Number of seeds per dry pod

Eight mature dried pods selected at random from each treatment were shelled and the seeds were counted. The mean for each treatment was then determined.

3.2.9.12. Yield per Plant

The total weight of matured pods/plant at each harvest was added from the beginning of harvest to the end to obtain the total yield/plant.

3.3. Experiment III: Study of effect of crop protection practices on shelf life and fruit quality of okra.

Fresh pods from all the treatments were stored in the physiology laboratory in the Crop Science Department, University of Ghana, Legon from 4th–27th June 2013. The pods were observed under ambient laboratory conditions with temperature of 23 ^{o}C (±5 ^{o}C) and relative humidity of >70% RH.

3.3.1 Experimental design and Methodology

Fruits collected from the various treatments in experiment IIa and IIb were used. A completely randomized design was used with three replicates. Each experimental unit consisted of 10 fresh pods of similar sizes, shape and colour and harvested the same day. The pods were packed in a single layer. A distance of 1cm separated each pod in a tier.

3.3.2 Experimental Treatments

Treatment one (T1a) was sample of pods harvested from T1a in the on–farm experiment. Treatment two (T2a) was sample of pods harvested fromT2a in the on–farm experiment. Treatment three (T0a) was sample of pods harvested fromT0a in the on–farm experiment.

Treatment four (T1b) was sample of pods harvested fromT1b in experimental field trial. Treatment five (T2b) was sample of pods harvested fromT2b in experimental field trial while Treatment six (T0b) was pods harvested from T0b in experimental field trial.

Treatments	Source of harvested pod
T1a	Sample of harvested pods from T1a
T2a	Sample of harvested pods from T2a
T0a	Sample of harvested pods from T0a
T1b	Sample of harvested pods from T1b
T2b	Sample of harvested pods from T2b
T0b	Sample of harvested pods from T0b

3.3.4 Data Collection

Data collection started two days after storage and thereafter every two days to the end of the experiment when all the okra pods had decayed. Data was taken on the following:

3.3.4.1 Sliminess of Okra

Fresh pods from all treatments of uniform sizes, shape and color were sliced and boiled in water at the temperature of 100°C for two minutes and the sliminess of the okra assessed by ten (10) volunteers on a scale of 1–5 with 1 being not slimy and 5 being extremely slimy.

3.3.4.2 Number of days to shriveling

The pods were observed every two days to check the rate of shriveling. A shriveled pod was visually assessed and was also identified by a decrease in pod girth and weight of pods and the number of days after storage (DAS) and the total number of shriveled pods recorded.

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3.3.4.3 Number of days to blackening

The pods were observed every two days and the blackening observed by the change in color. The rate of blackening and the number of days to onset of blackening were assessed and recorded.

3.3.4.4 Number of days to decay

The number of days to decay was assessed by observing the okra pods every two days and the rate of decay and the number of days to decay was recorded for pods that had rotted.

3.3.4.5. Weight loss

At every two days, the packed samples were weighed using an electronic scale. Weight loss was calculated as the difference between the initial weight and the weight on the day of assessment.

3.4 Data analysis

Data gathered from the questionnaires were analyzed by the use of Statistical Package for Social Sciences (SPSS version 18).

The data collected from experiments IIa, IIb and experiment III were analyzed using Analysis of Variance (ANOVA), Genstat statistical package (11th edition) and where significant differences were observed, the least significant difference (LSD) at $p=0.05$ was used to compare the means.

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CHAPTER FOUR

4.0 RESULTS

4.1 Field Survey

4.1.1 Sex distribution of okra farmers

Out of the 50 farmers sampled, 35 of them were male representing 70% whiles the remaining 15 which represented 30% of the farmers were female (Fig. 1).

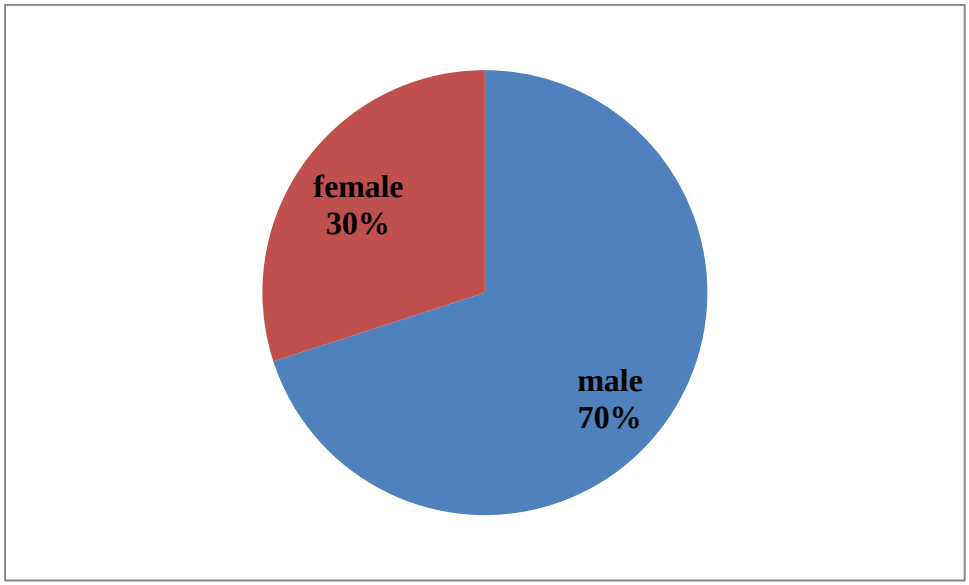

Figure 1: Sex distribution of peri-urban okra farmers in the greater Accra region.

4.1.2 Age distribution of farmers

Out of the 50 respondents, 4% were between the ages 24–30 years, 16% were between the ages of 31–35 years and another 16% of the respondents were between the ages of 36–40years. Fourteen percent and 8% were between the ages of 41–45years and 46–50years respectively whiles 42% of the respondents were above 50 years. Majority of the farmers were above 40 years representing 64%. (Fig.2).

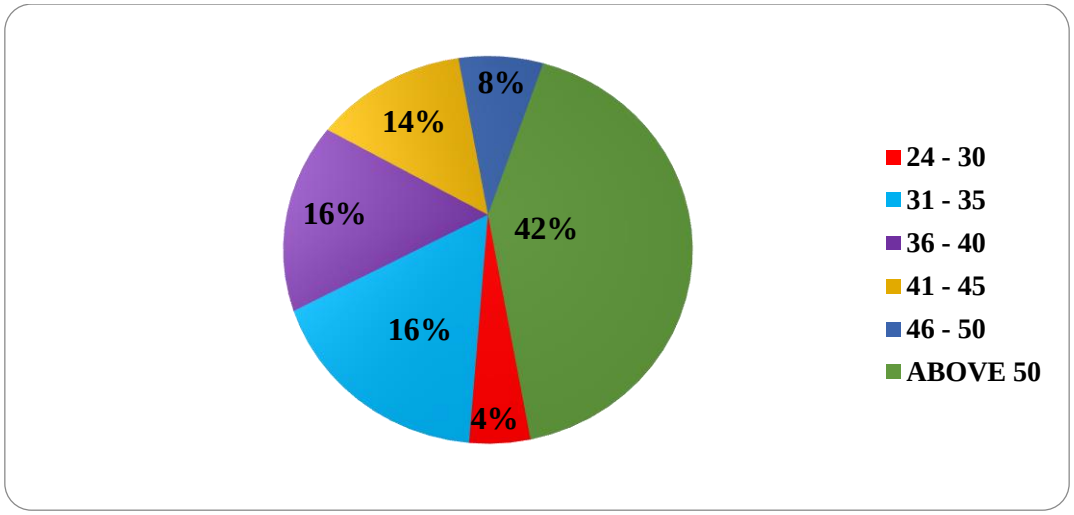

Figure 2: Age distribution of okra farmers.

4.1.3 Marital status of farmers

Majority of the farmers were married and this represented 64% of the farmers. Ten percent (10%) of the farmers were divorced while 26% were single. However, most of the single farmers were actually widows and widowers, and only 2 out of the single farmers are yet to get married (Fig.3).

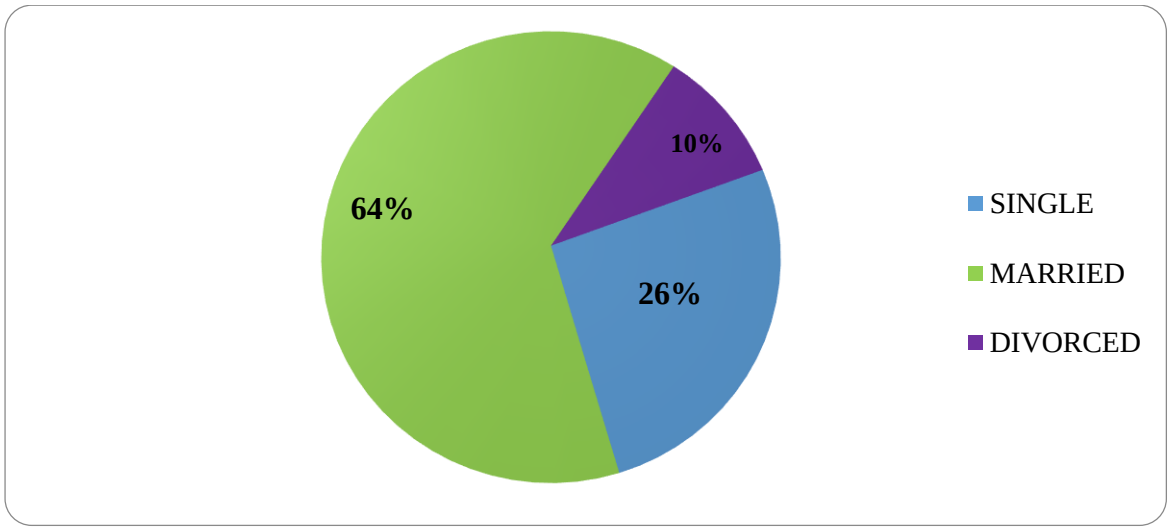

Figure 3: Marital status of okra farmers.

4.1.4 Educational background of farmers

Table 4 represents the educational background of respondents. About 24% of the respondents had no formal education and most of them were women. The remaining 76% had various levels of formal education of which only 6% were educated up to the tertiary level. Eighteen percent (18%) and 22% had high school and primary levels respectively. About 30% of the respondents which forms the majority had basic school education as their highest educational level. Only few respondents who reached basic stage of the educational ladder could read and write while all those from the high school and the university stage could read and write perfectly.

Table 4: Educational background of okra farmers.

Educational Background	Frequency	Percentage
No Education	12	24.0
Primary	11	22.0
Basic Education	15	30.0
High School	9	18.0
University	3	6.0
Total	**50**	**100.0**

4.1.5 Family size of farmers

Table 5 represents the family size of okra farmers. About 18% of the farmers had very small family of 2–3 persons and 18% of the farmers had very large family size of 10 persons and above. The average family size was 5 persons. Forty two (42%) of the farmers had family size of 4–6 persons whiles 22% of the farmers had a family size of between 7–9 persons.

Table 5: Family sizes of okra farmers.

Family Size	Frequency	Percentage
2–3	9	18.0
4–6	21	42.0
7–9	11	22.0
10 and above	9	18.0
Total	**50**	**100.0**

4.1.6. Okra Production Practices and Gender Profile of Operators

4.1.6.1 Gender Distribution in Okra Production

Okra production involves various activities and depending on the gender of the owner of the land and how big the land area is, farmers employ labourers or do tasks related to the okra production. Only a few women and youth were involved in peri–urban okra production. 74% of the respondents involved in land preparation were men. Fifty percent (50%) of the men were above 50 years of age whiles 38% were between the ages of 40–49 years and the remaining 12% were between the ages of 30–39 years. Only 6% of the respondents were women all of whom were between the ages of 30–39 years. Twenty percent (20%) of the respondents were (male and female) youth.

4.1.6.2 Land Preparation

The ages of youth involved in okra production ranges between 18 to 30 years of which only 24% were females. The remaining were male who actively participated in land preparation activities.

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4.1.6.3 Month of Planting and Frequency of Planting Okra

About 24% of farmers planted their okra from January–March 2012 whiles 16% planted their okra from April–June 2012. Another 16% of the farmers planted their okra between October–December 2012. However majority of the farmers representing 44% of respondents planted their okra between July and September 2012. About 60% of the farmers planted their okra between April and September which coincided with the major raining season whiles the remaining 40% of the farmers planted their okra during the lean season (Table 9).

Fifty two percent (52%) of respondents representing more than half of the farmers interviewed reported growing okra twice a year. Usually this practice was done both in the raining season and in the dry season. About 30% of them grew okra only once in a year but in combination with other crops at various times or at the same time but on different lands. Eighteen percent (18%) of the respondents also reported growing okra more than twice a year on different lands.

