EFFECT OF DIFFERENT NEEM LEAF EXTRACT CONCENTRATIONS ON INSECT PESTS OF SOYBEAN (*Glycine max* (L) Merrill)

OGBINAKA, Ewoma Jimmy Andrew
PG/09/10/177303

DEPARTMENT OF AGRONOMY (CROP SCIENCE),
POST–GRADUATE SCHOOL
FACULTY OF AGRICULTURE,
DELTA STATE UNIVERSITY, ABRAKA

AUGUST, 2016

EFFECT OF DIFFERENT NEEM LEAF EXTRACT CONCENTRATIONS ON INSECT PESTS OF SOYBEAN (*Glycine max* (L) Merrill)

OGBINAKA, Ewoma Jimmy Andrew
PG/09/10/177303

A DISSERTATION IN THE DEPARTMENT OF AGRONOMY, SUBMITTED TO THE POST–GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTERS OF SCIENCE (CROP SCIENCE)
DELTA STATE UNIVERSITY, ABRAKA

AUGUST, 2016

DECLARATION

I declare that this work is an original research work carried out by me in the Department of Agronomy

----

Ogbinaka, Ewoma J.A,
Student

CERTIFICATION

We certify that this work was carried out by Ogbinaka, Ewoma Jimmy Andrew of the Department of Agronomy, Delta State University, Asaba campus, Nigeria.

----------------------- -------------------

DR. F. O. TOBIH Date

Supervisor

----------------------- --------------------

PROF. S.O. AKPAROBI Date

Head of Department

DEDICATION

I dedicate this work to God Almighty, for the courage to carry on. Also to my wife: Cynthia, and my two daughters: Valerie Ewomamena and Mitchelle Ewomafome.

ACKNOWLEDGEMENTS

Thanks to God for inspiration, enablement and perfection of this course. The determination fully came from God.

I want to say a special thank you to all my lecturers for both their encouragement and academic guidance. My hearty thanks go to Prof. S.O. Akparobi (Head of Department), Prof. S.O. Emosairue, Prof. I.M. Ojeifo, Prof. P.G. Eruotor, and Dr. F.O. Tobih, (My dear Supervisor), Dr. F.N. Emuh, Dr. E.O. Egho, Dr. (Mrs) B.O. Bosah, Dr. C.N. Egbuchua, C.C. Obiazi, S.A. Ojobor, Dr. E.C. Enujeke and Prof. L.U. Okomah of the blessed memory. My greeting also go to my academic colleagues, Mr. P. Kator, Mr. Prosper Umukoro, Mr. Steve Onokpoma, Borhie, Osas and a host of others.

I wish to also remember very special family members and friends for the various roles they played. First is Dr. Karo Ogbinaka for his financial support, the entire Ureki family, Mrs. Oke Afamefuna, Mr. Mark Ogbinaka, Mr. Austin Emifoniye, all my other brothers and sisters, with a host of other family friends for their continued encouragement and concern.

Finally, I express my appreciation to the Delta State Government for the payment of a Scholarship through the Delta State Bursary Scheme under the leadership of Dr. Emmanuel Ewetan Uduaghan as Governor.

Thanks.

Ewoma J. A. Ogbinaka

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Field studies were conducted in the early and late season planting of 2012 at the Teaching and Research farm of the Department of Agronomy, Delta State University Asaba Campus, Delta State, Nigeria to identify major insect pests of Soybean, their types of damage and the effect of different Neem leaf extract concentrations on population of insect pests of the crop. Nine (9) treatments namely; 5%,10%, 15%, 20% Cold Neem Leaf Extracts (CNE), 5%, 10%, 15%, 20% Hot Neem Leaf Extracts (HNE), and the Untreated (Control) were laid out in a Randomized Complete Block Design and replicated three (3) times. Insects collected were identified and classified into orders. The most prevalent order was *Coleoptera* with *Podagrica fuscicornis* and *Cerotoma trifurcata* as the most prominent. The use of Cold and Hot Neem Leaf Extracts were effective in controlling the infestation of the insect pests. Insect population in the control plot during the early season planting was reduced from 51 insects to 24 and 18 number of insects in 20% CNE and 20% HNE respectively. Pest infestation was higher in the late season planting than in the early season planting. The results showed that there were no significant differences ($p > 0.05$) between treatments and Control in terms of number of damaged seeds, number of undamaged seeds, 100 seed weight and seed yield (t/ha) of both early and late season planting. Mean yield and yield related parameters of early planting were significantly different ($p > 0.05$) from that of late planting. 20% HNE and 15% HNE had the highest seed yield of 2.0 and 2.1 t/ha respectively, with 10% CNE having 1.9 t/ha, while 15% CNE, 20% CNE and the control had 1.4 t/ha each. Yield (t/ha) during the late planting were not as high as that of early planting but in the overall, 20% Hot Neem Extract did better in terms of reducing insect pests population and yield of soybean in Asaba.

CHAPTER ONE

INTRODUCTION

Soybean (*Glycine max* (L) Merrill) belongs to the family Fabaceae, genus Glycine and Subgenus soja (Moench) F.H. Herm. This subgenus is comprised of the annuals of the genus, while the cultivated soybean has an erect, bushy and annual growth habit. The form and structure of a soybean plant varies vastly (Guo, 1993).

The crop is grown mainly for special uses such as for food, feed, medicinal, religious and ceremonial purposes (Hymowitz, 2004). It is mainly pressed to extract soybean oil, which is a rich source of protein. Soybean oil can be used for the production of edible oils such as kitchen oil, salad oil. (Hu, Hsoio, Huang, Fu, Hang, Chen, Lu, 2004). Its oil is also used for the production of printing ink and biodiesel. Soybean meal is mainly used for the production of compound feed, serving as the main source of protein in feed for livestock farming.

Traditionally, it is mainly used directly for food in the form of soybean products such as bean curd, soybean milk, soybean paste and bean curd stick. The processing of these products has moved to commercial soybean products processing factories. The production of products has increased and the quality of products improved.

The crop is rich in oil (20%), protein (40%) and is used for both human and animal consumption as well as for industrial purposes, such as biofuels. it also plays an important role in crop diversification and benefits other crops by adding nitrogen to the soil during crop rotation (Singh, 2010).

The production of modern soybean processed products such as soybean milk flour, isolated soy protein and structural protein has also continuously increased, along with the production of functional soybean foods such as phospholipid, saponius isoflavones, oligosaccharides and edible fibre (Wang, 1985).

Soybean polypeptide is a hydrolyzed product of protein through special treatment. It has a high nutritional value, high digestibility co-efficient and low antigenicity. It can be used as a raw material for additive to health foods. It also has a therapeutic effect on high blood pressure and cardiovascular and cerebrovascular diseases, and is safe and reliable (Wang, Li, Yang, Zhou, Gao, Xu, Fang, Gang, Wu, Cai, Shi, Ge, 2004). Soybean polypeptide also decreases the deposition of subcutaneous fat and increases fat burning and it is, therefore a safe food for people who want to lose weight. It also has an antioxidant effect, and it has been claimed that the muscle cells of athletes recover faster when they imbibe a polypeptide containing drink (Wang *et al*, 2004).

Soybean isoflavones have inhibitory effects on the early transformation and proliferation of cancer cells. Isoflavones can effectively inhibit the angiogenesis of a cancer structure and thus block the supply of nutrients to cancer cells, therefore, isoflavone is of therapeutic use in breast cancer, colon cancer, lung cancer, prostate cancer, leukaemia and others (Wang, 1985).

The cultivation of soybean improves soil health through its deep root system and its ability to fix atmospheric nitrogen. It is therefore a human, animal and soil friendly crop (Singh, 2010).

Asia has the longest history of growing soybean and the cultivated area of soybean in China is the largest in the world. It is cultivated in Japan, the Republic of Korea (South Korea), the Democratic People Republic of Korea (North Korea), Indonesia, Thailand, Vietnam and other countries (Guo, 1993). Due to climatic reasons the cultivated area of soybean in Europe is not very large. Ukraine, Russia, Italy, Romania, Serbia, Croatia and France are all soybean producing countries. A small amount of soybean is produced in Australia (Wang, 1985).

The cultivated area of soybean in Africa is not large. Nigeria has a large area under soybean followed by South Africa, Uganda, Zimbabwe, Congo, Zambia and others. Africa has a great potential in the production of soybean with proper attention given to both introduction of improved varieties, processing and utilization of soybean and in the production of soybean foods suitable for consumption by the local people.

In Nigeria, production area has been over 600,000 ha, producing up to 605,000 and 604,000 tonnes with production of 960 and 946$kgha^{-1}$ in 2006 and 2007 respectively (FAO, 2009).

The increasing demand and continuous production of soybean in parts of the world and Nigeria has resulted to serious prevalence of pests and diseases. The plant is widely affected by insect pests. Several insect orders – *Orthoptera* (grasshoppers), *Coleoptera* (beetles) and *Lepidoptera* (caterpillars - moths and butterflies) are capable of feeding on soybean leaves. These insects typically have biting and chewing mouthparts that either remove leaf area or destroy the leaf surface.

Kogan and Turnipseed (1987), identified the following as major or frequent defoliators of soybean. *Helicoverpa zea* (corn earworm), *Heliothis armigera* (America bollworm), *Heliothis punctigera* (Australian bollworm). *Pseudoplusia includens* (Soybean looper), *Anticarsia gemmatalis* (Velvet bean caterpillar) and *Spilosome obiliqua* (Bihar hairy catapillar). The army worm (*Spodoptera exigna*) leaf beetle (*Cerotoma trifurcata*), aphids (*Aphis glycines*) feed on soybean leaf, while the strok bug (*Acrosternum hilare*), corn earworm (*Heliothis zea*) and soybean stem borer (*Dectes texanus*) feed on pods and stems (Boethel, 2004).

Members of the same orders of insects (*Coleoptera*, *Lepidoptera*) and species (*H. armigera*, *H.zea*, *C. trifurcata*) that feed on foliage also feed on pods and seeds.
Some species feed almost entirely within pods during the immature stages (*Etiella zinckenella*), causing moderate yield loss (Van den Berg, Shephard, Nasikin, 1998a).
The most widespread and significant pests of soybean during the later growth stages are *hemipterans*, specifically the pentatomid stinkbugs (Kogan and Turnipseed, 1987), such as *Nezara viridula* and *Piezodorus guildinii*.

Currently, farmers rely mostly on synthetic pesticides for the control of pest and diseases of most crops. The harmful effect of synthetic pesticides on the environment and humans is now compelling researchers to source for other forms of pesticides that are less harmful and environmental friendly.

In line with the above trend, field studies of plants that exhibit wide range of effects on insects as repellants, deterrent and anti-feedants are being carried out by scientists all over the world.

The objectives of this study therefore are to identify and categorize major insect pests of early maturing Soybean in Asaba, and to determine the effects of different concentrations of Hot and Cold Neem extracts on the yield and yield related parameters of the crop.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY AND ORIGIN OF SOYBEAN

The origin of soybean cultivation is China. China was the world's largest soybean producer and exporter during the first half of the 20^{th} century (Chang, 1989).

Scholars generally agree that the origin of soybean cultivation is in China. First, the annual wild soybean (*G.soja*), the kindred ancestor of the current cultivated soybean (*G.max*) is found throughout China. The distribution of *G.soja* is limited to China, Japan, Korea and the Far East area of Russia in East Asia, but its distribution in China is the most extensive, its numbers, the largest and its diversity of types, the richest. Second, China has the earliest written records of soybean cultivation (Chang, 1989).

According to the information disseminated on soybean by Shanrong the carbonized soybean seeds excavated from Jilin province, Li (1987, 1994) thought that the origin of soybean should be limited from the North Eastern Hebei province to South Eastern areas of the Northeast China.

Guo (1993) systematically collected literature related to soybean in past dynasties of China and wrote a book where he analyzed the argument related to the origin of soybean in ancient literatures and thought that the origin of cultivated soybean in China is Northern China, but that the exact origins of soybean remain unknown. He gave various possible locations including Northeast China, North China, the Central Shaanxi plain and the Yellow River Central Valley. He thought that these arguments are not conclusive in pinpointing the exact location and that therefore, research is needed.