4.1.6.4 Sowing

Fifty six percent (56%) of the respondents responsible for the seed sowing operation were men of whom 20% were above 50 years, 46% were between the ages of 40–49 years and the remaining 34% were between the ages of 30–39 years. Twenty (20%) of the respondents who sowed the crop themselves were women of which 58% of them were above 50 years of age, 32% between 40–49 years with the remaining 10% between the ages of 30–39 years. Twenty four (24%) of the respondents (male and female youth) were between the ages of 18–30 years of which 68% were male with the remaining 32% females.

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4.1.6.5 Fertilizer application

Majority (66%) of the respondents involved were male. Thirty–eight percent (38%) of the men were above 50 years of age whiles 18% were between the ages of 40–49 years and the remaining 44% were between the ages of 30–39 years. Fourteen percent (14%) of the respondents were female of whom 18% were above 50 years of age, 42% were between 40–49 years with the remaining 40% between the ages of 30–39 years. Twenty percent (20%) of the respondents (male and female youth) were between the ages of 18–30 years with 78% of them being male while the remaining 22% were females.

4.1.6.6 Weed control

Despite the use of herbicides among most respondents, 68% of the respondents (males) reported manually weeding their fields. Thirty–six percent (36%) of this number were above 50 years of age whiles 38% were between the ages of 40–49 years and the remaining 26% were between the ages of 30–39 years. The females comprised 18% of which 76% of them were above 50 years of age, 6% were between 40–49 years with the remaining 18% between the ages of 30–39 years. The youth group that also weeded the farms were 18% of the respondents (male and female) were between the ages of 18–30 years. Eighty eight percent (88%) of this number were male with the remaining 12% being females. The remaining 14% of the respondent do not weed their farms by themselves but rely on labour.

4.1.6.7 Pesticide Usage

Pesticide usage among the various gender groups represented in okra production was very rampant however most of the female respondents were not actively involved in pesticide spraying on their fields since they employed labour or requested their male counterpart to spray their crops for them. Ninety two percent (92%) of the respondents involved in pesticide spraying were male. Twenty six percent (26%) of the men were above 50 years of age whiles

32% were between the ages of 40–49 years and the remaining 42% were between the ages of 30–39 years. Only 4% of the respondents who performed pesticide spraying were females all of whom were between the ages of 30–39 years. Four percent (4%) of youth respondents (both male and female youth) were between the ages of 18–30 all of whom were male.

4.1.6.8 Irrigation

Irrigation is also a very important activity in okra production. 40% of the respondents involved in irrigation were male. Forty–eight percent (48%) of the men were above 50 years of age whiles 28% were between the ages of 40–49 years and the remaining 24% were between the ages of 30–39 years. Sixteen percent of the respondents were female of whom 18% of them were above 50 years of age, 32% were between 40–49 years with the remaining 50% between the ages of 30–39 years while 44% of the respondents consisted of both male and female youth between the ages of 18–30 years of whom 88% were male with the remaining 12% females.

4.1.6.9 Harvesting

Twelve percent (12%) of the respondents involved in harvesting were male. Thirty–eight percent (38%) of them were between the ages of 40–49 years and the remaining 62% were between the ages of 30–39 years. Fifty six percent (56%) of the respondents were female of whom 18% were above 50 years of age, 20% were between 40–49 years with the remaining 62% between the ages of 30–39 years. Thirty two percent (32%) of the respondents involved in harvesting were youth (male and female) between the ages of 18–30 years with 34% being males and the remaining 66% females.

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4.1.6.10 Transportation

Transportation of the produce was also mainly done by females. Only 6% of the respondents involved in the transportation of their produce were male with all of them between the ages of 30–39 years. Sixty six percent (66%) of the respondents were females. Only 12% of them were above 50 years of age, 36% were between 40–49 years with the remaining 52% between the ages of 30–39 years. The remaining 28% of the respondents were youth (males and females) between the ages of 18–30 years of which 68% were male with the remaining 32% females.

4.1.6.11 Selling of Produce

Selling of okra was also done by females mostly, with 64% of the respondents being females 10%, of whom were above 50 years of age, 32% were between 40–49 years with the remaining 58% between the ages of 30–39 years, 32% of the respondents (males and females youth) between the ages of 18–30 years of which 18% were male with the remaining 82% were females while only 4% of the respondents were male only were all between the ages of 30–39 years (Figure 4).

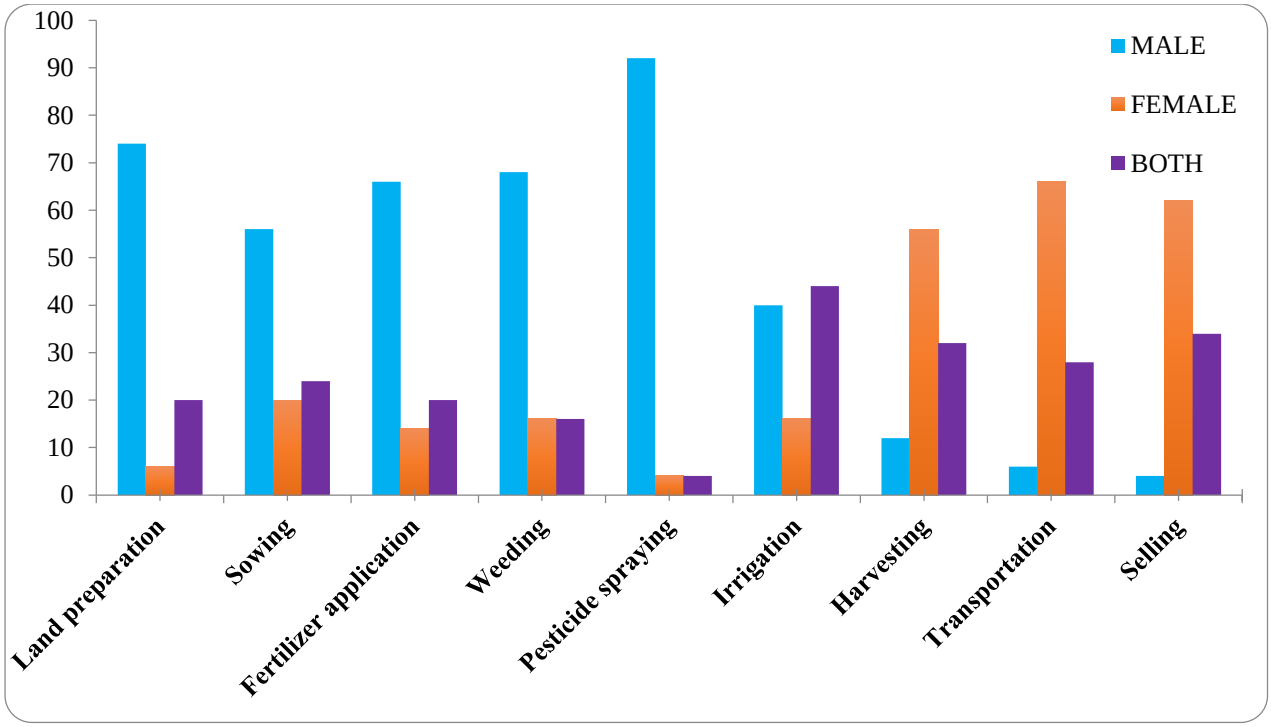

Figure 4: Gender distribution of peri-urban okra producers in greater Accra region

4.1.7 Land size usually cropped by farmers

Majority of the farmers engaged in small scale production of okra. The minimum land area cropped by farmers was 1012 m^2 and the maximum land area cropped was 8097 m^2. The average land size cropped by farmers was 4047 m^2. About 18% of the farmers cropped 4047 m^2 and 22% of them cropped a little below 4047 m^2 (Table 6).

Table 6: Land size used by Okra Farmers.

Land size usually cropped in Okra Production(m^2)	Frequency	Percentage
1012	8	16.0
2023	22	44.0
3035	11	22.0
4047	6	12.0
6070	1	2.0
8094	2	4.0

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Total	**50**	**100.0**

4.1.9 Farmers' experience and use of family labour in okra production

4.1.9.1 Farmers` Experience

Table 7 represents the experience of farmers in okra production. All the farmers used in the survey had some experience in okra production. The lowest period of experience was between 6 months to 2years and this covered 20% of the farmers. With this group only one person had a year's experience in growing okra with most of the remaining 20% having two years' experience. Twenty eight percent (28%) of the farmers also had between 3–8 years of experience. About 52% of the farmers were very experienced okra farmers, some of whom were best okra farmer's award winners. Their experience ranging from 9 years to 15 years and above. Some of the farmers had been growing okra for over 30 years. Most of the farmers interviewed also had experience in other crops such as maize, cassava and other vegetables which included tomatoes, pepper, garden eggs and leafy vegetables and had decided to go into okra production but on a relatively small scale.

4.1.9.2 Use of Family and Hired Labour

About 56% of the farmers did not use family labour. However, the remaining 44% of the farmers used family labour and employed various numbers of their family members in the production process. The number of family members engaged ranged from 1 person to 4 or more. About 72% of those who use family labour used only 2 persons with about 14% employing only one person to help in their okra fields. The remaining made up of about 14% of the respondents used 3 people and above on their okra farms.

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Table 7: Farmers production experience and use of family labour in okra production.

	Frequency	Percentage
Experience in Okra production		
6months–2years	10	20.0
3–5years	8	16.0
6–8years	6	12.0
9–12years	12	24.0
13–15years	5	10.0
above 15 years	9	18.0
Total	**50**	**100.0**
Use of family labour in okra production		
Yes	22	44.0
No	28	56.0
Total	**50**	**100.0**
Number of persons usually used as family labour in Okra production		
1	7	14.3
2	36	71.4
3	2	4.8
5 or more	5	9.5
Total	**50**	**100.0**

4.1.10 Water Source and Frequency and frequency of watering

Majority of the farmers (90%) used supplementary irrigation for their crops. A few (4%) of the farmers used boreholes. Six percent (6%) of the respondents used tap water and other water sources in watering their crops (Table 8).

In terms of frequency of watering, more than half (52%) of the farmers watered their crops once a week usually by flooding the whole area of land and this could maintain the soil moisture until the following week. About 20% of the farmers also watered their crops after

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every three days. About 16% of the farmers watered their crops every other day whiles the remaining 12% of the farmers water their crops every day. The irrigation regime adopted by farmers depended mostly on the stage of their crops, the soil type and the nature of land used in okra production.

Table 8: Source of water for irrigation and frequency of watering for okra farms.

	Frequency	Percentage
Water source used in Okra production		
Public Irrigation schemes	45	90.0
Public Borehole/Dam	2	4.0
Tap water and Others	3	6.0
Total	**50**	**100.0**
Irrigation frequency of Okra farmers		
Everyday	6	12.0
Every Other Day	8	16.0
3 Times A week	10	20.0
Once A week	26	52.0
Total	**50**	**100.0**

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Table 9: Okra planting patterns in Peri–Urban Greater Accra and its environs.

	Frequency	Percentage
Month of Planting Okra		
January–March	12	24.0
April–June	8	16.0
July–September	22	44.0
October–December	8	16.0
Total	**50**	**100.0**
Number of Plantings per Year		
Once	15	30.0
Twice	26	52.0
3 Times And Above	9	18.0
Total	**50**	**100.0**

4.1.12 Intercropping of Okra

About 48% of the respondents reported growing okra with other crops whiles the remaining 52% practiced sole cropping on their fields (Table 10). Of the total farmers growing different crops, 17% of them reported growing cabbage as an intercrop while 58% of them intercropped with maize. Only 4% of them intercropped with lettuce while the remaining 21%intercropped with several other crops including garden egg, pepper and leafy vegetables including ‘ayoyo’ and ‘gboma’ (local names).

The respondents gave different reasons for practicing intercropping. More than half of the respondents (54%) practiced crop rotation as a form of intensive system. Most of the farmers in this category grew maize to achieve this purpose. Others also grew cabbage to reduce pest infestation on their fields. This category consisted of about 17% of the respondents. Another

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17% of the respondents intercropped to gain more income from the different crops grown. The remaining 5% intercropped to obtain a variety of produce from their fields. None of the respondents indicated that they intercropped to check soil erosion.

Table 10: System of Okra cultivation among Peri-Urban Greater and environs.

	Frequency	Percentage
Intercropping of Other Crops with Okra		
Yes	24	48.0
No	26	52.0
Total	**50**	**100.0**
Crops Usually grown With Okra		
Maize	29	58.3
Cabbage	8	16.7
Lettuce	2	4.2
Any other crop	10	20.8
Total	**50**	**100.0**
Reasons For Growing Other Crops With Okra		
Rotation	27	54.2
Pest Control	8	16.7
More Income	8	16.7
Variety	6	12.5
Total	**50**	**100.0**

4.1.13. Okra Varieties Used by Farmers and Days to 50% Flowering

Table 11 represents the varieties of okra planted by the respondents. Farmers grew both exotic and local varieties of okra. About 34% of the farmers' grew the "Larbadi Dwarf" variety which is a local variety, 52% of the farmers also reported growing the "Legon finger" variety which is an improved variety. About 6% of the farmers produced "green velvet" whiles the remaining 8% of the farmers planted "Indiana" variety.

Days to flowering of okra depended on the variety of okra planted. Some varieties were early maturing whiles others were late maturing. Thirty–eight percent of the farmers planted okra varieties which flowered 40–45 days after sowing. Sixteen percent (16%) of the farmers planted okra varieties which flowered 46–50 days after planting and 24% of the farmers had varieties which flowered 51–60 days of planting. Six percent of the farmers had late varieties which flowered after 61–70 days of planting while 16% of the respondents also had extra late varieties which flowered after 71–80 days of planting.

Table 11: Okra varieties used by okra farmers and days to 50% flowering.

	Frequency	Percentage
Okra variety usually grown by farmers		
Labardi Dwarf	17	34.0
Green Velvet	3	6.0
Indiana	4	8.0
Legon Finger	26	52.0
Total	**50**	**100.0**
Days to flowering of Okra		
40–45days	19	38.0
46–50days	8	16.0
51–60days	12	24.0
61–70days	3	6.0
71–80days	8	16.0
Total	**50**	**100.0**

4.1.15. Seed Source and Seed Treatments by Farmers

Majority of the farmers (66%) used their own saved seeds or procured seeds from other farmers. Most of these farmer-saved seeds were of local varieties. The remaining 34% of the farmers purchased their seeds from agrochemical shops or seeds and agro inputs outlets. The seeds purchased from the agrochemical shops were either of local or exotic varieties.

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Only10% of the respondents reported conducting germination tests prior to planting. The remaining 90% of the respondents did not practice any form of germination test.

About 68% of the respondents did not pre–treat their seeds before planting. While very few (4%) of the respondents practiced pre–treatment of their seeds prior to planting. About 28% of the respondents were not sure of any pre–treatment carried out on the seeds. Of the total respondents surveyed, 4% practiced pretreatment of okra seeds prior to planting. Of the remaining, 68% reported no pre–treatment while 28% had no idea what a pre–treatment entailed.

About 80% of the respondents did not perform any seed conditioning treatment on their okra while the remaining 20% practiced seed conditioning treatments on their seeds by washing the seeds with warm water before planting and soaking the seeds in growth hormones solutions for 6–10hours before planting (Table 12).

Table 12: Seed source and pre-treatments by farmers.

	Frequency	Percentage
Seed Source		
Farmer saved	33	66.0
Commercial	17	34.0
Total	**50**	**100.0**
Germination test on Okra seeds		
Yes	5	10.0
No	4	90.0
Total	**50**	**100.0**
Pre-treatment of Okra Seed		
Yes	2	4.0
No	34	68.0
Not sure	14	28.0
Total	**50**	**100.0**
Conditioning and Treatment of Okra Seeds		
Yes	10	20.0
No	40	80.0
Total	**50**	**100.0**

4.1.16. Insect Pest Problems encountered during Okra Production in Peri–Urban Greater Accra

Tables 13 and 14 represent insect pest problem in okra production in Peri–Urban Greater Accra. All the okra fields surveyed had various degrees of insect pest infestation. Different types of insect pests were present on any particular field depending on the growth stage of the okra, climate, farm sanitation and the presence of other crops which were susceptive to insect attack.

About 40% of the farmers identified 3 major insect types on their fields. Twenty percent (20%) of the farmers identified 2 insect types on their fields. Twenty eight percent (28%) of

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the farmers also identified 4 insect types on their fields and the remaining 12% identified 5 or more insect types on their fields. About 80% of the farmers experienced a high rate of insect infestation on their fields with the number of insects types present on their fields ranging from 3–5 and above.

About 70% of the insects were identified during the hot period whiles 30% of the insects were identified during humid period which was usually characterized by high humidity, cloudiness and rainfall. Most insect pests were very active and caused major damage to crops during hot and sunny days.

Seventy six percent (76%) of these insects were found present on the field throughout the entire cropping season with 12% of the insect being found present mostly during the seedling stage of the crop. Ten (10%) of the insects were found present only during the vegetative stage of the crop and only 2% of the insects found present only in the reproductive stage of the crop.

The damage caused by insects were numerous and included chewing of leaves, piercing of pods, feeding on flowers and rolling of leaves. Fifty six percent (56%) of the insects chewed the leaves of the plant. Twenty percent (20%) of the insects pierced the pods making them unsightly. Ten percent (10%) of the insects fed on the flowers of the crop by sucking the nectar from the flowers thereby causing the flower to drop with the slightest wind or touch. 14% of the insects also caused the leaves to curl by feeding at the underside of the leaves and causing the leaves to roll.

Majority (32%) of the farmers reported the African boll worm as the major insect pest destroying their crops. Eighteen percent (18%) of the farmers had their crops mainly attacked by the ladybird beetle. Sixteen percent (16%) of the farmers reported aphids as the major pest of their okra, 10% identified grasshoppers as the main pest while 12% of the farmers

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encountered whiteflies as the major insect pest on their fields. Two percent (2%) of the farmers identified leaf miners and mealy bugs as major insects of okra respectively while 8% of the farmers identified other insect and non-insect pests such as snails affecting okra

The control of insect pests of okra was mainly through the use of chemicals. Almost all (98%) the farmers surveyed used chemicals on their field whiles the remaining 2% indicated the adoption of cultural methods of controlling insects such as hand picking of insects, practicing crop rotation and removal of other crops which serve as hosts to insects on their okra fields as additional control measures.

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Table 13: Insect problems in Okra Production.

	Frequency	Percentage
Number of different insect species on Okra field		
2	10	20.0
3	20	40.0
4	14	28.0
5 or more	6	12.0
Total	**50**	**100.0**
Crop stage of development affected by insects		
All Stages	38	76.0
Vegetative	5	10.0
Reproductive	1	2.0
Seedling	6	12.0
Total	**50**	**100.0**
Insect infestation as influenced by season		
Dry season	34	68.0
Rainy/Humid season	16	32.0
Total	**50**	**100.0**

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Table 14: Percentage Damage caused by insect pests on okra fields in Peri–Urban Greater Accra.

	Frequency	Percentage
Major insect problems in okra production		
Chewing of leaves	28	56.0
Piercing of pods	10	20.0
Feeding on flowers	5	10.0
Rolling of leaves	7	14.0
Total	**50**	**100.0**
Major insects of okra production		
Whiteflies (*Bermisia tabaci*)	6	12.0
Grasshoppers (*Zonocerus varigatus*)	5	10.0
Aphids (*Aphids gossypii*)	8	16.0
Bollworms (*Earias vittella*)	16	32.0
Ladybird beetle (*Coccinella septempunctata)*	9	18.0
Leaf miners (*Trachys herilla*)	1	2.0
Mealy Bugs*(Ferrisia virgata*)	1	2.0
Any Other	4	8.0
Total	**50**	**100.0**
Control methods of insects		
Chemical	49	98.0
Cultural	1	2.0
Total	**50**	**100.0**

4.1.17 Diseases of Okra

Disease problems of okra under cultivation was also a major challenge to peri–urban okra crop production. Most of the diseases which affected the okra plants were due to

unfavourable environmental conditions such as drought or flooding, transmission by vectors, soil borne pathogens, low nutrition and bad sanitations on the field. Some of the symptoms of diseases in okra included: stunted growth, yellowing of leaves, malformed pods and curling of leaves. On most of the farms visited, diseases were less of a problem compared to insect pest attack. Forty eight percent (48%) of the farmers had only one major disease problem whiles 42% and 10% had 2 and 3 major disease problems respectively as shown in (Table 15). Eighty percent (80%) of the farmers identified diseases throughout the entire growth period of the crop and 12% of the farmers identified the disease mostly during the vegetative stage of the crop. Only 2% of the farmers identified disease at the seedling stage of the crop and 6% of the farmers encountered diseases during the reproductive phase of the crop however the severity of the diseases at the various stages were not enough to cause any major damage to the crops.

Most of the farmers (58%) encountered disease on the farm during hot climate. The remaining 42% of the farmers encountered diseases on their fields during humid climates.

Forty–four percent (44%) of the farmers identified leaf curl as the major disease on their okra fields (Table 16). Twenty four percent (24%) of the farmers also identified powdery mildew as the major disease on their fields. Eight percent (8%) of the farmers were faced with nematode infestation on their fields with 4%, 6% and 2% of the farmers encountering early blight of okra, okra mosaic virus and okra leaf spot diseases respectively. Twelve percent (12%) of the farmers had their fields infected by other minor diseases of okra which included blossom blight, sooty mould, and black spot of okra.

The control method usually adopted by farmers in the management of okra diseases was through the use of chemicals. Seventy eight percent (78%) of the farmers used chemicals to control disease on their fields while 22% of the remaining farmers adopted the cultural

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method of disease control such as pruning of affected leaves, applying fertilizer, prompt irrigation, good sanitation, sterilization of soil and planting materials before planting.

Table 15: Disease problems of okra.

	Frequency	Percentage
Number of different diseases reported on an Okra field		
1	24	48.0
2	21	42.0
3	5	10.0
Total	**50**	**100.0**
Stage of crop development affected by disease		
All stages	40	80.0
Vegetative	6	12.0
Reproductive	3	6.0
Seedling	1	2.0
Total	**50**	**100.0**
Disease infestation as influenced by climate		
Hot	29	58.0
Humid	21	42.0
Total	**50**	**100.0**

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Table 16: Frequencies of different diseases on Okra farms and control measures adopted by farmers

Major disease of Okra	Number of farm fields	Percentage
Leaf Curl *(Abelmoschus spp.)*	22	44.0
Powdery Mildew (*Erysiphe cichoracearum*)	12	24.0
Early Blight (*Alternaria solani*)	2	4.0
Okra Mosaic Virus	3	6.0
Nematode *(Meloidogyne spp.)*	4	8.0
Okra Leaf Spot (*Ascochyta sp*)	1	2.0
Others	6	12.0
Total	**50**	**100.0**
Control measures		
Chemical	39	78.0
Cultural	11	22.0
Total	**50**	**100.0**

4.1.18. Weed problems in Okra Production

Only 2% of the respondents reported one major weed type on the field. Twenty four percent (24%) of the respondents had 2 weed types on their fields, whiles 60% of the respondents had 3 major weed types on their fields. Fourteen percent (14%) of the respondents had 4 major weed types on their fields. In all, approximately 75% of the respondents had very high weed infestation problems on their farms involving four or more major weed types (Table 17).

The presence of weeds on the okra fields depended mostly on the growth stage of the crop. Seventy-six percent of the respondents found weeds throughout the entire cropping period. Ten percent (10%) of the respondents identified weeds as challenging mostly during the

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seedling stage. Another 10% reported weeds to be a problem during the vegetative stage of the crop with only 4% of the respondents reporting weeds as a major problem during the reproductive stage of the crop.

Seventy-six percent (76%) of the respondents reported encountering serious weed problems during the humid periods whiles 18% of the respondents encountered weed problem during the dry periods. Majority of the respondents (about 60%) identified *Amarantus spinosus* (Amarantus) as the major weed present on their fields (Table 18).Only 4% of the respondents identified *Celosia laxa* (Celosia) as the major weed on their fields. Two percent (2%) of the respondents identified *Senna obtusifolia* (sickle pods) as the major weeds and, 6% of the respondents identified *Trianthema portulacastrum* (Pigweed) as the major weed present on their fields. Twelve percent (12%) of the respondents identified *Cyperus rotundus* (Nutsedge grass) as the major weed on their fields. About 10% of the respondents identified *Echinochloa colona* (Barnyard grass) as the major weed present on their fields and 8% of the respondents reported on other weeds which included *Digiteria horizontalis* (Crab grass), and *Paspalum orbiculare* (Ditch millet).

Seventy six percent (76%) of the farmers adopting the chemical control method only whiles 24% of the farmers used cultural method of weed control which included no tillage, weeding with hoe and cutlass and hand weeding.

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Table 17: Weeds associated with Okra Production.

Number of types of weeds present in farmers` field	Number of Respondents	Percentage of Respondents
1	1.0	2.0
2	12	24.0
3	30	60.0
4	7.0	14.0
Total	**50**	**100.0**
Crop stage of weed infestation		
All Stages	38	76.0
Vegetative Stage	5	10.0
Reproductive Stage	2	4.0
Seedling	5	10.0
Total	**50**	**100.0**
Season with highest weed infestation in okra farms		
Dry season	9	18.0
Rainy/Humid season	41	82.0
Total	**50**	**100.0**

Table 18: Weed species encountered inPeri–Urbanokra farms in greater Accra region and methods of control.