2.2 Botany of Soybean

Soybean belongs to the family Fabaceae, (Leguminosae), genus *Glycine* and Subgenus *soja* (Moenech) F.J. Herm (Kumudini, Pallikondo, and Steele, 2007). Arokoyo, Onyibe, Olowoniyan, Chindo (1999) stated that the international taxonomic classification of plant stipulates that the correct name of soybean is *Glycine max* (L) Merrill. They further noted that there are other species that belong to this genus *Glycine* and they include *G. clandestina* Wendl; *G. falcata* Benth; *G. latrobeana* (Meissn) Benth; *G. tabacina* (Labill) Benth; *G. tomentella* Hayata, *G. petitiana* (A. Rich) Schweinf. *G. javanice* L., *G. ussuriensis* Regal and Maack and *G. sericea* Benth. However, *Glycine max* is observed to be the most cultivated species.

The cultivated soybean has an erect bushy and annual growth habit. The form and structure of soybean plant varies vastly. The soybean has different leaf structures. Seed leaves (cotyledon), primary leaves (Unifoliate), trifoliate leaves and proplylls (Lersten and Carlson, 2004).

The first two leaf types occur on the first two nodes. All subsequent nodes have the alternatively arranged trifoliate leaves. Individual leaflets have entire margins and range in shape from oblong to ovate to Calceolate.

In certain situations, the alternatively arranged leaves may have four to seven leaflets and lateral leaflets may fuse with the terminal leaflets (Lersten and Carlson, 2004).

The stem is usually erect and much branched, though in some varieties, it tends to be creeping and twining and the heights of plants varies from two to six feet, depending on variety. The stem is hairy, the hairs being short, brown or grey structures (Bhatia, Patel, and Kale, 1983).

Soybean roots are composed of an outer layer of epidermis. Root hairs are formed from epidermal cells as early as four days after germination and about 1cm from the tip of the primary root. Nodules form on the roots of soybean plants as a consequence of a mutually beneficial relationship between the plant and *Bradyrhizobium japonicum*, a Gram-negative bacterium present in the soil. The bacterium multiplies within the soybean root nodules and obtains carbon-rich energy compounds from the plant. In exchange, the bacterium converts atmospheric nitrogen into ammonia which is subsequently utilized by plant (Lhuissier, De Ruijter, Sieberer, Esseling, Emons, 2001, Timmers, 2008).

The flowers has hairy calyx of five sepals, united to about half their length with two upper lobes and three lower lobes. The median of which is longer than the others. The pollen is shed before the flower opens and thus self-fertilization is the rule (Arokoyo *et al.*, 1999).

After fertilization, the flower style and stigma dry out while the calyx persists and the ovary starts developing into the fruit. The soybean pod consists of the two halves of the single carpel joined by a dorsal and ventral suture, which itself consists of the main and marginal veins of the former carpel. The wall of the young pod is composed of an epidermis with varying degrees of trichome density. As the pod matures, the outer epidermal cells develop thickened walls covered by a well developed cuticle. Separation of the two halves of the pod at maturity is preceded by the appearance of Clefts in the parenchyma of the dorsal and ventral sutures (Carlson and Lerster, 2004).

The mature soybean seed is generally oval in shape consists of a seed coat surrounding a large embryo. The seed coat has helium that varies in shape and colour. The dominant embryo consists of two fleshy cotyledons, two well developed primary leaves enclosing a trifoliate leaf promodium and a hypocoty-radicle axis. The fruit of soybean is a hairy pod that grows in clusters of 3-5. Each pod is 3-8cm long and usually contains 2-4 seeds that are 5-11mm in diameter. The pod are carried on short stalks and the colour varies from white through red and brown, yellow to greenish yellow to black in the different varieties (Carlson and Lersten, 2004). However, only the yellow and the greenish yellow varieties are commonly grown and preferred in Nigeria (Arokoyo *et al*., 1999).

2.3 Economic Importance of Soybean

Soybean has many uses. It is mainly pressed to extract soybean oil, after which a soybean meal remains which is a rich source of protein. The United States Development Agency (unclassified) in analyzing the chemical composition of soybean matured seeds raw nutritional value per 100g noted the following in table 1.

Table 1: Chemical/Nutritional Composition of Soybean

Nutrients	**Value per 100g**
Energy	1866kg (466kcal)
Carbohydrates	30.16g
Sugars	7.33g
Dietary Fibre	9.3g
Fat	19.94g
Saturated	2884g
Monosaturated	4.404g
Polyunsaturated	11.255g
Protein	36.49g
Tryptophan	0.591g
Threomine	1.766g
Isoleucine	1.971g
Leucine	3.309g
Lysine	2.706g
Methionne	0.54g
Cystine	0.655g
Water	8.54g
Vitamin A equivalent	1ug
Vitamin B6	0377ug
Vitamin B12	0ug
Vitamin C	6.0ug
Vitamin K	4.7ug
Calcium	277mg
Iron	15.70mg
Magnesium	280mg
Phosphorus	704mg
Potassium	1797mg
Sodium	2mg
Zinc	4.89mg

Source: USDA Nutrient Database.

Soybean oil can be used for the production of edible oils such as kitchen oil, seed oil and others through refining and deep processing. Soybean oil is also used for the production of printing ink and biodiesel. Soybean is the main protein source in feed for livestock farming. The food processing industry uses soybean for the production of soybean protein rich foods. For instance wheat flour is supplemented with a certain amount of soybean protein for the production of bread and cake (Singh, 2010).

Soybean protein supplementation improves the water absorption of meat and the palatability of sausages. Soybean protein can be used to process protein fibre, which can be blended with cotton wool or chemical fibres. The texture of the resulting fibre is soft and is of high quality. Some soybean food products processed by using soybean as raw materials include bean curd, bean curd stick and soybean milk. Fermented soybean products are soy paste, soybean cheese, soybean sauce and others. Seed sprouts of soybean are used for making dishes or soup. Soybean sprout soup is common in Korea, while soybean sauce soup is often eaten in Japan (Singh, 2010).

Phosphatide, Sterone and Vitamin (E) can be extracted from the residues that remain after soybean extraction. The main contents of soybean phosphatide are phosphatidycholine, phosphatidylethanolamine, Phosphatidylinositol, Phosphatidylserine and phosphatidic acid.

Soybean phosphatide is a natural emulsifier and can be used to supplement the nutrients requirements of the human body; therefore it is used extensively in the production of candies, biscuit, chocolate, artificial cream and other food products (Singh, 2010).

Soybean has a broad prospect for application in food, medicine and animal production, In Medicine, soybean polypeptide which is a hydrolyzed product of protein through special treatment has a high nutritional value, high digestibility coefficient and low antigenicity. It is used as a raw material for additive to health foods. It has a therapeutic effect on high blood pressure and cardiovascular diseases, and is safe and reliable. It also decreases the deposition of subcutaneous fat and increases fat burning and is a safe food for people who want to lose weight (Wang *et al*; 2004).

The crop plays a role in improving soil properties through its deep and proliferated top-root system, residue incorporation by way of shedding leaves as well as green manuring crop, soil and moisture (conservation due to its thick and dense foliage, contribution to soil nitrogen enrichment through biological nitrogen fixation (BNF) and improvement in the soil biological health).

Soybean protein content in lactoserum is 8.2%. Lactoserum waste water is produced during the processing of bean curd and other products of soybean. Through filitration of lactoserum waste water by using dynamic membranes, 85-93% of protein can be recovered. The lactoserum protein is a natural surface active agent and can be used for cosmetics. Lactoserum protein is easily digested and assimilated and has a high metabolic rate and biological value. Lactoserum waste can be used for the extraction of oligosaccharides which can promote intestinal peristalsis and ease constipation. It also promotes the growth of Bifidobacterium and improves the structure of the intestinal bacterial flora (Wang *et al*, 2004; Singh, 2010).

Isoflavones also can be extracted from lactoserum waste water. Soybean isoflavones consists of flavine glycoside (97-98%) and aglycones (2-3^0C). Aglycones have biological activity. Isoflavones glycoside is separated from glycones by the actions of different isoflavones-glycosidases, and the genistein with biological activity is then released. Genistein can attenuate post menopausal osteoporosis in human. Isoflavones have inhibitory effects on the early transformation and proliferation of cancer cells. They can effectively inhibit the angiogenesis of a cancer structure and thus block the supply of nutrients to cancer cells. Therefore, isoflavone is of therapeutic use in breast cancer, colon cancer, lung cancer, prostate cancer, leukaemia and others (Singh, 2010).

2.4 Ecophysiological Requirements of Soybean Production

2.4.1 Soil and Temperature

Soybean can be grown on wide variety of well-drained soils but thrives best on clay loam soils (Reedy, Sabba, Takkar, 1999). The crop is better adapted for production on clay than either corn or cotton. It is also suited for production on muck. Soybean prefers a slightly acid soil. (pH 6.0-6.5) (Mclean and Brown, 1984). However it grows quite well on calcareous clay soils (pH 7.5) if the free lime level is not too high. Soybean is rated as a moderately salt tolerant crop and the reported salanity threshold is about $5ds^{m-1}$ (Maas, 1986).

Soybean is classified as a warm-season crop; its cultivation now extends from the tropics to 52^{O}N. The major commercial production of soybean is between 25^{O}N and 45^{O}N Latitude and at Altitudes of <1000m (Fageria, Baligor, Jones, 1991). Soybean is a temperature-sensitive crop and is usually grown in environment with temperature between 10^{O}C and 40^{o}C during the growing season (Whigham, 1983). It is a short day plant, but cultivars may differ with respect to the maximum dark period required to induce flowering.

2.4.2 Rainfall and Water

Water is an important input for assured agricultural production. Important sources of water for raising agricultural crops include rainfall, canal water, underground water and moisture in the soil profile. Soybean is mostly grown as a rainfall crop in many parts of the world. Both water-logging and drought affect soybean production to valued degrees.

The water requirement of soybean varies depending upon the growing season, crop cultivars, irrigation method, and rainfall. Cultivars of longer duration are expected to need higher amounts of moisture than those of short duration. Adequate and timely rainfall during the crop season is essential for obtaining high soybean yields under rainfed conditions. A timely onset of rains ensures timely results in poor emergence owing to crust formation or oxygen deficiency (Hamada, Shaka, Sawada, Kojima, 2007).

Rainfall may also influence soybean yields due to the effect of time of rain, pattern of distribution, intensity of rain and so on. Delayed onset of rains, erratic distribution and high intensity rainfall are expected to result in low yields (Hajare, Mandal, Challa, 2003).

2.4.3 Nutrient Requirements of Soybean

Under optimal conditions, soybean shows a fairly uniform composition regardless of region. Carbon, hydrogen and oxygen from the air make up 90% of dry matter production. However, these cannot be assimilated unless the other major and minor elements are present in the soil in sufficient quantity. In decreasing order of importance, these essential elements are nitrogen, potassium, calcium, magnesium, phosphorus and sulphur (Tandon, 1989).

Soybean can fix substantial amounts of atmospheric nitrogen approximately 4 weeks after germination. Most estimates show that soybean derives between 25% and 75% of its nitrogen from fixation (Diebert, Jeriego, Olson, 1979). Different, sufficient and high concentration of nutrients for upper fully developed trifoliate of soybean prior to pod set have been compiled by Fageria *et al*, (1991), from Small and Ohlrogge (1973) and Rosolem (1980). The respective concentrations are 40,45-55 and 56-70gkg^{-1} for nitrogen, 1.5, 2.6-5 and 6-8gkg^{-1} for phosphorus, 12.5, 17-25 and 26-28gkg^{-1} for potassium, 2.0, 3.6-20 and 21-30gkg^{-1} for calcium and 1.0, 2.6-10 and 11-15gkg^{-1} for magnesium. Similarly different, sufficient and high concentrations respectively, for micronutrients are 30, 51-350 and 351-500$mgkg^{-1}$ for iron, 14, 21-100 and 101-250$mgkg^{-}$

^{1} for manganese , 10, 21-50 and 51-75mgkg^{-1}for Zinc, 10, 21-55 and 56-80mgkg^{-1}for Boron, 4, 10-30 and 31-50mgkg^{-1} for Copper and 0.4, 1-5 and 6-10mgkg^{-1} for Molybdenum. These data provide some guidelines for understanding the mineral requirements of the soybean crop.