	Frequency	Percentage
Major weeds found in Okra production		
Barnyard Grass (*Echinochloa crusgalli*)	5	10.0
Amaranthus (*Amaranthus spp.*)	29	58.0
Celosia (*Celosia spp.)*	2	4.0
Pigweed (*Amaranth spp*)	3	6.0
Sickle Pod (*Senna obtusifolia*)	1	2.0
Cyperus (*Cyperus esculentus*)	6	12.0
Others	4	8.0
Total	**50**	**100.0**
Control methods practiced		
Chemical	38	76.0
Cultural	12	24.0
Total	**50**	**100.0**

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4.1.19 Agrochemicals used by peri–urban okra farmers.

Most of the agrochemicals used by farmers in peri–urban okra production were fertilizers, herbicide and insecticides. None of the farmers used fungicides or any other agrochemical.

4.1.19.1 Fertilizers use by farmers

Most of the respondents in peri–urban okra production adopted the split application of fertilizers. About 60% of the respondents applied two different fertilizers in splits while 18%

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of the respondents used three different fertilizers in split application. 23% of the respondents however applied only one type of fertilizer in a single application.

Thirty–four percent (34%) of the respondents used only 15:15:15 NPK to fertilize their okra whiles 16% of the respondents applied 23:10:5 NPK fertilizer to their crops (Table 19). Fourteen percent (14%) of the respondents applied 15:15:15 NPK in addition to urea in split application. 10% of the respondents applied 15:15:15 NPK plus ammonia in split application. 8% and 6% of the respondents applied 23:10:5 NPK fertilizers in splits with urea or ammonia. Twelve percent of the respondents however used other fertilizer types which include agro boost and super grow (foliar fertilizers), and poultry manure.

Majority of the respondents (78%) adopted the Band placement method of applying fertilizer. 20% of the used the Ring method while only one respondent representing 2% used the side dressing method to apply fertilizer.

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Table 19: Fertilizer combinations and fertilizer types used by farmers.

Number of fertilizer combinations used in Okra production	Frequency	Percentage
One Type	**11**	23.0
Two Types	30	59.0
Three Types	9	18.0
Total	50	100.0
Types of fertilizers usually used in Okra production		
Only 15;15;15 NPK	17	34.0
Only 23;10;5 NPK	8	16.0
15;15;15 NPK + Ammonia	5	10.0
15;15;15 NPK+ Urea	7	14.0
23;10;5 NPK+ Urea	4	8.0
23;10;5 NPK+ Ammonia	3	6.0
Others	6	12.0
Total	**50**	**100.0**
Method of fertilizer application used by Peri-Urban Okra farmers		
Band Placement	39	78.0
Ring	10	20.0
Side Dressing	1	2.0
Total	**50**	**100.0**

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4.1.19.2 Pesticides used by farmers

About 31% of the farmers used Round-up (active ingredient Isopropylamine salt of glyphosate) on their fields. About 33% of the farmers used Chemosate (active ingredient Isopropylamine salt of glyphosate) while about 26% of the farmers used glyphosate (active ingredient Isopropylamine salt of glyphosate). About 5% of the farmers use Salosate (active ingredient Isopropylamine salt of glyphosate) and Agil EC (active ingredient Propaquizafop–100 g) respectively (Table 20).

More than half of the respondents (62%) used a mixture of two insecticides while 20% used a mixture of three insecticides to control insects on their fields. However, 18% of the respondents used only one insecticide in controlling insects.

A third of the respondents (31%) used 'Power' insecticide in controlling insects on their fields while 29% used 'Attack' insecticide. Ten percent (10%) of the respondents used neem oil extracts while 18% of the respondents used 'Auntie Atta' insecticide in controlling insects. Twelve percent (12%) of the respondents however used other types of insecticides depending on the severity of insect attack of the crops or in attempt to control a specific insect.

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Table 20: Pesticides used in Okra production in Peri–Urban Greater Accra.

		Number of users	Percentage
Name of herbicide used in okra production	**Active Ingredient**		
Round Up	Isopropylamine salt of glyphosate (502g/L)	16	32.0
Chemosate	Isopropylamine salt of glyphosate (400g/L)	17	34.0
Glyphosate	Isopropylamine salt of glyphosate (360g/L)	13	26.0
Salosate	Isopropylamine salt of glyphosate (450g/L)	2	4.0
Agil EC	Propaquizafop (100 g/L)	2	4.0
Total		**50**	**100.0**
Name of insecticide usually used in Okra production			
Power	Lambda cyhalothrin (97g/L)	16	32.0
Attack	25g/litrepermethrin + 475g/L pirimiphos–methyl	15	30.0
Neem Extract	Neem	5	10.0
Auntie Atta	Imidacloprid(178g/	8	16.0

L)		
Others	6	12.0
Total	**50**	**100.0**

4.1.20Misuse of Insecticides among Farmers

Among the respondents who used Power insecticide, half used the recommended rate while one third of the respondents over applied by using between 60–100 ml/15L knapsack sprayer instead of 50ml/15Lof the chemical and the remaining 20% under applied the insecticide by using 40ml/15L knapsack sprayer. Among the respondents that used Attack insecticide, about one third of the respondents used the recommended application rate of 50 ml/15L knapsack sprayer, 40% of the respondents over applied the chemicals by using between 60–100 ml/15L knapsack sprayer while 30% of the respondents under applied by using 40ml/15L knapsack sprayer. The few respondents that used the neem extract claimed to have used the recommended rate however they mixed the chemical with other insecticides. Among the respondents that used 'Auntie Atta', majority (70%) of them reported using the recommended rate, although the remaining (30%) over applied the chemical by using rates ≤ 50 mL/15L knapsack sprayer (Table 21).

Table 21: Degree of misapplication of insecticide among Peri-Urban okra farmers.

Insecticide	Recommended Rate	% of farmers who under apply	% of farmers who follow recommended rate	%of farmers who over apply
Power	50ml/15L of water	20	50	30
Attack	0.5–1L/ha in 100–300L of water	30	30	40

Neem Extract	50ml/L of water	0	100	0
Auntie Atta	50ml/15L of water	0	70	30

4.1.22 Frequency of Pesticide Spraying

The recommended spraying interval for most insecticides is usually between 7–14 days depending on the level of attack and numbers of insects present. Most of the farmers were observed to have followed strict spraying calendar, 58% of the farmers spray their crops every week while 20% of the farmers sprayed their crops every two weeks. Only 4% of the respondents sprayed their crops every month with the remaining 18% of the farmers spraying their crops as often as possible (Table 22).

Table 22: Frequency of pesticide spraying.

Frequency of Pesticide Spraying	Practitioners	Percentage
Every Week	29	58.0
Every 2 weeks	10	20.0
Every Month	2	4.0
As often as possible	9	18.0
Total	**50**	**100.0**

4.1.21Important Constraints in Okra Production

Forty–six percent (46%) of the respondents identified insect pests as the most important constraint in the okra production. About 18% of the respondents identified disease as the most important constraint with 12% of the respondents identifying marketing of their produce

as the major constraint in their okra production. Twenty four (24%) of the respondents identified irrigation as the most important constraint in their okra production (Figure 5).

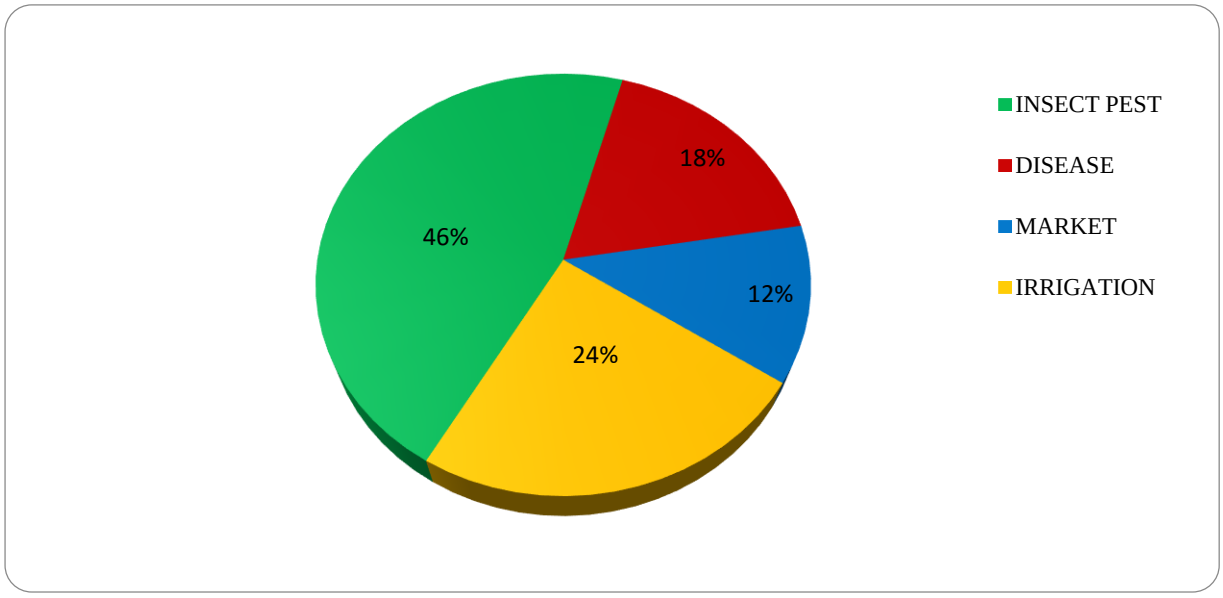

Figure 5: Percentage of farmers acknowledging each of the four identified major constraints in Okra Production.

4.1.22. Practice of Record Keeping in Okra Production

Majority of the farmers (60%) did not keep records of their various activities in okra production. The other 40% of the farmers reported keeping records on okra production. The majority of the farmers that did not keep records on their okra production activities claimed they did not grow only okra but grew other crops. They usually grew okra to be able to invest the funds they got into other crops. Some also claimed that the harvesting pattern of okra which is usually every two or three days makes it very tedious to keep records on the crops compared to crops such as maize which is harvested all at once.

Eighty percent (80%) of the respondents that kept records did so only to estimate cost of production. Most of the farmers grew okra as a sole crop. The remaining 20% kept records on their okra production to be able to facilitate informed decisions making in future. Some of

them claimed they were not very experienced in okra production and therefore kept records to serve as sources of future references (Table 23).

Table 23: The practice of record keeping in Okra Production.

Record keeping in Okra production	Frequency	Percentage
Yes	20	40.0
No	30	60.0
Total	**50**	**100.0**

4.2. Field studies on Okra

4.2 Effects of pesticide application on the growth of Okra in On–farm Okra field studies

4.2.1 Plant Height

Figure 6 represents plant heights of okra as influenced by pesticide applications three to nine weeks after emergence (3–9 WAE). There were no significant differences in the plant height at 3 WAE. It followed a similar trend at 5 WAE. However at 7 WAE, the mean height of plants treated with a mixture of insecticides plus herbicide (T2a) proved significantly $p \leq 0.05$ taller than all the remaining treatments. A similar trend occurred at 9 WAE.

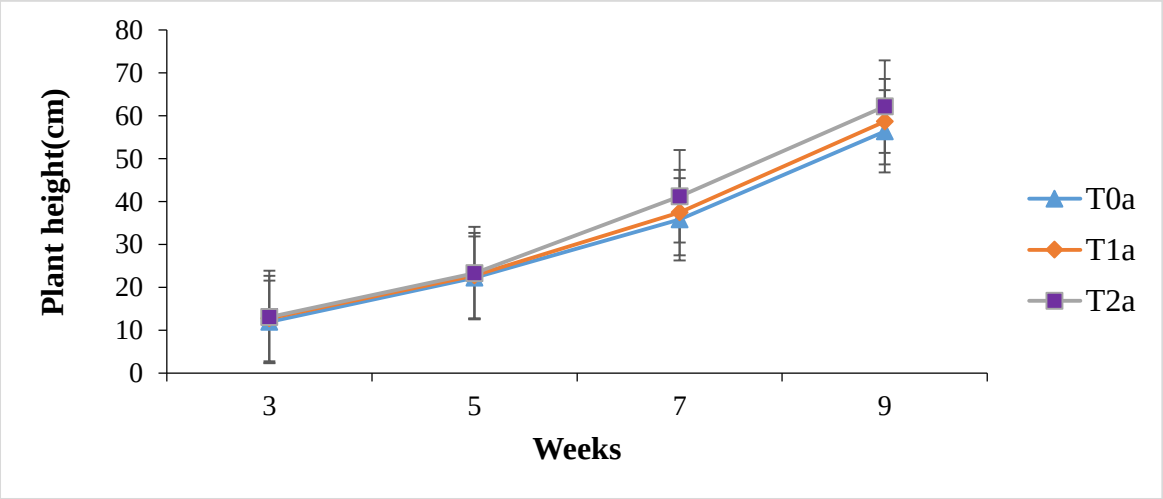

Figure 6: Mean Plant Heights of Okra from 3–9 WAE (on–farm experiment).