Nitrogen is required in the highest amount of all plant nutrients absorbed from soil. It is present in all amino acids which are the building blocks of protein, nucleic acids and chlorophyll (Jones, Wolf, Mills, 1991). Soybean plants can use nitrogen released by mineralization, residual soil nitrogen, fertilizer nitrogen or atmospheric nitrogen which is converted into a usable form of root nodules through a symbiotic relationship between *Bradyrhizobium japonicum* bacteria and the soybean plant. While the soil is the primary source of nitrogen for many crops, Soybean obtains 65-85% of its needs through the symbiotic nitrogen fixation process. A high rate of nitrogen fertilizer suppresses nitrogen fixation and most specialists recommend either no fertilizer nitrogen or a modest application of 30-50kg ha^{-1} either at sowing or just before flowering (Eaglesham, Hassouna, Seggers, 1983).

2.4.4 Planting Date of Soybean

Early or too late sowing of soybean, results in drastic reduction in yield (Singh, 2010). The optimum time for soybean sowing may vary at different locations due to different climate conditions. For Nigeria, the United States Agency for International Development in its Commercial Crop Production Series on growing soybean in Nigeria noted the time of planting soybean in the savanna, that late maturing varieties be planted from early June to middle of June, while medium and early maturing varieties are planted from early July to middle of July, it further noted that for the forest zone, late varieties are planted from early July to Middle July and early medium varieties from the middle of July to the end of July. A timely sown crop generally results in higher yields than late-sown crops, unless there is a specific problem such as drought, water-logging, high incidence of insect pests and diseases or lodging. Higher yields in the timely sown crops may be due to better plant growth and yields attributes, longer maturity duration and higher Agro - climatic indices such as growing degree days, heliothermal units and photothermal units. Lower yields in late planted crops could be due to a variety of reasons including shifting of the reproductive phase into less favourable environment (shorter days) lower temperature and isolation, less availability of soil moisture and a shorter growth period (Singh, 2010).

2.4.5 Sowing of Soybean

Soybean is sown in rows on a flat bed either in a well prepared field or as a no-till crop. It can also be sown on raised beds. In some areas, it is grown as a sole or mixed crop. While in others, intercropping with cereals, oilseeds, grain legumes and fibre crops is also practiced.

The crop should be sown at the proper depth to ensure optimum germination and emergence. If the crop is sowed very deeply, seedling will not emerge as the food stored in the cotyledons will be exhausted before the coleoptiles emerge. Conversely, in the case of shallow sowing the surface soil becomes dry very quickly, leaving very little moisture for seeds to imbibe. Sowing of Soybean at a 2.5-5.0cm depth is considered optimum (Pederson and Laver, 2003; Chauhan and Joshi, 2005; PAU, 2009). Christmas (2008) advocated sowing soybean to 2.5-3.7cm depth only.

2.4.6 Weeding/Maintenance of Soybean

The wide row spacing and slow initial growth rate of soybean provide a congenial atmosphere for an abundant population and profuse growth of weeds in soybean farm. The infestation and competitive stress of grassy weed is very serious. Weeds compete with soybean for solar radiation, nutrients and soil moisture when they are limited and the early season competition is the most critical. The effects of weed competition depend on the growth habits of the weed species, number and density of weeds, stand and cultivars of soybean crop, climatic factors and competition for nutrients, soil moisture and the mutual shading of crop and weeds. The loss comprises:

i. Direct yields losses from competition

ii. Indirect losses from reduced crop quality

iii. Increased costs in harvesting, land preparation and similar operations; and

iv. Harboring of insects pests and diseases.

Weeds in soybean have been found to deplete soil fertility (Chhokar, Balyan, Pahuja, 1997). Weeds particularly affect crop productivity via competition for inorganic nutrients

(Oerke, 2006). Managing weed in soybean requires an integrated approach that utilizes preventive, cultural, mechanical, chemical and biotechnological methods in a mutually supported manner in the crop production system, with due consideration of economic environmental and sociological consequences (Yaduraju and Mishra, 2004). No single method of weed control can reach the desired level of efficiency under all situations. The most promising single approach to weed control in crops combines manual, cultural and mechanical methods with herbicides. The United States Agency for International Development in its Commercial Crop Production Guide Series "Growing Soybean in Nigeria' recommend at least twice weeding, the first 2-3 weeks after planting then, subsequent weeding should be carried out as found necessary.

2.4.7 Harvesting/Post-Harvest Handling of Soybean

Soybean is harvested when the seeds are mature and the foliage is dry. Soybean is a highly productive crop, with a normal production cycle of 90-110 days from planting to harvesting. Typically, soybean is harvested at 13-15% moisture content to avoid field losses due to shattering of over dried seeds and to reduce drying time to achieve safe storage moisture content. Harvesting at <12% moisture content creates seed cracks and shattering losses. Harvesting could be by hand or mechanized harvesting. In hand harvesting, plants are uprooted from field when 85% of the pods are dry. The uprooted plants are spread in the sun and turn over every other day until all pods are dry. Threshing is done manually by beating piles of the dried plants with a wooden club on a cemented floor or on a tarpaulin. Winnow and sieved to remove thrash.

Soybean need to be stored until they are processed or consumed. Storage time can vary from a few months to more than a year. It is advisable to remove foreign materials, weed seeds from soybean and to inspect them for mould, insects or insects damaged seeds before drying and storage for better and longer storage (Parde, Kamsal, Jayas,White, 2002). The drying temperature for soybean to be used as food and oil should not exceed 49^{o}C (White, 2001). The maximum safe drying temperature for its storage is 38^{o}C.

The following are storage procedures outlined by White (2001);

1. Prepare the bin before storing a new seed type; sweep or vaccum the floor and walls. Burn or bury sweepings that contain spoiled or infested seeds; seal cracks to keep out flying insects, rain and snow; and spray the walls and floors with recommended insecticides.
2. Install an aeration system to reduce temperature gradients and moisture condensation.
3. Dry tough or damp seeds soon after harvesting as they are more likely to heat and become infested with insects and mites, dry seeds, and then cool after drying.
4. Examine stored seeds every 2 weeks for signs of heating or infestation, check temperature, CO_2 levels and insect activity by traps or probe and screen samples.

5. Move heated/or infested seeds into another bin if out door temperatures are sufficiently cold to break up hot spots and control infestations.
6. Check the top of binned seeds and remove snow, if present before a crust of mould develops.
7. If an insect infestation occurs and aeration is not available, seal the bin and fumigate the bulk with phosphine gas.

2.5 Insect Pests and Control of Soybean Insect

Soybean can be attacked by pests at any stage from seedlings to close to harvest, but are most attractive from flowering onwards. It is important to note that soybeans are very tolerant of insect damage at many stages of crop development, and that noticeable damage (particularly leaf damage) does not necessarily translate to yield loss.

Soybeans can tolerate up to 33% leaf loss without yield loss but their ability to compensate for pest damage decreases as pods develop. Seeds damaged by pod sucking bugs during early pod fill are often lost at harvest, or are graded out at post harvest, as they are lighter than undamaged seeds. Seeds damaged from mid pod fill onwards are similar in weight to undamaged seeds, not lost at harvest or able to be graded out without resorting to colour sorters. Crops remain susceptible to late bug damage until the pods harden just prior to harvest. As a result, late bug damage is a major factor affecting seed quality (Brier, *et al*., 2008).

Many insects feed on soybean and can threaten yield and quality. However, the frequency and severity of pest damage vary considerably between production areas – even within and between fields and from season to season. Therefore, it is important to inspect plants regularly and base control decisions on established economic thresholds or action levels.

Several insect pests from different orders feed on soybean throughout the season. The most significant pests as noted by Kogan and Turnipseed (1987) and Sinclair, Kogan, McGlamery, (1997) have been highlighted in table 2.

Table 2: Insect Pests of Soybean based on Plant Growth Stage

	EARLY SEASON	MID SEASON	LATE SEASON
North America	**Seedlings** *Delia plutura*	**Defoliators** *Helicoverpa zea* *Heliothis virescens* *Pseudoplusia includes* *Anticarsia gemmatalisL* *Spodoptera spp L C. trifurcata*	***Seed feeders*** *H.zea L,* *Nezera vividula* [H]*,* C.*trifurcata* L *Acrosternum hilare* [H]
	Leaf feeders *Cerotoma trifurcata*	**Leaf feeder** *Tetranychus urticea* [A] **Pholoem *feeders*** *A.glycines* [H]	
South America	**Leaf feeders** *Agrotis spp* [D]	**Defoliators** *P. Incudens* [L] *Spodoptera spp*[L] *Anticarsia aporema* [L] *Cerotoma spp* [C]	**Seed feeders** *Etiella zinckenella* L. *Maruca testulalis* *Laspeyresia fabivora* [D], *N. viridula* [H]. *Piezodorus guildinii* [H] *Euschistus spp* [H]
	Stem and stalk borers *Elasmopalpus lignosellus* [D] seedlings [D].	**Phleom feeders** *Bemisia tabaci* [H]	
Asia	**Seedlings** *D. platura* [D]	**Defoliators** *Heliothis viriplaca* [L] *Matsumuraeses phasoli* [L], *Agrotis ipsilon* [L], *Melanagromyza spp.* [D], *Anomala rufocuprea* [C]	**Seed feeders** *H. viriplaca* [L] *Etiella zinckenella* [L] *Hedylepta indicata* [L], *Piezodorus hybneri* [H], *Dolycoris baccarum* [H], *Riptortus clavatus* [H], *Asphondylia spp* [D]
	Phloem feeders Aphis glycines [H]	Phleom feeders *A. glycines* [H], *Aulacorthum solani* [H]	
	Stem and stalk borers *Melanagromyza spp.* [D]		

Adapted and updated from Sinclair et al 1997.

A, Arachnid; C, Coleoptera (beettes); D, Diptera (fly); H, Hemiptera (aphids and true bugs); L, Lepidoptera (butterflies and moths)

Table 3: Soybean Pests in Nigeria

Plant Part Attacked	Pest	Order and Family
Leaves/stem	*Aspavia armigera* Fab *Coptosoma spp* Grasshoppers *Halydicoris Spp Lagria villosa* Fab *Ootheca mutabilis* Sah 16	***Hemiptera*** *aphididae* ***H****.Pentatomidae* ***H****. Plataspididae* ***Orthoptera*** ***Hemiptera*** *pentatomidae* ***Coleoptera*** *lagrindae* ***Coleoptera*** *chrysomelidae*
Flowers	*Maruca vitrata* Geyer Thrips	***Lepidoptera*** *pyralidae thysanoptera*
Young seedlings	Fowl and other birds (controlled by scaring)	
Pods	*Aerosternum acute* Dellas *Anoplocnemis curvipes Aspavia armigera* Fab *Clavigralla spp. Riptortus dentipes* Fab. *Mirperus jaculus* Thunberg. *Nezara virudule* L. *Prezodorus* sp.	***Hemiptera*** *Pentatomidae Coreidae Pentatomidae Coreidae Aphididae Coreidae Pentatomidae Pentatomidae*
Girdle Beetles	*Tetragonothoras Sp Cynophoras Sp.*	

Arokoyo et al; (1999)

They observed that soybean plant share a wide range of insect pests with cowpea. The types of herbivores that feed on soybean based on their feeding habits are: Defoliators, Phloem feeders, Seed and Pod feeders and Stem borers and Root feeders.

2.5.1 Defoliators

Orthoptera (grasshoppers), *Coleoptera* (beetles) and *Lepidoptera* (moths and butterflies) insect orders are capable of feeding on soybean leaves. These insects typically have biting and chewing mouth parts that either remove leaf area or destroy the leaf surface.

Members of the last two orders have been identified as some of the most significant global soybean pests. The immature (larva caterpillar) stages of *Lepidoptera* participate in leaf feeding. Adult *Lepidoptera* do not have chewing mouthparts. Both the adults and immature stages of *Coleoptera* soybean pests' posses biting and chewing mouthparts and can damage leaves.

Kogan and Turnipseed (1987) identified the following as major or frequent defoliators of soybean: *Helicorpa zea* (Corn earworm), *Heliothis armigera* (America Bollworm), *Heliothis punctigera* (Austrialian bollworm), *Pseudoplusia includens* (soyabean copper) *Anticarsia gemmatalis* (Velvet bean caterpillar and *Spilosoma obliqua* (Bihar hairy caterpillar)

Both adults and immature stages of *Orthoptera* are capable of feeding on soybean leaves. Although grasshoppers often feed on soybean, they rarely reach pest status (DeGroyer and Browder, 1994).

Although some defoliators of leaves show very distinct patterns of feeding (e.g. *S.obliqua*), it is often difficult to determine which species is responsible for loss of leaf tissue.

2.5.2 Phloem Feeders

Insects that feed on phloem are generally found in the order *Hemiptera* and possess piercing and sucking mouthparts that are capable of entering vascular tissues. Both immature (nymph) and adult stages are capable of this feeding. Damage is often not visibly apparent to the same degree as defoliation. Some phloem feeders such as *Spissistilus festinus* (three cornered alfalfa hopper) can girdle the stems of plants, resulting in lodging, this can reduce yields especially if it occurs late in the growing season.

Kogan and Turnipseed (1987) identified *Bemisia tabaci* (sweet-potato whitefly) as a major or frequent phloem feeder of soybean. Within the native range of soybean, three aphid species- *Aulacorthum solani*, *Aphis craccivora* and *Aphis glycines* have been identified as soybean pests. Like most other phloem feeding insects, aphids and white flies excrete honey dew (incompletely digested phloem), which contains a high concentration of sugars. When populations of these insects are large, so much honey dew is excreted that the leaf surface is darkened from the growth of mould growing on this sugary substances. Therefore, in addition to reducing yields by direct feeding in the plant, the buildup of this sooty mould can further reduce photosynthesis (Macedo, Bastos, Highey, Ostilie, Madhavan, 2003). Many phloem feeding insects are efficient vectors for plant viruses (Jones, 2003, Verma and Malathi, 2003) as is *A. glycines* (Clark and Perry, 2002).

The transmission of plant viruses can occur via insects that are transients within a soybean field (Perring, Gruenhagen, Farvar, 1999, Pedersen, Gran, Cullen, Hill, 2007).

2.5.3 Seed and Pod Feeders

Pod and seed feeders also cause yield loss in soybean. Many of order of insects (*Coleoptera*, *Lepidoptera*) and species (*H. armigera*, *H.zea*, *C. trifurcata*) that feed on foliage also feed on pods during the immature stages (*Etiella zinckenella*) causing moderate yield loss (Van den Berg *et al*; 1988a). The most widespread pests of soybean during the later growth stages are *Hemipterans* specifically the pentato mid stinkbugs (Kogan and Turnipsed, 1987) such as *Nezara viridula* and *Piezodorous guildinii*. The most ubiquitous and possibly damaging is *N. viridula*, which is found in all soybean producing areas of the world.

2.5.4 Stem Borers and Root Feeders

As with the seed and pod feeding habits, many of the same orders of insects (*Coleoptera*, *Lepidoptera*, *Diptera*) that feed on foliage also feed on stems within Asia. Members of the leaf-miner fly family (Agromyzids, specifically the genus melanagromyza) are thought to have a co-evoloved relationship with soybean (Chiang and Norris 1983). Stem-boring flies can interfere with growth (Talekar, 1989) but this damage does not often result in yield loss (Van den Berg, Shephard, Nasikin, 1998b). In general the damage observed by growers to stem feeding maybe at harvest when the weakened stems are prone to falling, often referred to as lodging, making harvest difficult. There are few known Soybean obligate root feeders. Several generalist root herbivores, including various species of grubs (*Scarabaeidae* species), Wireworms (*Elateridae species*) and the seed corn maggot (*Delia platura*), have been reported to cause stand loss (Turnipseed and Kogan, 1976, Hammond,1995), especially when soybean is planted in high resistance situations (mature hey stands, some no-till fields and following cover crops). The larval stage of *C. trifurcata* (bean leaf beetle) have been recorded feeding on the roots of soybean (Pedigo, 1994), although the impact of this feeding is not considered to be great.

2.6 Diseases of Soybean

More than 300 species of pathogens attack soybean worldwide, although relatively few cause significant economic damage (Hartman, Sinclair, Rope, 1999). Parasitic

Micro-organisms such as bacteria, fungi, nematodes, stramenopiles and viruses are responsible for the most economically important soybean diseases.

In 1994, the estimated worldwide loss due to soybean diseases was 11% (Hartman, Sinclair, Rope, 1999). From 2001 to 2003, the estimate jumped to 23%, 11% due to plant parasitic bacteria and fungi, 1% to viruses and 11% to animal pest including plant parasitic nematodes (Oerke, 2006). Some early season diseases of soybean are;

Seed Decay: Seed decay in soybean is primarily caused by *Phomopsis longicolla* (Hartman *et al*, 1999), although soft-rotting bacteria, including *Bacillus subtilis* and other fungi in the *Diaporthe-phomopsis* complex of species may also be involved to a lesser extent (Hartman *et al*, 1999). Symptoms of decay caused by *P. longicolla* are shrivelled, cracked, elongated seeds with a white, chalky appearance; however, sometimes no visible seed symptoms are observed. Infected seeds are slow to germinate or may not germinate at all.

Seedling Diseases: The emergence of soybean plants from seeds that have survived seed decay pathogens normally takes about 5-10 days depending on the temperature, moisture, planting depth and cultivar genetics. The seedling radicles, or primary roots, may be attacked by fungal pathogens soon after seed germination. Radical infections may spread up through the hypocotyls and attack the cotyledoms. As emergence continues, lateral roots begin to grow from the radicles. Root hairs appear and provide key nutrients and water absorbing functions and the taproot continues to grow and branch. Root hairs are particularly vulnerable to attack from soil-borne pathogens. Loss of both cotyledons at or soon after emergence of soybean seedlings will reduce yield infection that occurs at this stage can result in pre and post-emergence death of the seedlings or damping off or the pathogens remains latent with symptoms developing later in the growing season. *Rhizoctonia solani* and *Pythium species* are soil-borne fungi and the most common pathogens causing damping off of soybean seedlings.

Phytophthora Root and Stem Rot: *P. sojae* attacks soybean at any growth stage, but it is most damaging early in the season when it attacks emerging seedlings and rots the roots of young soybean plants (Hartman *et al*, 1999). Soybean plants surviving damping off may succumb to *P. sojae* root infection, which can cause wilting, stunting and death of infected plants.

Diseases mainly associated with soybean at mid-season are:

Bacterial pustule: it is distributed worldwide and is most important in tropical and subtropical regions. The cause of bacterial pustule is *Xanthomonas axonopodis* Pv. Glycines a Gram negative, rod-shaped bacterium with a single polar flagellum. (Hartman *et al*, 1999). The diagnostic symptom of bacterial pustule is the presence of pustules, which are minute pale-green spots with elevated centers usually on the abaxial surface of leaves, formed through hypertrophy and hyperplasia, when foliage is covered with pustules, premature defoliation can occur, reducing yields by reducing seed size and quantity.

Viral Diseases: As temperature increase in temperate regions, insects become active including insect vectors of important soybean viruses. The bean leaf beetle, *Cerotoma trifurcate*, is the primary vector of Bean pod mottle virus (BPMV) while aphids including the soybean aphid *Aphis glycines*, are vectors of soybean mosaic virus (SMV) (Hartman *et al*, 2001)

Other mid-season diseases are Bean pod mottle, Soybean Mosaic, Sclerotinia stem rot, Frogeye leaf spot and Soybean rust.

In the late-season of soybean which is typified by rapid pod growth and the beginning of seed development, diseases such as Soybean cyst, stem canker, Sudden death syndrome, Cercospora leaf blight, Anthracnose and charcoal root can cause stress which causes a greater yield reduction than at any other time, mainly result to fewer pods.

2.7 Neem Tree (*Azadirachta indica.* A. Juss)

The neem tree belong the family Maliaceae. The tree is an attractive broad leaved evergreen which can grow up to 30m tall with spreading branches covering 10m across. Its seeds consist of a shell and 1-3 kanels which contain azadirachtin and its homologues. Both the bark and leaves also contain biologically active molecules (Allan, Stuckbury and Mordue, 1999).

The tree is grown in most tropical and sub-tropical areas of the world for shade, for reforestation programmes and in plantations for the production of compound which have toxic, anti-feedant and repellant properties against insects.

The natural chemical called azadirachtin which is found in all parts of the tree has been known to be effective against more than 200 insect species, such as some mites, nematodes, fungi, bacteria and virus. Neem extracts do not usually kill insect pests immediately. They change the feeding or life cycle of the insect until it is no longer able to live or produce new ones. Other insects will however avoid a plant treated with neem extracts. Several neem constituents are used for insect and pest control of some nematicidal, bactericidal, fungicidal and pests like leaf miners, aphids and thrips (Marcello, Oliviero, Tiziana, Susanna & Fabio, (2012)

Neem based pesticides are suitable for use in developing countries because the useful chemicals can be easily removed from the neem without the use of expensive and complicated equipment. Neem leaves are effective and can be easily sourced for.

2.8 The Use of Neem Extracts in Insect Pest Control

Extracts of neem containing azadirachtin together with several structurally related molecules have formed the basis of neem usage in insect control (Isman, 1997). Neem insecticides are effective mainly as insect growth regulates and sterilants, against a broad spectrum of pest insects.

Neem pesticides may also have a useful role to play in resistance management. It has been demonstrated that the effects of neem in reducing levels of detoxification enzymes (due to its blockage of protein synthesis) may make insecticides more effective in resistant strains of insect (Lowery and Smile, 2000).

In Nigeria neem has been reported to protect many crops, it protected cowpea against the post harvest grain pests *Callosobruchus maculatus* (Ivbijaro, 1983; Sowunmi and Akinnusi, 1983). Jackai, 1993 reported on how local cowpea growers used aqueous extracts to ward off grasshoppers from their crops during the dry season in some parts of Borno state, in North East Nigeria.

Emosairue *et al*. (1996) studied the effects of different concentrations of neem kernel extracts on *Podagrica spp* in Calabar where he observed that the use of neem products was promising as an alternative to synthetic pesticides in controlling Okra flee beetles in the area. It was also observed in another study by Emosairue and Ubana, 1996 that neem significantly reduced the pod and seed damages caused by *Maruca testulalis* in a field evaluation of neem for the control of some cowpea insect pests in South East Nigeria.

Other findings where neem extracts has been used against rice pests in Asia (Saxena, 1989), Cassava in West Africa (Olaifa and Adenuga, 1988), Cowpea (Cobbinah and Osei-Owusu, 1988; Oparaeke, 2004; 2006) had positive results.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Location

Two field experiments were conducted in July for early season and October 2012 for late season at the Department of Agronomy Teaching and Research Farm of the Delta State University, Asaba campus Anwai.

Asaba is located at Latitude 6^0 $14^{'}$N and Longitude 6^0 $49^{'}$E, which lies in the typical rainforest zone with a hot humid climate and Bimodal rainfall pattern. Rainy Season is between April and October with a mean annual rainfall of 1500mm to 2000mm with peak rainfall July to September, The mean temperature is 23.3^{0c} with a maximum temperature of 37^{0c}. The mean monthly soil temperature at 100cm depth is 28.3^{0c}; Mean relative humidity is 77.2% and a monthly sunshine of 4.8bars. (Federal Ministry of Aviation Meteorological Station Asaba, 2003).

3.2 Experimental Design/Planting Material

The experiments were laid out in a pre-fallowed piece of land in a randomized complete block design (RCBD) with three replicates.

Each plot measured 4.5m by 0.5m and was separated by a 1m path. The planting material was TGX 1987-91F Soybean variety obtained from the International Institute of Tropical Agriculture, Ibadan. The variety is a medium maturity variety. Seeds were sown at a depth of 2.5cm at a recommended plant spacing of 75cm x 10cm. Two seeds per stand were planted and later thinned down to 1 plant per stand leaving a plant population of 20 plants per plot.