4.2.2 Mean Plant Girth

Figure 7 represents mean plant girth of okra as influenced by pesticide applications three to nine weeks after emergence (3–9 WAE). There were no significant $p \geq 0.05$ differences in the plant girth at 3WAE. At 5WAE, the mean girth of okra treated with a mixture of insecticide and herbicide (T2a) proved significantly $p \leq 0.05$ larger mean girth among the treatments. A similar trend followed at 7 WAE. By 9 WAE significant differences $p \leq 0.05$ were observed only in the mean girth of okra treated with a mixture of insecticide and herbicide (T2a) as the mean girth of plants treated with a single insecticide plus herbicide (T1a) and the control (T0a) were no longer significantly different ($p \geq 0.05$)in terms of girth.

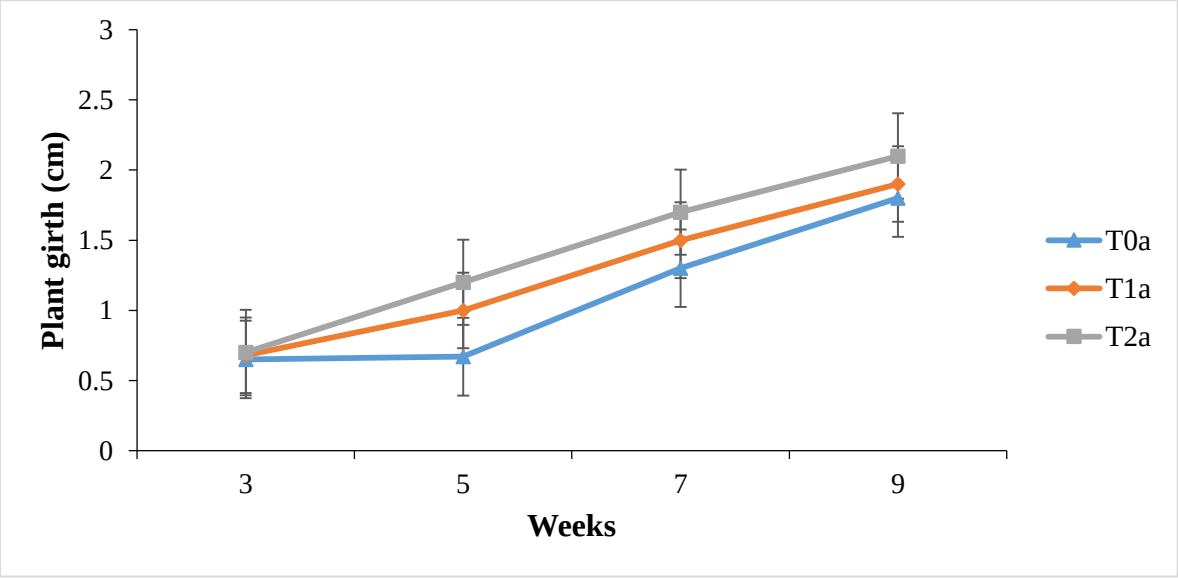

Figure 7: Mean Plant Girth 3–9 WAE (on–farm experiment).

4.2.3 Mean Leaf Numbers

Figure 8 shows the mean leaf numbers at 3–9 WAE. At 3 WAE, there were no significant $p \geq 0.05$ differences among all the treatments. The mean leaf number at 5 WAE showed

significant $p \leq 0.05$ difference only in the plants treated with a single insecticide plus herbicide (T1a). The difference in leaf numbers of okra treated with a mixture of insecticide plus herbicide (T2a) and the control (T0a) were not significant $p \geq 0.05$. At 7 WAE, there were no significant $p \geq 0.05$ differences among all the treatments. By 9 WAE significant differences $p \leq 0.05$ were observed only in the leaf number of okra treated with a mixture of insecticides and a herbicide (T2a). The mean leaf numbers of plants treated with a single insecticide plus a herbicide (T1a) and the control (T0a) were no longer significantly different ($p \geq 0.05$).

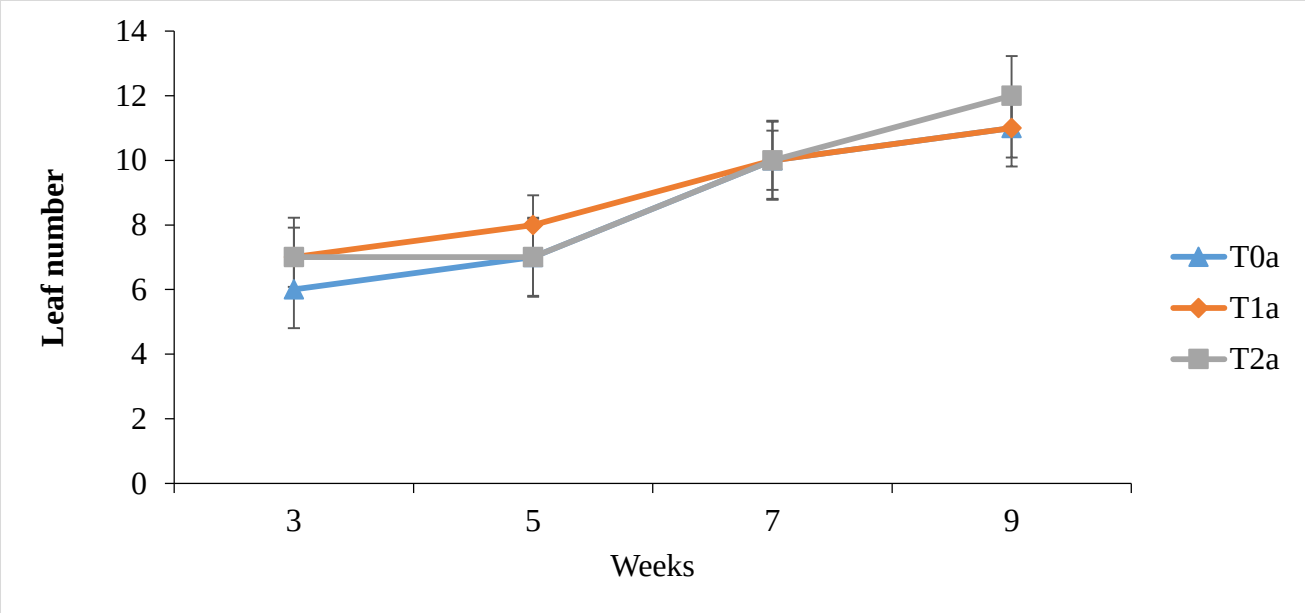

Figure 8: Mean Leaf Numbers 3–9 WAE (On–farm experiment).

4.2.4 Mean Dry Weights

Table 24 shows the root and shoot dry weights of plants in three treatments of the on-farm experiment. The root dry weight of plants showed significant $p \leq 0.05$ differences only between plants treated with a mixture of insecticides plus herbicide (T2a) and the control

(T0a). No significant differences were observed between the plants treated with a mixture of insecticides plus a herbicide (T2a) and plants treated with a single insecticide plus the herbicide (T1a). The dry weight of shoots followed a similar trend.

Table 24: Fresh Weight of Plant, Root and Shoot Dry Weights (On–farm experiment).

Treatment	Dry Weight of Roots (g)	Dry Weight of Shoot (g)
T1a	5.008	13.358
T2a	5.150	13.692
T0a	4.842	12.70
LSD(p=0.05)	**0.31**	**0.67**

4.2.5 Mean Pod Length and Pod Diameter in On–farm experiment (IIa)

Table 25 shows the pod length and diameter of okra in the on-farm experiment. There were no significant $p \geq 0.05$ differences in pod length among all the treatments. No significant $p \geq 0.05$ differences in pod diameter were also observed among all the treatments.

Table 25: Mean Pod Length and Pod Diameter (On–farm experiment).

Treatment	Pod Length (cm)	Pod Diameter(cm)
T1a	10.384	2.30
T2a	10.41	1.88
T0a	10.08	1.92
LSD(p=0.05)	**N.S.**	**N.S.**

4.2.6 Mean Number of Seeds/Pod and Mean Number of Pods/Plant

The mean number of seeds per pod and the mean number of pods per plant of okra in the On–farm experiment are shown in Table 26. No significant $p \geq 0.05$ differences were observed in the mean number of seeds per pod among all the treatments. However plants treated with a

mixture of insecticides plus herbicide (T2a) proved significantly different $p \leq 0.05$from the remaining treatments in terms of mean number of pods/plant. Significant difference $p \leq 0.05$was also observed between the plants treated with a single insecticide plus herbicide (T1a) and the control (T0a).

Table 26: Mean Number of Seeds/Pod and Mean Number of Pods/Plant (On–farm experiment).

Treatment	Mean Number of Seeds/Pod	Mean Number of Pods/Plant
T1a	65	15
T2a	67	17
T0a	64	13
LSD(p=0.05)	**NS**	**2**

4.2.7 Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra.

Table 27 shows the mean number of days to 50% flowering, number of productive branches and yield of okra in the on-farm experiment. Significant differences $p \leq 0.05$ were observed only in the mean number of days to 50% flowering of okra plants treated with a mixture of insecticides and a herbicide (T2a). Plants treated with a single insecticide plus herbicide (T1a) and the control (T0a) showed no significant differences ($p \geq 0.05$) in terms of mean number of days to 50% flowering. A similar trend was observed in the mean number of productive branches. However, in terms of yield, plants treated with a mixture of insecticides plus a herbicide (T2a) proved significantly different $p \leq 0.05$from the remaining treatments. Significant difference $p \leq 0.05$was also observed between the yield of plantstreated with a single insecticide plus the herbicide (T1a) and the control (T0a).

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Table 27: Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra (Experiment IIa).

Treatment	Mean number of days to 50% flowering	Mean number of productive branches	Mean yield (tons/ha)
T1a	48	3	6.97
T2a	46	4	7.66
T0a	49	3	4.93
LSD(p=0.05)	**2**	**1**	**0.804**

4.3 Effects of pesticide application on the growth of Okra in the experimental field.

4.3.1 Mean Plant Heights.

Figure 9 represents the mean plant height of okra as influenced by pesticide applications three to nine weeks after emergence (3–9 WAE) in the experiment IIb. At 3WAE, plants treated with Attack insecticide (T1b) proved significantly different $p \leq 0.05$ from the remaining treatments (Plants treated with neem oil extract- T2b and control- T0b). At 5WAE, significant $p \leq 0.05$ differences occurred among all the treatments. At 7WAE, there were significant differences $p \leq 0.05$only between the control and the remaining treatments in terms of plant height. However, no significant differences $p \geq 0.05$ were observed between plants treated with Attack insecticide (T1b) and Plants treated with neem oil extract (T2b). A similar trend was observed at 9WAE.

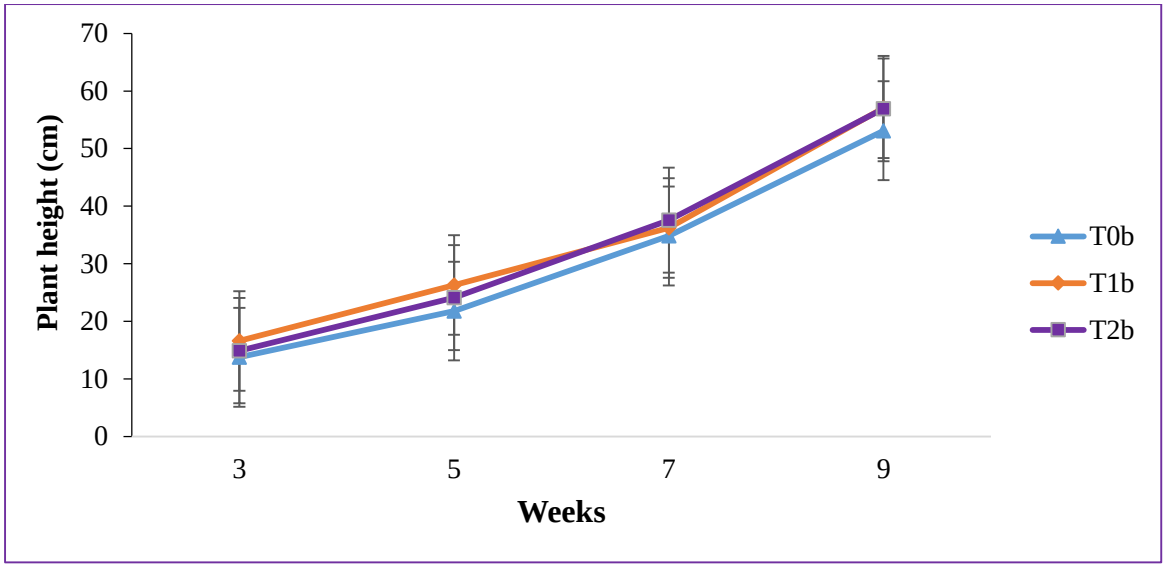

Figure 9: Mean Plant Height of Okra 3–9 WAE (Experimental field).