Application of neem extracts commenced one month after planting and continued weekly till first harvest. Neem extacts were applied early in the morning between the hours of 6.30am to 7.30am on a sunny day using a knapsack sprayer, spraying all plants parts to runoff.

3.3 Treatments and Application Treatments

1. Untreated (Control)
2. 5%Concentration of Cold Neem Leaf Extract (CNE)
3. 10% Concentration of Cold Neem Leaf Extract(CNE)
4. 15% Concentration of Cold Neem Leaf Extract(CNE)
5. 20% Concentration of Cold Neem Leaf Extract(CNE)
6. 5% Concentration of Hot Neem Leaf Extract(HNE)
7. 10% Concentration of Hot Neem Leaf Extract(HNE)
8. 15% Concentration of Hot Neem Leaf Extract(HNE)
9. 20% Concentration of Hot Neem Leaf Extract(HNE)

3.4 Preparation of Cold and Hot Neem Leaf Extract

Fresh leaves of neem were collected and dried at room temperature in the Department of Agronomy Laboratory in Delta State University. The dried leaves were ground with grinding machine to powder.

The powdered neem leaves were measured and weighed with an electronic weight into the following;

50g for 5%

100g for 10%

150 for 15%

200g for 20%

The 5% cold neem extract was prepared by soaking 50g of powder paste in one litre of cold distilled water for 24hours before filtering through a clean muslin cloth. Additional water was added to make up one litre of filtrate**.**

$$\frac{50g}{1000ml} \times \frac{100}{1} = 5\%$$

For 5% hot, neem leaf extract concentration, powdered paste was soaked in one litre hot (100^{o}C) water and was poured over the powder and left for 24 hours. The same process was used to obtain 10% concentration, 15% concentration and 20% concentration.

$$\frac{100g}{1000ml} \times \frac{100}{1} = 10\%$$

$$\frac{150g}{1000ml} \times \frac{100}{1} = 15\%$$

$$\frac{200g}{1000ml} \times \frac{100}{1} = 20\%$$

3.5 Land Preparation

A fallowed piece of land was mapped out at the Research farm of the Department of Agronomy, Delta State University Abraka, Asaba Campus, during the early and late planting season of 2012. The land was manually cleared, tilled and measured with tape and divided into three replicates with 1.0m pathways between replications using pegs. The replicates were further divided into 9 plots of 4.5m by 0.5m each with a 1m pathway between plots.

3.6 Cultural Practices

Weeding was done twice, at second and sixth week after planting. The used land had been left fallow for 3-4 years.

3.7 Data Collection and Statistical Analysis

Data on insect pests were collected starting from 4 weeks after planting (4WAP), running through the vegetative phase till harvest. Insect collection started a day before the first day of spraying treatments. Insects were collected during the early hours of the morning when they were less mobile with a sweep net and put into an insect box. The collected insects were counted and recorded according to the plots where they were collected from. They were later subjected to identification and classification.

The identification of the specimens was confirmed by the use of Soybean Insects Guide, Handbook of Soybean Insect Pests by Highley and Doethel, (1994). The relative abundance of each insect species collected from the experiment was calculated using the formula as suggested by Levings and Window, (1984).

$$\text{Relative abundance (\%)} = \frac{\text{Total number of each species}}{\text{Total number of all species}} \times \frac{100}{1}$$

Data on Yield and Yield Related Parameters

- **Plant height at harvest-** A total of 6 plants from the middle rows were selected and heights measured with metre rule starting from base of each plant to the tip of the plant before harvest and values from each measurement recorded.
- **Pods and grain yield-** The pods from each of the sampled plants were harvested at 100% maturity, the pods and grains yield per plants in each plots were counted and recorded accordingly.
- **Number of seeds per pods-** The number of seeds per pods was counted from 20 pods per plots selected at random. Each pod was threshed and seeds recorded. The mean value from each plot was recorded.
- **Number of undamaged seeds-** The total number of undamaged seeds was counted.
- **Number of damaged seeds-** The total number of damaged seeds was separated from the undamaged seeds and then counted.
- **100 seed weigh (g) -** After threshing, 100 seeds per plot was also collected at random and weighed using a sensitive top loading balance and weight recorded.

3.9 Statistical Analysis

Data collected on insects were subjected to simple percentage prevalence calculation and T - test, while yield data were subjected to analysis of variance and treatment means separated using Duncan Multiple Range Test (DMRT) at 5% Level of significance.

CHAPTER FOUR

RESULTS

4.1 Insect Species Associated with Early Maturing Soybean in Asaba

A total number of 13 insect species of Soybean were collected and identified during the early season and 9 in late season in this study. These insect species belong to five (5) different families of: *Coleoptera, Lepidoptera*, *Hemiptera*, *Orthoptera* and *Diptera.* The most prevalent six (6) insect species in both early and late season were noted as major pests associated with Soybean in Asaba.

Table 4 shows the identified insects, their orders, scientific names, families, planting season in which they occurred and plant part attacked. The *Coleopterans* were the most predominant insect pest, followed by the *Lepidoptera, Hemipteran* with *Dipteran* having the least occurrence.

In the early planting season, the major insect pests collected were *Psuedoplusia includens*, *Hypena scabra*, *Cerotoma trifurcate, Colaspis brunnea, Odontota hor*ni, *and Podagrica fuscicornis*. While those from the late planting were *Psuedoplusia includens, Anticarsia gemmatalis, Cerotoma trifurcata, Colaspis brunnea, Odontota horni and Podagrica fuscicornis.*

Fig 1 is a bar chart showing the population response of insect order to early and late season planting. It was observed that both early and late season planting had equal numbers of insect in the *Lepidoptera* order while a higher number of *Hemiptera* were collected in the early season planting. Both the *Coleoptera* and *Orthoptera* orders also had higher number of insects in the early season planting. Insects of the *Diptera* order were found only in the early season planting. The *Coleoptera* had more insect population in both season planting.

Table 4; Identification and Categorization of Collected Insect Pests of Soybean in Asaba

Insect order	Scientific names of species	Season	Status	Insect family	Parts attacked
Lepidoptera	*Psuedoplusia includens*	Early & Late	Major	Nactuidae	Leaves
Lepidoptera	*Anticarsia gemmatalis*	Early & Late	Major	Erebidae	Leaves
Lepidoptera	*Hypena scabra*	Early & Late	Major	Erebidae	Leaves
Hemiptera	*Acrosternum hilare*	Early	minor	Pentatomidae	Pods/Seeds
Hemiptera	*Euschistus servus*	Early & Late	minor	Pentatomidae	Pods/Seeds
Coleoptera	*Cerotoma trifurcata*	Early & Late	Major	Caccinellidae	Leaves
Coleoptera	*Colaspis brunnea*	Early & Late	Major	Chrysomelidae	Leaves
Coleoptera	*Odontota horni*	Early & Late	Major	Chrysomelidae	Leaves
Coleoptera	*Apion begnignum*	Early	minor	Apionidae	Leaves
Coleoptera	*Podagrica fuscicornis*	Early & Late	Major	Chrysomelidae	Leaves
Diptera	*Delia platura*	Early	minor	Anthomylidae	Pods/Seeds
Orthoptera	*Melanoplus differentialis*	Early	minor	Acrididae	Leaves
Orthoptera	*Melanoplus femurrubrum*	Early & Late	minor	Acrididae	Leaves

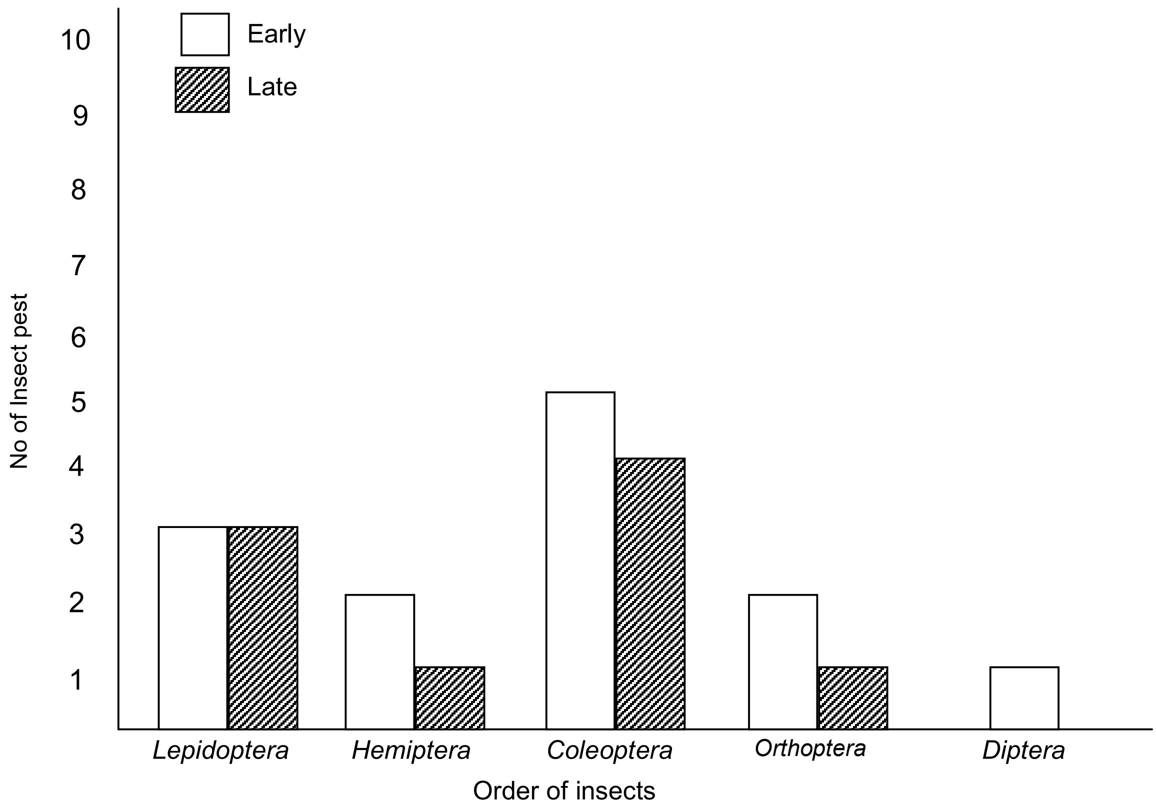

Fig 1: Population response of insect order to early and late season planting.

a, b; Means followed by the same letters are not significantly different at 5% level significance using DMRT.

4.2 Description of Types of Damage on Soybean by Insect Pests

Soybean is associated with numerous kinds of insects. These insects belong to different orders. In the course of this study, insect pests that belong to the *Coleoptera*, *Lepidoptera*, *Hemiptera*, *Orthoptera* and *Diptera* are the major orders where insect pests were found. Soybean insect pests feed on foliage, pods and stems.

The foliage feeders were present in the field throughout the growing seasons. These insects typically have biting and chewing mouth parts that either remove leaf area or destroy the leaf structure.

The *Coleoptera* (beetles) and *Lepidoptera* (moths and butterflies) orders were significant. The type of damage caused was feeding on foliage, thereby making holes in the leaves. *Cerotoma trifurcata* and *Podagrica fuscicornis* which were very prominent created rounded holes in the leaves. *Psueudoplusia includens* created large holes in the leaves and others with similar characteristics are larvae and beetles. The Grasshoppers (*Orthoptera*) are occasional visitors that strip plants off their leaves but damage is often not alarming.

Seed and Pod feeders of soybean are mainly of the order *Hemiptera* and pest of the orders of *Coleoptera* and *Lepidoptera*. They suck the juice from immature soybean seeds and cause pod drop and yield loss. It was observed that the *Hemipterans*, *Acrosternum hilare* and *Euschistus serves* were prominent at this stage. This is in line with the findings of Kogan and Turnipseed (1987).

Loss from stem feeding (Stem Feeders) insects was relatively low and hardly noticeable. It was noticed that damaged plants were severely stunted.

4.3 Effect of Cold and Hot Neem Leaf Extract Concentrations on Insect Pests of Soybean in Asaba

It was observed that in both early and late season planting, the control plots had more number of insects when compared with the various plots of Neem Extracts. A total number of 51 and 66 insects were collected respectively in the control plots. Table 5 which showed the effect of cold and hot neem extract at different concentrations in the early season planting indicated that *Cerotoma trifurcata* and *Podagrica fuscicornis* were the most predominant, having 18 insects each with percentage prevalence of 35.3 under the control plot, and 10 insect each with 27.8% prevalence under 5%CNE. It was also observed that *Podagrica fuscicornis* showed more resistance to the various Cold Neem Extracts, having the highest percentage population abundance of 18(35.5%) in the control plot, 10(27.8%) in 5%CNE, 9(34.6%) in 10%CNE, 11(37.9%) in 15%CNE, and 7(29.1%) in 20% CNE, as shown in Table 5.

Table 5 also shows the effect of Hot Neem Leaf Extract concentrations on the identified insects. It was observed that *Cerotoma trifurcata* showed more resistance to the hot neem extracts, under 5%HNE it had 10 insects at 26.9% and 8 insects at 33.3% for both 10% and 15%HNE respectively.

Among Cold and Hot Neem Extract concentrations, the hot neem concentrations controlled the insect pests of the Soybean more effectively than the Cold neem extracts. In Table 5, the numbers of insects collected under Cold Extracts were 115, while that of Hot Extracts was 98, although when the data on insect collection was subjected to a T-test, there were no significance between cold and hot neem extract. The decision on performance of cold and hot was based on the percentage prevalence calculation.

Hypena scabra had the least occurrence in the early season while *Antacarsia gemmatalis* had the least occurrence in the late season planting. It was also observed that higher concentration levels in both Cold and Hot Neem Extracts showed better ability in controlling the insect pests of Soybean. Tables 5 also showed how insect pest population reduced from 36 insects in 5% CNE to 24 insects in 20%CNE, and in Hot Neem Leaf Extract it reduced from 30 insects in 5%HNE to 18 insects in 20%HNE.

Fig 2, is a bar chart showing the population response of insect pests to treatment with cold and hot neem extract concentrations in early season planting. From the bar chart, it could be seen that the control plot had the highest number of insect pests, followed by 5% cold and hot extract. 10% cold and hot extract concentration had the same number. The least insect population was recorded under 20% concentration with the hot extract having a lower number in the early season planting.

Table 5: Effect of Cold and Hot Neem Leaf Extracts on the Percentage Prevalence of some Major Insect Pests of Soybean (*Glycine max*) during 2012 Early Season Planting in Asaba

Neem Extracts	Insect Species	No. of insects	Prevalence (%)	No. of insects	Prevalence (%)
CONTROL	*Cerotoma trifurcata*	18.0	35.3	18.0	35.3
	Colaspis brunnea	5.0	9. 9	5.0	9. 9
	Odontota horni	6.0	11.8	6.0	11.8
	Podagrica furcicornis	18.0	35.3	18.0	35.3
	Pseudoplusia includens	1.0	2.0	1.0	2.0
	Hypena scabra	3.0	5.9	3.0	5.9
	Sub Total	**51.0**		**51.0**	
		COLD		**HOT**	
5%	*Cerotoma trifurcata*	10.0	27.8	10.0	33.3
	Colaspis brunnea	3.0	8.3	1.0	3.3
	Odontota horni	6.0	16.7	8.0	26.7
	Podagrica furcicornis	10.0	27.8	8.0	26.7
	Pseudoplusia includens	5.0	13.9	2.0	6.7
	Hypena scabra	2.0	5.6	1.0	3.3
	Sub Total	**36.0**		**30.0**	
10%	*Cerotoma trifurcata*	6.0	23.1	7.0	26.9
	Colaspis brunnea	2.0	7.7	5.0	19.2
	Odontota horni	3.0	11.5	6.0	23.1
	Podagrica furcicornis	9.0	34.6	6.0	23.1
	Pseudoplusia includens	3.0	11.5	1.0	3.8
	Hypena scabra	3.0	11.5	1.0	3.8
	Sub Total	**26.0**		**26.0**	
15%	*Cerotoma trifurcata*	8.0	27.6	8.0	33.3
	Colaspis brunnea	2.0	6.9	2.0	8.3
	Odontota horni	4.0	13.8	1.0	4.2
	Podagrica furcicornis	11.0	37.9	11.0	45.8
	Pseudoplusia includens	2.0	6.9	1.0	4.2
	Hypena scabra	2.0	6.9	1.0	4.2
	Sub Total	**29.0**		**24.0**	
20%	*Cerotoma trifurcata*	10.0	41.7	4.0	22.2
	Colaspis brunnea	3.0	12.5	1.0	5.6
	Odontota horni	3.0	12.5	2.0	11.1
	Podagrica furcicornis	7.0	29.1	4.0	22.2
	Pseudoplusia includens	1.0	4.1	5.0	27.8
	Hypena scabra	-	-	2.0	11.1
	Sub Total	**24.0**		**18.0**	
	Total	**Cold 115**		**Hot 98**	
	Grand Total			**51 + 115 + 98 = 264**	

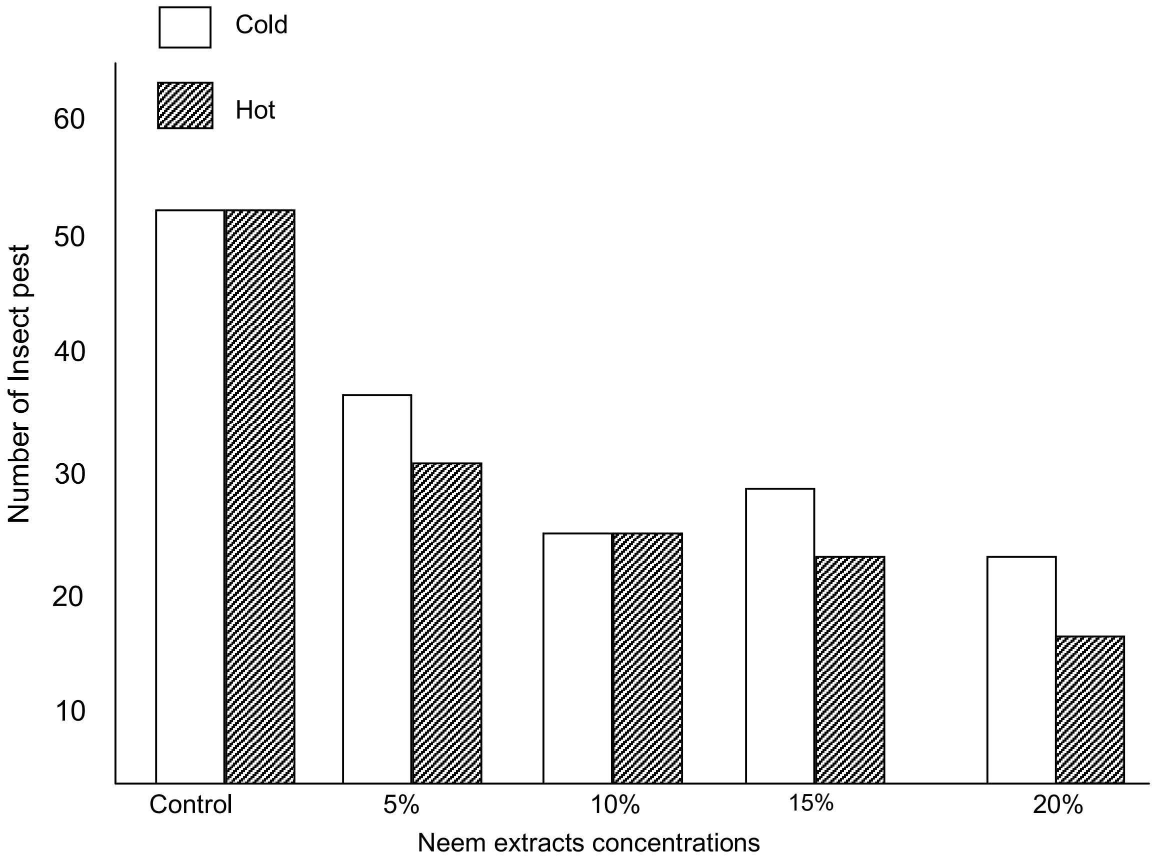

Fig 2: Population response of insect pests to treatment with cold and hot neem extracts concentration in early planting

a, b; Means followed by the same letters are not significantly different at 5% level significance using DMRT.

TABLE 6: Effect of Cold and Hot Neem Leaf Extracts on the Percentage Prevalence of some major Insect Pests of Soybean (*Glycine max*) during 2012 Late Season Planting in Asaba

Neem Extracts	**Types of Insects**	**No of Insects**	**Prevalence (%)**	**No of Insects**	**Prevalence (%)**
CONTROL	*Cerotoma trifurcata*	20.0	30.3	20.0	30.3
	Colaspis brunnea	17.0	25.8	17.0	25.8
	Odontota horni	14.0	21.2	14.0	21.2
	Podagrica furcicornis	7.0	10.6	7.0	10.6
	Pseudoplusia includens	5.0	7.6	5.0	7.6
	Antacarsia gemmatalis	3.0	4.5	3.0	4.5
	Sub total	**66.0**		**66.0**	
			COLD		**HOT**
5%	*Cerotoma trifurcata*	8.0	17.4	13.0	28.9
	Colaspis brunnea	10.0	21.7	14.0	31.1
	Odontota horni	9.0	19.6	7.0	15.6
	Podagrica furcicornis	9.0	19.6	7.0	15.6
	Pseudoplusia includens	7.0	15.2	3.0	6.7
	Antacarsia gemmatalis	3.0	6.5	1.0	2.2
	Sub total	**46.0**		**45.0**	
10%	*Cerotoma trifurcata*	9.0	34.6	**9.0**	31.0
	Colaspis brunnea	4.0	15.4	6.0	20.7
	Odontota horni	2.0	7.7	7.0	24.1
	Podagrica furcicornis	3.0	11.5	2.0	6.8
	Pseudoplusia includens	4.0	15.4	4.0	13.8
	Antacarsia gemmatalis	4.0	15.4	1.0	3.4
	Sub total	**26.0**		**29.0**	
15%	*Cerotoma trifurcata*	6.0	26.1	4.0	23.5
	Colaspis brunnea	2.0	8.7	2.0	11.8
	Odontota horni	5.0	21.7	0.0	0.0
	Podagrica furcicornis	7.0	30.4	5.0	29.4
	Pseudoplusia includens	1.0	4.3	3.0	17.6
	Antacarsia gemmatalis	2.0	8.7	3.0	17.6
	Sub total	**23.0**		**17.0**	
20%	*Cerotoma trifurcata*	6.0	28.6	3.0	18.8
	Colaspis brunnea	5.0	23.8	5.0	31.3
	Odontota horni	3.0	14.3	3.0	18.8
	Podagrica furcicornis	4.0	19.0	2.0	12.5
	Pseudoplusia includens	1.0	4.8	2.0	12.5
	Antacarsia gemmatalis	2.0	9.5	1.0	6.3
	Sub total	**21.0**		**16.0**	
	Total	**COLD 116**		**HOT 107**	
	GRAND TOTAL			**66 + 116 + 107 = 289**	