4.3.2 Mean Plant Stem Girth.

Figure 10 represents plant girth of okra as influenced by pesticide applications three to nine weeks after emergence (3–9 WAE). At 3WAE, there were no significant $p \geq 0.05$ differences among all the treatments. At 5WAE, there were also no significant $p \geq 0.05$ differences in plant girth among all the treatments. At 7WAE, significant $p \leq 0.05$ differences occurredbetween plants treated with Attack insecticide (T1b) and the remaining treatments. However, no significant $p \geq 0.05$differences occurred between plants treated with neem extract oil (T2b) and the control (T0b) in terms of stem girth. A similar trend was observed at 9WAE.

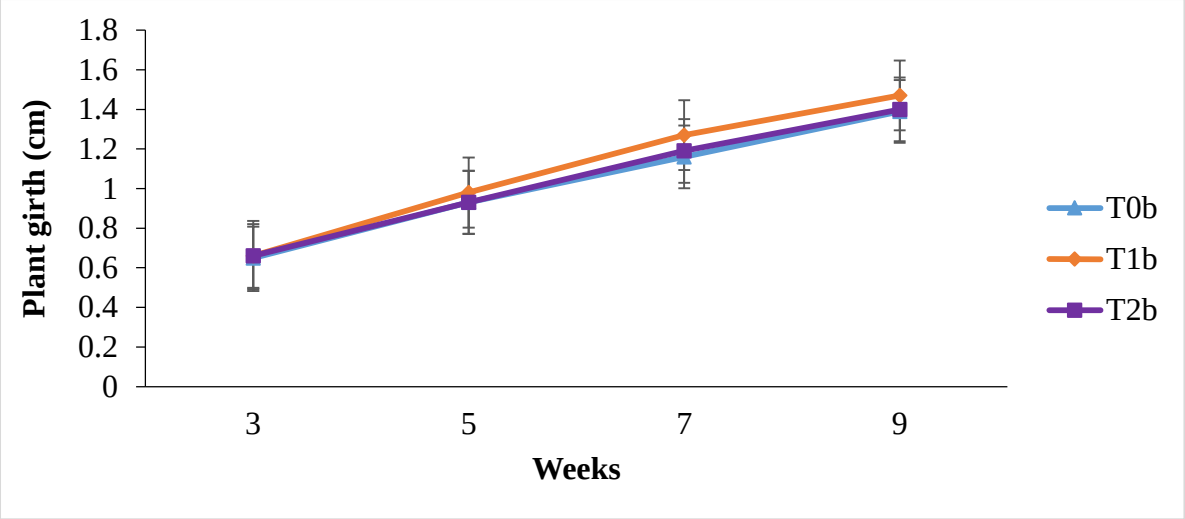

Figure 10: Mean Plant Girth 3–9 WAE (Experimental field trial).

4.3.3 Mean Leaf Numbers.

Figure 11 represents the mean number of leaves per plant of okra as influenced by pesticide applications three to nine weeks after emergence (3–9 WAE). At 3WAE, the control (TOb) plants were significantly $p \leq 0.05$ different from plants treated with Attack insecticide (T1b) and plants treated with neem oil extract (T2b) but no significant $p \geq 0.05$ differences were observed between plants treated with Attack (T1b) and plants treated with neem oil extract (T2b). At 5WAE,plants treated with Attack insecticide (T1b) only were significantly $p \leq$ different from theplants treated with neem oil extract (T2b) and the control (T0b) but plants treated with neem oil extract (T2b) and the control (T0b) were not significantly ($p \geq 0.05$)different. At 7WAE, no significant $p \geq 0.05$ differences existed in the mean leaf number among all the treatments. A similar trend in plant mean leaf numbers were recorded at 5WAE and at 9 WAE,

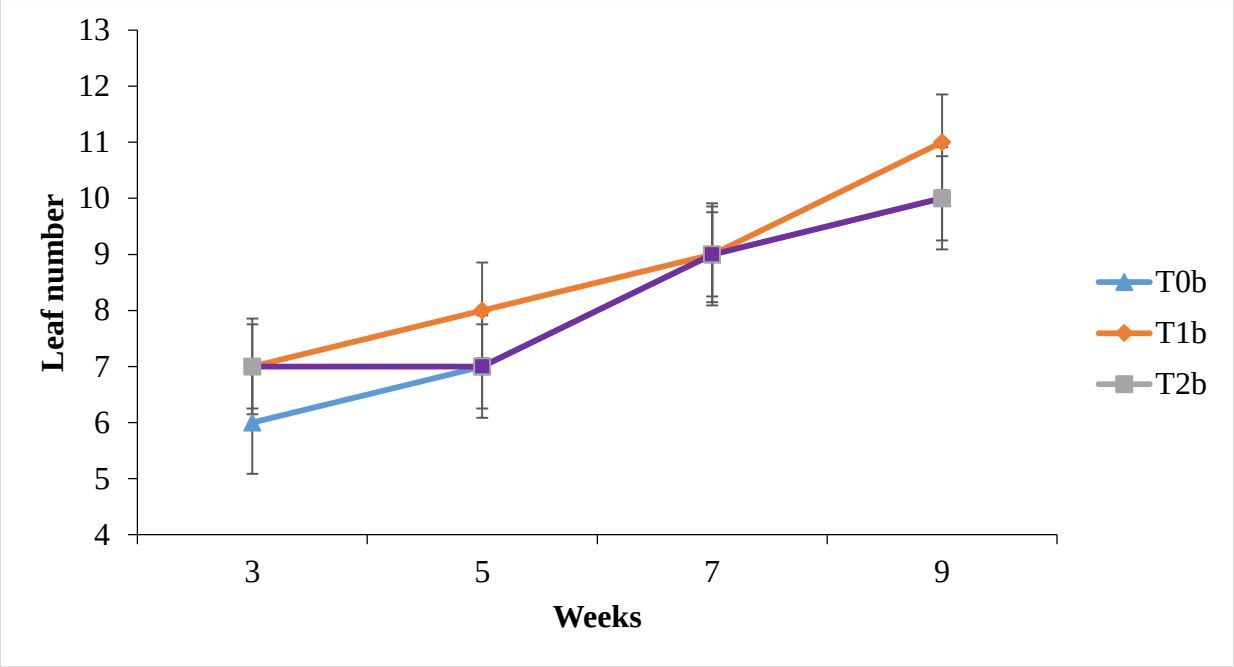

Figure 11: Mean Leaf Numbers 3–9 WAE (Experimental Field trial).

4.3.4 Mean Plant Dry Weight

Table 28 represents the root dry weight and shoot dry weight. No significant ($p \geq 0.05$)differences were observed among all the treatments in terms of dry weight of roots. However, the dry weight of shoots recorded, significant $p \leq 0.05$ differences occurred amongst all the treatments with plants treated with Attack insecticide (T1b) recording the highest weight followed by plants treated with neem oil extract (T2b) and the control (T0b) in that order.

Table 28: Dry Weight of Plant Root and Shoot (Experimental field).

Treatment	Dry weight of roots (g)	Dry weight of shoot(g)
T1b	4.66	12.85
T2b	4.54	11.98
T0b	4.24	11.09

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LSD(p=0.05)	**N.S.**	**0.3**

4.3.5 Mean Pod Length and Pod Diameter.

Table 29 represents the mean pod length and mean pod diameter. Plants treated with Attack insecticide (T1b) was significantly p≤ different from the control (T0b). Plants treated with Attack insecticide (T1b) and neem oil extract (T2b) were not significantly (p≥ 0.05)different. No significant differences (p≥ 0.05) were observed in pod diameter among all the treatments.

Table 29: Mean Pod Length and Pod Diameter (Experimental field trial).

Treatment	Pod Length (cm)	Pod Diameter(cm)
T1b	9.56	2.43
T2b	9.00	2.29
T0b	8.51	2.03
LSD(p=0.05)	**0.66**	**N.S.**

4.3.6 Mean Number of Seeds/Pod and Mean Number of Pods/Plant

Table 30 represents the mean number of seeds/pod and the mean number of pods/plant as influenced by pesticide application. There were no significant p≥ 0.05 differences in the mean number of seeds/pod among all the treatments. Significant p≤ 0.05 differences existed in mean number of pod per plant. Plants treated with Attack insecticide (T1b) recorded the highest number of pods per plant followed by plants treated with neem oil extract and the control.

Table 30: Mean Number Seeds/Pod and Mean Number of Pods/Plant (Experimental field trial).

Treatment	Number of Seeds/Pod	Number of Pods/Plant
T1b	66	14
T2b	67	12
T0b	64	11
LSD(p=0.05)	**N.S.**	**1**

4.3.7 Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra.

The mean number of days to 50% flowering, number of productive branches and yield of okra as influenced by pesticide application are presented in Table 31.Plants treated with Attack insecticide (T1b) proved significantly $p \leq 0.05$ different from the remaining treatments in terms of mean number of days to 50% flowering. There were significant $p \leq 0.05$ differences among all the treatments for mean number of productive branches. Plants treated with neem oil extract (T2b) recorded the highest mean number of productive branches followed by plants treated with Attack insecticide (T1b) and the control (T0b). There were significant $p \leq 0.05$ differences in yield amongst all the treatments. Plants treated with Attack insecticide (T1b) recorded the highest yields followed by plants treated with neem oil extract (T2b) and the control (T0b).

Table 31: Mean Number of Days to 50% Flowering, Number of Productive Branches and Yield of Okra (Experimental field trial).

Treatment	Mean number of days to 50% flowering	Mean number of productive branches	Mean yield (tons/ha)
T1b	49	3	5.67

T2b	50	4	4.98
T0b	51	2	3.90
LSD(p=0.05)	**1**	**1**	**0.391**

4.4 Laboratory Studies on effect of agrochemical (pesticides) usage on okra storability and quality.

4.4.1. Sliminess of Okra

Ten respondents were invited to assess the sliminess of okra. Harvested pods from all the treatments (experiment IIa and IIb) were sampled, washed, sliced and boiled at a temperature of 100°C for two minutes. Sliminess of okra was assessed on a scale of 1–5 with 1 being not slimy and 5 being extremely slimy.

Table 32 represents the assessment of the sliminess of okra pods under Laboratory conditions. All the sliced okra had some degree of sliminess as none of the respondents observed the sliced okra as not slimy. Amongst the ten respondents who assessed the sliminess of okra, 10% of the respondents observed sliced okra treated with a single insecticide plus herbicide slightly slimy (T1a), 40% of the respondents observed (T1a) as slimy while 20% and 10% observed the same treatment (T1a) as very slimy and extremely slimy respectively. Thirty percent (30%) of the respondents observed okra treated with a mixture of insecticide plus herbicide (T2a) as slightly slimy, 60% observed the okra as slimy, 10% observed the okra as very slimy as none of the respondents observed the same treatment (T2a) as extremely slimy. Twenty percent (20%) of the respondents observed the sliced okra from the control treatment of the on-farm experiment (T0a) as slimy, 50% and 30% observed the same treatment (T0a) as very slimy and extremely slimy respectively. Amongst the respondents who observed the sliced okra, 10%, 50%, 30% and 10% observed okra treated with attack insecticide (T1b) as slightly slimy, slimy, very slimy and extremely slimy

respectively while 20%, 40% and another 40% of the respondents observed okra treated with neem oil extract (T2b) as slimy, very slimy and extremely slimy respectively. Forty percent (40%) and sixty percent (60%) observed okra from the control treatment of the experimental field trial (T0b) as very slimy and extremely slimy respectively.

Table 32: Sliminess of okra pods (Laboratory experiment).

	Percentage of Respondents					
Treatment	**Not slimy**	**Slightly slimy**	**slimy**	**Very slimy**	**Extremely slimy**	**Total**
T1a	0	10	40	20	10	**100**
T2a	0	30	60	10	0	**100**
T0a	0	0	20	50	30	**100**
T1b	0	10	50	30	10	**100**
T2b	0	0	20	40	40	**100**
T0b	0	0	0	40	60	**100**

4.4.2 Mean Days to Shriveling, Blackening and Decay.

Table 33 represents the mean number of days to pod shriveling, blackening and decay in the laboratory studies. Okra pods from plants treated with neem oil extract (T2b) and control treatment of the experimental field trial (T0b) proved significantly different ($p \leq 0.05$) from all the remaining treatments in terms of the mean number of days to shriveling. Pods from plants treated with a single insecticide plus herbicide (T1a), plants treated with Attack insecticide (T1b) and the control treatment of (T0a) proved significantly different ($p \leq 0.05$) from pods from plants treated with a mixture of insecticides plus herbicide (T2a). Pods from T2a started to shrivel within a few days in storage unlike the other treatments. Okra pods from plants treated with neem oil extract (T2b) and control treatments of both the on-farm experiment and the experimental field trial (T0b) proved significantly different ($p \leq 0.05$)

from all the remaining treatments in terms of number of days to blackening. Okra pods from plants treated with Attack insecticide (T1b) also proved significantly different ($p \leq 0.05$) from plants treated with a single insecticide plus herbicide (T1a) and pods from plants treated with a mixture of insecticides plus herbicide (T2a). Pods from plants treated with a single insecticide plus herbicide (T1a) was significantly different ($p \leq 0.05$) from okra pods from plants treated with a mixture of insecticides plus herbicide (T2a) in terms of number of days to blackening. Significant ($p \leq 0.05$) differences were observed among all the treatments in terms of mean number of days to decay of okra pods under storage. Pods from plants treated with neem oil extract (T2b) had a prolonged storage life of 18days followed by the control treatment from the experimental field trial (T0b), pods from plants treated with Attack insecticide (T1b), control treatment from the on-farm experiment (T0a) with pods from plants treated with a mixture of insecticides plus herbicide (T2a) had the least number of days to decay during storage.

Table 33: Mean Days to Shriveling, Blackening and Decay

Treatment	Mean days to shriveling	Mean days to blackening	Mean days to decay
T1a	5	3	14
T2a	4	2	13
T0a	5	5	15
T1b	5	4	16
T2b	6	5	18
T0b	6	5	17
LSD(p=0.05)	**0.4405**	**0.3746**	**0.3706**

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4.4.3. Weight loss of okra pods during storage

Figure 12 represents the weights of okra recorded every six days for eighteen days in the laboratory studies. At 6 days after storage (6 DAS) no significant ($p \geq 0.05$) differences existed among all the treatments. At 12 DAS, okra pods from control treatment in the experimental field trial (T0b) proved significantly $p \leq 0.05$ different from the all the treatments in terms of weight loss. No significant ($p \geq 0.05$) differences existed among pods from plant treated with Attack insecticide (T1b), Neem oil extract (T2b) and the control treatment of the on-farm experiment (T0a). Differences between the weight loss of pods from plants treated with a mixture of insecticides plus herbicide (T2a) and plants treated with a single insecticide plus herbicide were also significant ($p \leq 0.05$). At 18 DAS, no significant($p \geq 0.05$) differences existed among plants treated with Attack (T1b), Neem oil extract (T2b) and the control treatment of the experimental field trial (T0b). Significant ($p \leq 0.05$) differences were also observed between pods of plants treated with single insecticide (T1a), the control treatment of the on-farm experiment (T0a) and the pods from plants treated with a mixture of insecticide and herbicide (T2a). Control treatment's pods of the experimental field trial (T0b) and pods from plants treated with neem oil extract (T2b) recorded the lowest weight loss whiles pods from plants treated with a mixture of insecticides and a herbicide (T2a) recorded the highest weight loss.

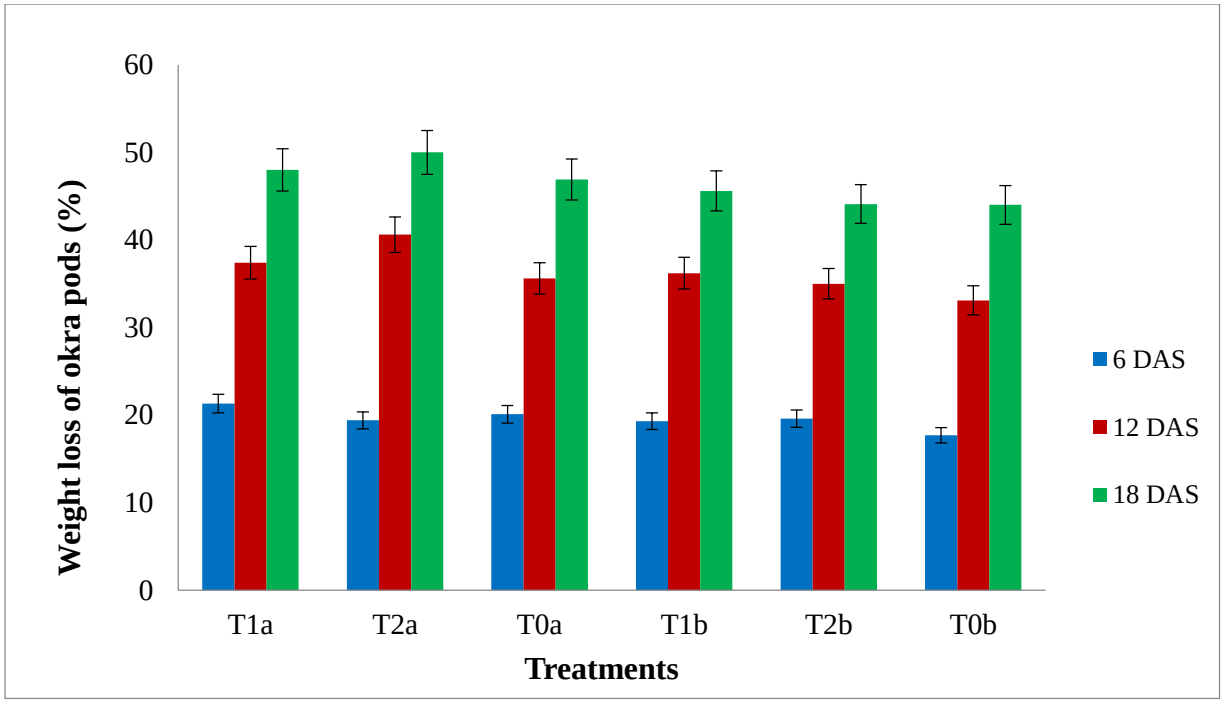

Figure 12: Weight loss of okra under storage (Laboratory studies).

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CHAPTER FIVE

5.0 DISCUSSION

5.1 Field Survey

5.1.1 General Background of respondents

Majority of the respondents involved in peri–urban okra production were men. Very few of them (30%) were women. Most of the women did not have their own land for farming but depended on their spouses to lease them the land consequently their husbands dictated the types of crops they should grow. The women who were widows inherited the land from their late husbands who were also farmers. Majority of the respondents were above 60 years of age and still carried out cultivation themselves. Few of the respondents were below the age of 40years. This implies that most youth in peri–urban okra production may not be encouraged to adopt farming as a long term occupation in the peri-urban areas as a result of challenges with land tenure. Similar observations were made by Horna *et al.* (2008) when they investigated pesticide usage by vegetable growers in Ghana.

Majority of the respondents had up to elementary school level of education, an indication of some basic form of education. In spite of this, most of them could not read nor understand the harmful effects of the agrochemicals they use. As a result, they tend to misapply the chemicals to their crops. They also deviate from the recommended dosage of chemicals in their applications. Similar observations were made by Horna *et al.* (2008) in their survey to investigate pesticide use by vegetables growers in Ghana

5.1.2 Gender distribution in okra production

The farmers involved in peri-urban okra production were predominantly men while the women were largely involved in the harvesting and marketing of the okra pods. That dominance of the male farmers may probably be attributed to the arduous task of crop

production and the role of male farmers as land owners was also observed by (Laary, 2012). Most of the women complained about the weight of the knapsack sprayers usually resulting in back ache which adversely affected their performance in pesticide application. However most farming operations involved in okra production were performed by both sexes (Horna *et al*., 2008). Irrigation is one important task in which both gender participated. Throughout the survey, it was discovered that some farm operations like land preparation, sowing, weeding, pesticide spraying and fertilizer application were male dominated while few operations like harvesting, transportation and marketing were mainly performed by females with the sexes complimenting each other in the performance of the farming operations. These observations agree with those made by Horna *et al*. (2008).

5.1.3 Agronomic practices

Irrigation regimes adopted by respondents in peri-urban okra production varied from location to location and was dependent on the type source and availability of water in a particular location. Almost all of the respondents had access to irrigation water. However they had different irrigation regimes. Some irrigated their crops weekly by flooding ridges they had created in the entire land area. This ensured that the soil remained moist until the following week. Where there were no ridges, farmers irrigated their okra crops every three days. All the farmers who practiced irrigation were in cooperative groups which from time to time invited resource persons to educate them on various topics concerning the various crops they cultivated. These patterns of irrigation have also been reported by Justo (2012) to be common in peri-urban okra production

The time of planting of okra differed among the respondents. However majority of the respondents planted their crops between July and September and a few others planted between April and June with others planting their okra between October and January. Most farmers reported planting okra twice in a year. This observation confirms a report by MOFA

(2008) that okra is usually planted twice a year, from April to June and October to January in Ghana and also in some parts of Africa.

Most farmers use local varieties of okra which have diverse local names usually based on the locality or the person that developed that variety (Essilfie *et al.*, 2010). Aikins (2007) also reported on the consumer preference of ten local varieties of edible matured okra fruits in some selected markets in greater Accra region. Most of the local varieties were used because they could withstand adverse local environmental conditions such as high temperatures, drought, floods and pest infestations. This was in conformity with Oppong–Sekyere (2011) who reported that some local varieties of okra cultivars exhibited high resistance to the mosaic and leaf curl viral diseases of okra. However, those who used the exotic variety used them because they were high yielding and also had export demand (Nkansah, 2007).

Most of the farmers however used their own saved seeds or bought seeds from other farmers within their locality for planting while others bought seeds from commercial outlets. Farmers mostly did not perform germination tests of their seeds before planting nor pre–treat their seeds with fungicide. Similar results observed by Justo (2012) were confirmed.

5.1.4 The use of agrochemicals in peri-urban okra production.

Most of the respondents from the survey adopted the chemical control method in combating pests and diseases. They also used more chemical fertilizers than organic fertilizers in their okra production because the use of chemical fertilizers resulted in higher yields instantly compared to organic fertilizers. These observations agree with reports by Omotoso and Shittu (2007).

The agrochemicals usually used in okra production were mainly fertilizers, insecticide and herbicides. This confirms observations made by Ntow (2004) and Laary (2012) on agrochemicals used in Ghana. Majority of the farmers applied fertilizers in two splits. The

first application was two weeks after sowing and the last fertilizer application was done before flowering of the plant. Akanbi *et al*. (2005) also reported similar trend. Two different fertilizers from inorganic sources were used which were usually a combination of 15:15:15 NPK or 23:10:5 NPK combined with Urea or Ammonia. The application method adopted for fertilizer application was mainly the band method with a rate of 250kg/ha for each kind of fertilizer. This result was in conformity with the findings of Omotoso and Shittu (2007) who reported on the effect of NPK fertilizer rates and method of application on growth and yield of okra.

The herbicides usually used in okra production were "Round-up", "Chemosate", "Glyphosate", "Salosate" and "Agil EC". Despite the use of herbicides, farmers also weeded their farms manually with hoes and cutlasses (Amoah *et al.*, 2005; Fianko *et al.*, 2011)

The insecticides used by farmers were mainly "Power", "Attack", neem oil extract and "Auntie Atta". However most of the respondents did not use the recommended dosage for spraying their crops and also sprayed their fields every week. Chemical control was very effective in controlling insects however, the health hazards associated with the indiscriminate application and lack of proper protective equipment were not considered by farmers. This supports the findings of Horna *et al*. (2008) in their survey to investigate the pesticide use on vegetables in Ghana.

From observation, most of the farmers did not adopt Good Agricultural Practices (GAP) on their okra fields which resulted in low yields and reduced crop quality as most of the farmers who used chemicals usually did not follow the specifications on the bottles. Most of them tended to increase the dosage of the chemicals for quicker and faster results. Some of the farmers did not use the right herbicide in controlling their weeds. The timing of spraying or speed/rate of chemical application by most of the farmers was inappropriate. Farmers in their bid to finish spraying on time rush through the fields to escape the scorching sun or any

sudden unfavorable condition such as wind. Farmers often used only one type of pesticide in all the stages of plant growth. The nozzle and the knapsack sprayers used were also not properly checked. This resulted in unequal and uneven distribution of the chemicals on the fields which became evident after some days of spraying where patches of weeds on the field that did not get into contact with the chemical were seen in the case of herbicide use. Some of the labels on the bottles containing the insecticides used by the farmers were illegible or completely off in some cases which made it very difficult to check the expiring dates, chemical composition, active ingredients and the rate of application and recommended dosages. The use of protective clothing and boots were also not adopted by almost all the farmers involved in okra production. Horna *et al.* (2008); Ntow (2004) and Laary (2012) reported similar results.

5.1.5 Important constraints in okra production

Majority of the farmers had insect pest problems due to the time of planting which coincided with the dry season where insect activity was very high and usually very difficult to control (Obeng–Ofori, 2008). Almost all the respondents who reported diseases as the most important constraint planted their okra during the wet season which is usually characterized by high humidity which results in high microbial activity leading to diseases (Siemonsma, 1991).

5.2 Experiment two: Effects of agrochemical on growth and yield of okra

5.2.1 Effect of agrochemicals on Plant height and other growth parameters

All the growth parameters recorded were positively influenced by the application of agrochemicals.