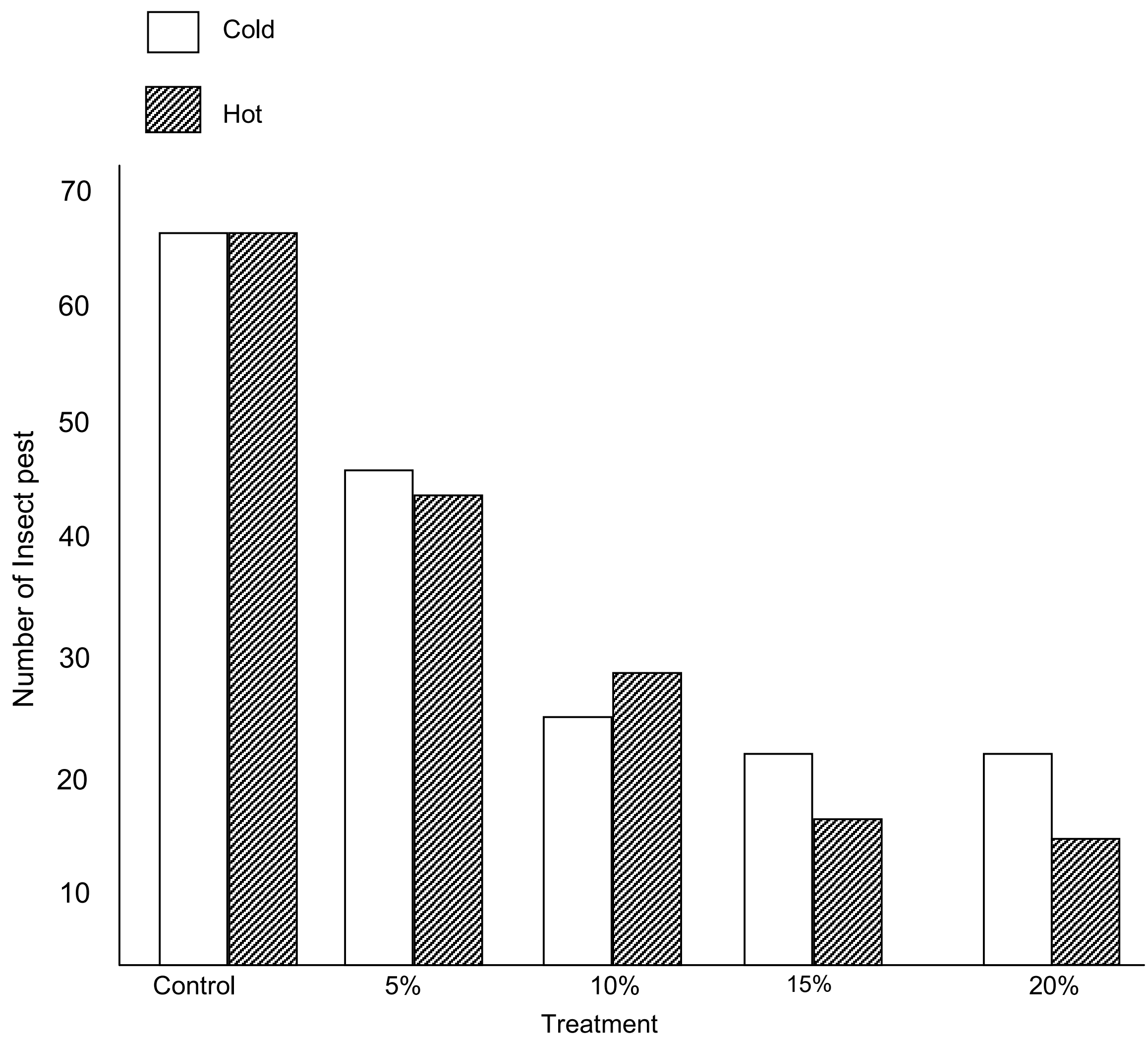

Fig 3: Population response of insect pests to treatment with cold and hot neem extracts concentration in late planting

a, b; Means followed by the same letters are not significantly different at 5% level significance using DMRT.

Table 6 showed the effect of cold and hot neem leaf extract on the percentage prevalence of the major insect pests of soybean during late season planting in Asaba. From the table, *Colaspis brunnea* showed more resistance under 5% cold and hot neem extract concentrations, having 10 insects at 21.7% in cold and 14 insects at 31.1% in hot. At 20% cold and hot the number of insects under *Colaspis brunnea* had reduced to 5 insects each for both cold and hot neem extracts concentrations. Both cold and hot neem extract concentrations were able to reduce the number of insects during the late season planting.

Comparison between Early and Late season planting showed that Insect pest infestation was higher during the late season planting. A total number of 289 insects were collected against only 264 that were collected in the early season. The number of insects found in the untreated plots rose from 51 in the early season to 66 in the late season. Higher concentrations of Neem Extracts were also observed to have had more effect in controlling the insect pests. *Cerotoma trifurcata* and *Colaspis brunnea* were more prominent in the late season planting, having 20 insects (30.3% prevalence) and 17 insects (25.8% prevalence) respectively in the untreated plot. *Antarcarsia gemmatalis* which replaced *Hypena scabra* in the late season as a major insect also showed least prominence. It was also observed that the Hot Neem Extract was more effective in terms of controlling the insect pests of Soybean in the late season planting as also recorded in the early season. A total of 116 insects were collected in the Cold Neem Extracts, while 107 were collected in the Hot Neem Extracts during the late planting season.

Fig 3 is a bar chart showing the population response of insect pests to treatment with cold and hot neem extract concentrations during the late season planting. The control plot had the highest insect population. At 5%, cold extract had a higher number of insect than hot while at 10% concentration the hot extract had higher number of insects. It could be observed that 20% cold and hot neem extract concentration had the least number of insects.

Table 7: Mean Yield and Yield Related Parameters of Soybean after Treatment with Neem leaf extracts during early Planting Season of 2012 in Asaba

Neem Extract Conc.	Plant height at harvest (cm)	Pods/plant	No of seeds per pod	undamaged seeds	damaged seeds	100 seed weight (g)	Seed yield t/ha
O (control)	41.28a	57.56a	2.00a	100.50ab	12.90a	12.70ab	1.40ab
5% Cold NE	41.28a	43.06a	2.00a	64.39c	10.97b	11.00bc	1.10b
10% Cold NE	37.22a	59.67a	2.00a	103.67ab	11.97ab	12.30abc	1.90a
15% Cold NE	43.77a	54.44a	2.00a	80.56c	11.69ab	11.70bc	1.40ab
20% Cold NE	47.83a	52.17a	2.00a	73.67c	12.03ab	12.00abc	1.40ab
5% Hot NE	44.56a	53.00a	2.00a	77.89c	10.70b	10.70b	1.30ab
10% Hot NE	41.39a	54.78a	2.00a	102.67ab	13.40a	13.70a	2.10a
15% Hot NE	40.44a	54.72a	2.00a	76.61c	12.10ab	12.00abc	1.20b
20% Hot NE	40.33a	66.39a	2.00a	113.11a	11.70ab	11.00bc	2.00a

Means followed by the same letters are not significantly different at 5% level significance using Duncan's Multiple Range Test.

Table 8: Mean Yield and Yield Related Parameters of Soybean after Treatment with Neem leaf extracts during late Planting Season of 2012 in Asaba

Neem Extract Concentration	Plant height at harvest (cm)	← pods /plant	No of seeds per pod	undamaged seeds	damaged seeds →	100 seed weight (g)	Seed yield t/ha
O (control)	33.89a	36.83a	2.00a	62.28ab	11.77ab	11.67ab	1.20ab
5% Cold NE	34.83a	23.39a	2.00a	39.33c	10.37bc	10.33b	0.70b
10% Cold NE	32.78a	41.44a	2.00a	67.22ab	11.23abc	11.67ab	1.40a
15% Cold NE	35.33a	35.94a	2.00a	59.83c	10.97abc	11.33ab	1.10ab
20% Cold NE	36.67a	29.69a	2.00a	49.17c	11.30abc	11.33ab	1.00b
5% Hot NE	39.06a	28.72a	2.00a	49.89c	9.90c	10.00b	0.80b
10% Hot NE	36.67a	36.09a	2.00a	65.00ab	12.57a	12.67a	1.30ab
15% Hot NE	35.89a	36.06a	2.00a	65.06ab	11.50abc	11.67ab	1.20ab
20% Hot NE	34.22a	42.94a	2.00a	80.22a	10.27bc	11.33ab	1.40a

Means followed by the same letters are not significantly different at 5% level significance using Duncan's Multiple Range Test.

4.4 Effect of Different Cold and Hot Neem Leaf Extract Concentrations on Yield and Yield Related Parameters of Soybean

The results of yield and yield related parameters of Soybean in response to treatments with Neem Extracts during the early and late plantings are presented in Tables 7 and 8. The two tables showed that the performance of the early planting was better than that of late planting. There were no significant differences ($p > 0.05$) among treatments in terms of Plant height of both early and late plantings. However, it could be observed in Table 7 that 20% CNE had the highest mean plant height at harvest of 47.83cm with 10%CNE having the least mean height of 37.22cm. There were significant differences in the mean number of pods, number of damaged seeds, undamaged seeds, 100 seed weight (g) and seed yield (t/ha) among treatments including the control plots.

20% HNE had the highest mean number of pods yield (66.39). The least mean Number of Pods yield was recorded in 5% CNE (43.06). 10% HNE which had the second highest number of undamaged seeds (102.67) also had the highest number of damaged seeds (13.40) in Table 7; this was followed by the control plot (12.90), while 5%HNE and 5%CNE had the least mean number of damaged seeds of 10.70 and 10.97 respectively. 10%HNE had the highest 100 Seed weight value of 13.7g followed by control plot 12.70g, while 5%HNE had the least mean 100 seed weight of 10.70. 20% HNE,10% HNE and 10% CNE had an average yield of 2.0 t/ha, 5% HNE, 20% CNE, 15% CNE and control plot had average of 1.4 t/ha each with 5% CNE and 15% HNE having the least yield 0f 1.1 t/ha and 1.2 t/ha respectively in the early planting. Table 8, which showed mean yield and yield related parameters of late planting, also had similar trends as in Table 7 but lower figures were recorded showing lower performance except in number of Seeds per Pods, which had a uniform number of 2.

In Table 8, 5% HNE attained the highest plant height of 39.06, followed by 10%HNE and 20%CNE (36.67 and 36.67) respectively. 10%CNE and the control plot had the least plant height, having 32.78 & 33.89 respectively. It was also observed in the late planting that 20%HNE and 10%CNE had the highest number of pod yield (42.94 and 41.44 respectively), while 5%CNE and 5%HNE had the least number of Pods (23.39 and 28.72 respectively). 20%HNE recorded the highest numbers of undamaged seeds (80.22) followed by 10%HNE (77.22), while 5%CNE had the least number of undamaged seeds recording 39.33.

The number of damaged seeds as recorded in Table 8 showed that 5%HNE had the least number (9.90), while 10%HNE had the highest number of damaged seeds (12.57). Results of 100seed weight also showed that 10%HNE had the highest weight of 12.67, while 5%HNE had the lowest weight of 10g. The late planting which recorded lower yield had 20% HNE and 10% CNE having 1.4 t/ha respectively as the highest yield, while the control plot had yield of 1.2 t/ha with 5% CNE and 5% HNE having the least yield of 0.7 and 0.8 t/ha respectively.

CHAPTER FIVE

DISCUSSION

5.1. Identified Insect Pests of Soybean in Asaba

The menace of insect pests in soybean production is a major biological constraint. According to Jakai and Singh (1987), insect pest infestation can cause up to 50 - 60% loss of soybean yield if not controlled. In Calabar, Nigeria Umoetock and Usua, 1997, recorded thirty-two insect pests associated with the crop, they listed eighteen insect pests as the prevalent insect pests of soybean in Calabar. These insects were mainly of the orders; *Hemiptera*, *Coleptera, Orthoptera*, *Lepidoptera*, and *Diptera*, causing damages ranging from leaf defoliation, leaf scarification, sap sucking to pod sucking.

It was observed from the experiment that the soybean crop like most other commonly grown crops in Nigeria are prone to insect pest attack, a moderately high pest load was associated with the crop during the two planting season the study was conducted in Asaba. Insect pests collected and identified were not different from some of the major insects of the orders already associated with the soybean crop as noted by Umuoetok and Usua (1997), Kogan and Turnipseed (1998) and Sinclair *et al* (1997) as could be found in Table 2. Thirteen (13) insect species of soybean were identified in the early planting season of April - July in Asaba, *Coleoptera* (5), *Lepidoptera* (3), *Hemiptera* (2), *Orthoptera* (2) and *Diptera* (1). During the late planting season of August - October, Nine insect species were identified in the orders *Coleoptera* (4), *Lepidoptera* (3), *Hemiptera* (1) and *Orthoptera* (1).