There were significant differences in height among all the various treatments in both experiments. On–farm experiment recorded taller plants than the Experimental Field. This

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may be due to the different environmental conditions existing in the two sites and the differences in treatments. The experimental site for the on–farm experiment (Atomic Energy Rd. Haatso) had crops frequently irrigated with water from a river whereas the site for experimental field (University farm) which depended on potable water system interruptions experienced frequent pipe water shortages which affected irrigation. Differences in heights of plants treated with agrochemicals may also be attributed to the favourable growing conditions for the plants as competition was reduced while nutrient uptake was enhanced. This observation agreed with reports by Steiner (1991) and Singh *et al.* (2004).

Okra plants stem girth from the on-farm experiment had significant differences among all treatments. Of these, a mixture of agrochemicals (T2a) treatment had the largest stem girth throughout the experiment. Experimental field trial also showed plants treated with Attack insecticide (T1b) to perform better than the remaining treatments whiles the controls of both experiments (T0a and T0b) produced the lowest plant girth. The results obtained can be attributed to the ready availability of fertilizers to plants and the frequent supply of water which encouraged better growth in plant girth in the "on-farm" plants compared to plants in the experimental field. Lack of water in the experimental field affected the fertilization of okra. This observation confirms reports by Owusu–Sekyere & Annan (2010) and Gunawardhana & De Silva (2011) on water stress in okra. Increases in plant girth as a result of fertilizer application have also been reported by (Roijuben, 2011) and (Omotoso & Shittu, 2007)

Other growth parameters like the number of leaves increased significantly in most of the agrochemical treated plots compared to the control.

The increased leaf numbers in treated plants over the control supports reports by Senjobi *et al.* (2013), Roijuben (2011) and Omotoso and Shittu (2007) who observed increased photosynthetic activity in the leaves which directly influenced assimilates production. They

reported that higher dry matter production at high nutrient levels favoured the development of plant growth parameters which culminated in better production of dry matter. When nutrients are available in the right proportion, the photosynthetic activity of plants will be considerably favoured. This improves plant growth and leaf production, light interception, dry matter production, accumulation and partitioning.

5.2.2 The effect of agrochemicals on yield and yield components

There are some varietal characteristics of yield and yield components that do not change such as pod length, pod diameter and seed numbers of okra. Absence of a significant effect of excess application of pesticide implies no benefit and hence constitutes waste (Singaravel *et al.*, 2008).

Agrochemicals were found to be effective in promoting flower bud formation and inducing early flowering in the okra. It was discovered that, plants treated with a mixture of insecticides plus herbicide (T2a) in the on-farm experiment flowered very early compared to all other treatments in both experiments whiles the controls took longer days to flower.

The number of productive branches, number of fruits, fruit weights and yield increased in both field studies. The use of agrochemicals was found to be very effective in promoting growth and yield in all treatments compared to the control treatments in which no agrochemicals were applied. The increase in yield may be due to the performance rate of the pesticides used in reducing pest and enhancing flowering/reproductive growth. This could also be due to the optimum availability of nutrients to the plants. Similar results have been reported by Senjobi *et al.* (2013), Roijuben (2011) and Omotoso & Shittu (2007). It has been reported that when N supply is not limiting, dry matter production, assimilate partitioning as well as organic compounds production (Protein) would not be disturbed. However, a shortage in any of the nutrient requirements causes adverse effects in the physiological processes in the crops (Senjobi *et al.*, 2013).

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5.3.1 Effect of agrochemicals on the quality of okra fruits

Throughout the entire experiment, the use of agrochemicals was very effective in promoting the growth and yield of okra crops. However, it was not effective in maintaining the quality of the fruits under uniform storage conditions. All the respondents who assessed the sliminess of the cooked okra pods identified the pods from the control treatments of both field experiments as being extremely slimy compared to those treated with agrochemicals. The pods from plants treated with neem oil were also very slimy but not as slimy as the pods from the control treatments. Pods from plants treated with a mixture of insecticides plus herbicide (T2a) proved the least slimy among all the treatments. This result contradicts the findings of Ibe and Madukwe (2010) who found the use of high dosage of agrochemicals as effective in enhancing high viscosity of okra.

The higher rates of agrochemicals administered to the okra plants resulted in high rates of shriveling, blackening and decaying of the okra pods. The shelf life was longer in the controls of both field experiments (T0a and T0b) and pods from plants treated with neem oil extract (T2b). The pods from plants treated with a mixture of insecticides plus herbicide (T2a) recorded the highest deterioration. These findings implied that the best quality of okra could be achieved by using lower rates of agrochemicals especially botanicals. These observations are similar to reports by Ngure *et al.* (2009), Kodithuwakku and Kirthisinghe (2009) and Hoque *et al.* (2010).

The decrease in weight of the pods under storage could be attributed to high respiration rate of the pods due to the oxygen level within the storage room which caused the pods to lose moisture and shrivel. These observations were in conformity with reports by Hoque *et al.* (2010) and Aguiar *et al.* (2011).

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CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

- The results of the present studies revealed that agrochemicals are predominantly used by farmers in peri-urban okra production. The agrochemicals used in okra production were mainly fertilizers, herbicides and insecticides.
- Most of the farmers in peri–urban okra production had some formal education but their level of education did not reflect in their use of agrochemicals since majority could not read and understand the information on the labels of the agrochemicals which they purchased. Chemical application was more arbitrary than recommended as the farmers' objective was to obtain good fruits aesthetically.
- The seeds used in local okra production were mainly farmer saved seeds. Farmers did not perform germination test on their seeds before planting nor pre–treat their seeds nor apply fungicide in okra production.
- Okra pods from plants treated with a mixture of insecticides plus herbicide (T2a) produced the poorest results in terms of quality of pods under uniform storage conditions whiles the pods from the control plants in both experiments had better quality.
- The pods from plants treated with recommended rates of agrochemicals in both experiments and the pods from plants treated with neem oil extract (T2b) showed the best storage quality.
- Pods from the controls however were most slimy compared to pods from all the other treatments.

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- The use of agrochemicals is very necessary in okra production to ensure optimum growth and yields but misapplication could result in poor pod quality and high post–harvest losses.

5.2 RECOMMENDATIONS

Farmers in peri–urban okra production and consumers need to be educated on the harmful effects of using agrochemicals indiscriminately on their health and the environment as a whole as well as product quality and shelf–life.

Further research must be carried out to investigate the chemical residues that remain on crops from the use of agrochemicals.

Farmers must also be encouraged to obtain their seeds from certified agrochemical outlets or shops to ensure good germination and subsequent high yields of their crops.

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APPENDIX

QUESTIONNAIRE

COLLEGE OF AGRICULTURE AND CONSUMER SCIENCES

Topic: AGROCHEMICAL USE IN PERI–URBAN OKRA PRODUCTION

Name of Respondent /Farm…….

Location…….....

District……

Part 1 General Background

Sex ( ) Male ( ) Female

Age () 18–24 ( ) 25–30 ( ) 31–35 ( ) 36–40 ( ) 41–45 ( ) 46–50 () above 50

Marital status ( ) Single ( ) Married ( ) Divorced

Educational background

( ) None

( ) Primary School

( ) Elementary

( ) High School

( ) College

( ) University

Size of family …….

Gender distribution in okra Production

- Land Preparation	( ) M ( ) F ( ) Both
- Sowing	( ) M ( ) F ( ) Both
- Fertilizer application	( ) M ( ) F ( ) both
- Weeding	( ) M ( ) F ( ) Both
- Pesticide spray	( ) M ( ) F ( ) Both
- Irrigation	( ) M ( ) F ( ) Both
- Harvesting	( ) M ( ) F ( ) Both
- Transportation	( ) M ( ) F ( ) Both
- Selling	( ) M ( ) F ( ) Both
- Who control the family's income?	( ) M ( ) F ( ) Both
-Who decides on family's expenditure?	( ) M ( ) F ( ) Both

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Part 2

2.1 Total Agriculture land area……m^2

2.2 Total okra growing area……. m^2

2.3 Farm Type ( ) Low land (leveling) ( ) Low land (Ditch and dike)

2.4 Water Source

( ) 1. Irrigation

( ) 2. Public Borehole/dam

( ) 3. Your own Borehole/dam

( ) 4. Other……..

2.5 i) Use of family labour ( ) Yes ( ) No

ii) Number of persons ……..

2.6 Experience in growing okra…….months/years

2.7 Marketing of okra ( ) Farm gate ( ) wholesale market ( ) retail market.

Part 3 Crop Management

3.0 **Cropping Calendar**

3.1What month did you start growing okra?

	MONTH											
AREA	1	2	3	4	5	6	7	8	9	10	11	12

3.2 Frequency of Okra production. How many times do you grow okra in a year?

……times

3.3 **Farm Management**

3.3.1 Land Preparation methods adopted: ( ) Mechanical ( ) manual

Plowing…….… Interval……

Cost of plowing……

Depth of plowing …….. cm.

Harrowing Interval……

Cost of Harrowing……

Do you apply agricultural lime? ( ) Yes ( ) No

Do you grow other crop in the same land? ( ) Yes ( ) No

If Yes, What crop? ……...

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Why? ……

Varietal name of okra……..

Seed Source: ( ) Farmer saved seeds ( ) Commercial seeds ( ) Other …….

Quantity of seeds…… Kg/Ha

Cost of seeds……. /Kg

Percentage of germination……%

Do you ever practice germination test of seed? ( ) Yes ( ) No

If Yes, Please explain how you go about it

……

Are seeds pre-treated? ( ) Yes ( ) No ( ) Not sure

Any pre-germination treatment carried out? ( ) Yes ( ) No

If yes, ( ) cold water ( ) warm water

For how long did you treat the seeds? ( ) <1hr ( ) 1-6hrs ( ) 6-12hrs ( ) 12-24hrs ( ) Few days

Do you mix fungicide with seeds before sowing? ( ) Yes ( ) No

If yes, what fungicide?

……..

3.2.3 **Sowing Methods**

Distance between row……..cm.

Distance within row……. cm.

Number of seeds per hole……. seeds

Sowing method ( ) Manual ( ) Mechanical

3.2.4 **Irrigation Regime**

( ) Every day after sowing ( ) Every other day after sowing ( ) Every day after flowering stage

( ) Others……

3.2.5 **Weed Control**

Weed control method used: ( ) Manual ( ) Cultural ( ) Chemical ( )Biological

Do you apply any herbicide before sowing? ( ) Yes ( ) No

If yes, which herbicide? …… Rate……

Source of labour: ( ) Family ( ) Hired

The number of hand weeding/ tillage……time/season.

Labour source ( ) Family ( ) Hired

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3.2.6 **Fertilizer Application**

No.	Name of fertilizer	Quantity	Methods	Price	Family/Hired	Remarks

3.2.8 (Pruning)

Do you prune your okra plant? ( ) Yes ( ) No

( ) If yes, when? ……

Insect Pest Management:

3.2.9 Insect Pests (From the beginning of the season till harvesting)

Insect Pest	Crop Stage	Climate	Control Methods

What are the major insect pest problems? ……

3.2.**10 Plant Disease Management:**

Disease (From the beginning of the season till harvesting)

Disease	Crop Stage	Climate	Control Methods

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What is the major disease? ……

3.2.**11**

Weeds (From the beginning of the season till harvesting)

Weeds	Crop Stage	Climate	Control Methods

What is the major weed? ……

3.2.12 Chemical and Bio pesticide used

Name	Source	Price	Quantity/ time /Kg	Frequency of spraying	No. of application	Family /Hired	Purpose

4.Harvesting/Storage/Marketing Procedures

When did the harvesting start and finish?

MONTH											
1	2	3	4	5	6	7	8	9	10	11	12

- The first day of harvesting……. DAS

- The number of harvesting in 1 season…… times

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- What method of harvesting do you use? ( ) Manual ( ) Mechanical ( ) Other.
- Labor in harvesting

( ) Hired. …… person

Permanent Labor…… person

Temporary labor……. person

( ) No hiring……..

- Total Yield of okra (last year)……
- Any storage of okra after harvesting? ( ) Yes ( ) No

If yes, how do you store okra before transporting to market?

…….

What storage equipment do you use?

……

- In grade (qualify by company)……. Low grade…….
- Price of okra in grade 'A' Price……. 'B' Price…….

Low grade Price…….

- ( ) Grading before sending to company ( ) Send all okra yields without grading
- Income from growing okra……
- The cost of investment of growing okra (last year) …….
- What company did you sell okra to? ……
- What is the most important constraints in okra production farmers?

( ) Insect Pest ( ) Disease ( ) Lack of technique ( ) Market

( ) Irrigation ( ) Seeds ( ) Transportation

( ) Money

Others……

6. Record Keeping

Do you ever record (Chemical use and fertilizer use)? ( ) Yes ( ) No

If yes why? ……

6.1. Any observation for chemical usage in okra production?

……

……

***7.* Needs**

What do you want to know more in order to improve your okra production?

.....……

…….

…….

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