Soybean crop accommodates a lot of larvae of Lepidoptera insects and other insect pests during its vegetative growth stage, some of which were identified as *Psuedoplusia includens*, *Anticarsia gemmatalis*, *Hypena scabra, Acrosternum hilare,* and *Cerotoma trifurcuta which* is in line with the findings of Kogan and Turnipseed (1987), as well as Boethel, (2004) identification of major or frequent defoliators of Soybean. The collected insects where identified and confirmed with the use of Soybean Insect Guide, Handbook of Soybean Insects Pests by Highley and Boethel, 1994. In the early planting, insects identified were *Psuedoplusia includens*, *Anticarsia gemmatalis*, *Hypena scabra*, *Acrosternum hilare*, *Euschistus servus*, *Cerotoma trifurcata, Colaspis brunnea*, *Odontota horni*, *Apion begnignum*, *Podagrica fuscicornis*, *Delia platura*, *Melanoplus differentialis* and *Melanoplus femurrubrum.* While those from the late planting were *Psuedoplusia includens, Anticarsia gemmatalis, Hypena scabra, Euschistus servus, Cerotoma trifurcata, Colaspis brunnea, Odontota hor*ni*, Podagrica fuscicornis, Melanoplus femurrubrum.* The order, family and part attacked by the insects are earlier shown in table 4 above.

5.2. Type of Damages Caused by Insect Pests of Soybean

Soybean insect pests are characterized by various kinds of damages, insect pest's posses biting and chewing mouth parts that either remove leaf area or destroy the leaf surface, some other pest's posses piercing and sucking mouthparts that are capable of entering vascular tissues. The piercing and sucking insect pests girdle the stem of plants which results to lodging, thereby reducing yields. According to Macedo *et al*. (2003), insects like aphids not only reduce yields by direct feeding in the plants but they also excrete honey dew (incompletely digested phloem) which contains a high concentration of sugars that can darkened the leaf surface of crops during large infestation thereby resulting to reduction in photosynthetic ability of crops. Jones (2003) also stated that many insect pests that fed on phloem are efficient vectors for plant viruses.

The order *Coleoptera*, which had more insect pests were observed in all the developmental stages of the Soybean crop. Immature and matured stages of the pests were prominent throughout the experimental period. *Podagrica fuscicornis* and *Cerotoma trifurcata* were the most prominent. The matured stage of *Cerotoma trifurcata* was observed feeding on leaves and pods of Soybean. *Delia platura* found and identified in this study have been reported to cause stand loss by Turnipseed and Kogan (1976) and Hammond (1995). The insect pests were observed feeding on seeds inside the pods.

The *Coleoptera* (beetles), *Lepidoptera* (moths and butterflies) orders were also significant. Their type of damage ranges from eating foliage to making holes in the leaves. *Cerotoma trifurcata* and *Podagrica fuscicornis* which were very prominent eat rounded holes in the leaves. *Psueudoplusia includens* eat large holes in the leaves and others with similar characteristics are caterpillars and beetles. The *Orthoptera* order (grasshoppers) is occasional visitors that strip plants off their leaves but damage is often not prominent. According to DeGooyer and Browde (1994), grasshoppers which are

Orthopteran often feed on soybean but they rarely reach pest status and this was clearly observed in this study.

Seed and Pod feeders of soybean are mainly of the order *Hemipterans* and pests of the same orders of *Coleoptera* and *Lepidoptera*. They suck the juice from immature soybean seeds and cause pod drop and yield loss. It was observed that the *Hemipterans*: *Acrosternum hilare* and *Euschistus serves* were prominent at this stage. This is in line with the findings of Kogan and Turnipseed (1987).

5.3. Effect of Hot and Cold Neem Extracts on Soybean in Asaba.

Neem extracts which contains a phyto-chemical called azadarachtin is known to be an antifeedant, and its derivatives have been reported to provide broad spectrum control over 200 species of phytophagous insects (Ascher, 1993, Xie, Fields, and Isman, 1995, Zenhnder and Warthen, 1998). The prevalent occurrence of Soybean insect pests in this study was grossly reduced by both the cold and hot Neem extracts used in controlling the insect pests. However, the efficacy of hot Neem leaf extracts was significantly higher. According to Amadioha (2000), the advantages and prospects of using extracts of plant origin for pest and diseases management has been emphasized.

Earlier studies had revealed that the diverse effects of azadarachtin on insect pests include feeding deterrence, reproduction disturbance and insect growth regulation (Emosairue and Ukeh, 1996).

The level of infestation of these insects was reduced as the concentration levels of the Neem leaf extracts was increased. The cold neem leaf extracts was characterised with a poignant soured smell that could ordinarily put an individual off, while the hot neem leaf extract was moderately shocking but could show a higher level of efficacy. The predominantly most prevalent insect pests, (*Podagrica fuscicornis* and *Cerotoma trifurcate*) were reduced by both forms neem leaf extracts when compared with the control plots.

Results from percentage prevalence table shows how the various concentration levels of both cold and hot Neem Leaf Extracts were able to control the insect pests of Soybean. Outright killing of pests was not seen. Insects only showed avoidance to treated plots in respect to increased concentration levels which is also in line with earlier studies which revealed that most insects are not able to feed on neem treated products due to phagodeterence or the presence of antinutritional factors (Emosairue and Ukeh; 1996, Schmutterer; 1995, Saxena; 1987, Jakai and Oyediran; 1991, Jakai; 1993).

5.4 Effect of Neem Extract on Yield and Yield Related Parameters of Soybean in Asaba.

The performance of the early season planting was better than that of late planting; this could be as a result of effect of planting dates. Singh (2010) noted that too late sowing of Soybean results in drastic reduction in yield. According to the United States Agency for International Development in its Commercial Crop Production Series on growing early maturing Soybean in the forest zone of Nigeria, planting is from middle of July to the end of July. The actual date of sowing in this study for early season planting was 20th July. It went further to state that a timely sown Soybean crop generally results in higher yields than late sown crops. Higher yields in the timely sown crops may be due to better plant growth and yields attributes, longer maturing duration and higher Agro climatic indices such as growing degree days, heliothermal units and photothermal units. Singh (2010) also associated lower yields in late planted crops to variety of reasons which includes shifting of reproductive phase into less favourable environment (shorter days), lower temperatures and isolation, less availability of soil moisture and shorter growth period. Anyim (2002) noted that soybean crop planted on August had a significant higher incidence of defoliators and stinkbugs than in other planting dates, with soybean planted on July 21st being the least infested. He further stated that seed yield of soybean planted on July 21st were significantly higher than those planted in other dates. This indicates that soybean could be planted in July within the second and third week to reduce the level of yield loss mainly caused by stinkbugs and defoliators. The various yield and yield related parameters examined in this study were comparable with other research work earlier done in Nigeria.

In Adeniyan and Ayoola (2006) and Okonmah (2012), average plant height at harvest is between 40cm to 50cm, depending on variety. The 100 seed weight and seed yield (t/ha) obtained in this study were in the average of 12.00g, and 2.0 t/ha in line with the findings of Adebisi, Kehinde, Salau, Okesola, Porbeni, Esuruoso and Oyekale (2013) and Okonmah (2012). According to USAID Commercial Crop Production Guide Series “Growing Soybeans in Nigeria” with good management, a grain yield of 1 to 2 t/ha is obtainable in Nigeria.

It was observed in this study that yield in the late planting season where significantly lower than that of early planting. The highest yield in the late planting was 1.4 t/ha and this was obtained under 20% hot neem extract and 10% cold neem extract concentrations. 5% cold and 5% hot neem extracts recorded yield as low as 0.7 and 0.8 t/ha respectively. It was also noticed that 10% hot neem extract and the control plot recorded the highest number of damaged seeds in the late season planting. During the early season planting, yield were appreciably higher and comparable with past research findings, while the control had 1.4 t/ha, higher neem extract concentrations recorded 1.9 t/ha at 10% cold neem extract, 2.1 t/ha at 10% hot neem extract and 2.0 t/ha at 20% hot neem extract concentration. 20% hot neem extract had the highest numbers of undamaged seed (113.11) with 5% cold neem extract having the least value of 64.39.

CHAPTER SIX

SUMMARY, CONCLUSION, AND RECOMMENDATION

The study was to identify and classify major insect pests of early maturing Soybean cultivar (TGX 1987-91F) in Asaba, Delta State, and to describe the nature of damage by the insect pests to the crop. The study was also to determine the effects of Cold and Hot Neem Leaf Extracts on the insect pests and its impact on yield and yield related parameters.

A total of 13 insect species from 5 orders and 8 families were identified in the early planting (July) of 2012 while 9 insect species from 4 orders and 4 families were identified in the late planting (October) of 2012. The insects were collected all through the vegetative phase of the plant till harvest. Insects of the orders *Coleoptera* and Lepidoptera were most prominent. *Podagrica fuscicornis* and *Cerotoma trifurcata* (both *Coleoptera*) were the most occurring insects from the percentage prevalence tables.
Insect pest infestation was higher during the late season planting than the early season planting.

The Neem Leaf Extracts was able to control the insect pests of the crop. Higher concentration levels of both Cold and Hot Neem Leaf Extracts were more effective, but 20% Hot Neem Leaf Extract had more effect.

There were no significant differences in the mean yield and yield related parameters of plant height at harvest, number of pods, number of seed per pods and number of undamaged seeds. But there were significant differences in number of damaged seeds and 100 seed weight. Yield of early season planting was better than that of late season planting.

It is therefore recommended that planting of early maturing Soybean be done in late July because this planting period had less pest load when compared with the late planting season of October. Hot and Cold Neem Leaf Extracts significantly controlled Soybean major insect pest population.

This study recommends application of higher concentrations of Neem Leaf Extracts for better results. Thus, application of 20% Hot Neem Leaf Extract is recommended for use, for effective control of Soybean major insect pests in Asaba and that further studies be conducted on concentrations above 20%. Highest yield was also achieved in 20% Hot Neem Leaf Extract application.

Finally, this study recommends that farmers should be encouraged to go into Soybean farming in Asaba as pest infestation is not as predominant as that of other crops like cowpea.

Contributions to Knowledge

This study established that:

i. 13 insect species from 5 orders and 8 families were identified during the early season planting of July 2012 and 9 insect species from 4 orders and 4 families were identified in the late planting season of October 2012, in Asaba, Delta State.

ii. Major insect pests of the crop in the area are;

Cerotoma trifurcata, *Podagrica fuscicornis*, *Odontota horni*, *Psuedoplusia includens*, *Colaspis brunnea* and *Hypena scabra* were the major insect pests of early maturing soybean in the early planting season, while *Cerotoma trifurcata*, *Podagrica fuscicornis*, *Odontota horni*, *Psuedoplusia includes*, *Colaspis brunnea* and *Antacarsia gemmatalis* were the major insect pests of the crop in the late planting season. Hence efforts are needed to observe and control these insect pests for maximum yield in cultivating Soybean in Asaba area of Delta State.

iii. Pest infestation was higher in the late season planting of October than in the early season planting of July.

iv. 20% Hot Neem Leaf Extracts was more effective than other extracts used. It showed better result in terms of insect pest control and yield.

v. Early planting of July had better yield that late planting of October.

REFERENCES

Adebisi, M.A., Kehinde, T.O., Salau, A.W., Okesola, L.A., Porbeni, J.B.O., Esuruoso, A.O. & Oyekale, K.O. (2013). Influence of Different Seed Size Fractions on Seed Germination, Seedling Emergence and Seed Yield Characters in Tropical Soybean (*Glycine max* L. Merrill)

Adekunle,A.A., Fatumbi, A.O., Asiwe, J.A.N., & Abikoye, J.O. (2005)Growing Soybean Commercially in Nigeria. *International Institute for Tropical Agriculture (IITA)* ISBN 975-131-254-816 Pp.

Adeniyan, O.N., and Ayoola, O.T. (2006). Growth and Yield performance of some improved Soybean varieties as influenced by intercropping with maize and cassava in two contrasting locations in Southwest Nigeria. *African journal of Biotechnology* Vol. 5(20), pp. 1886-1889.

Allan, E. J., Stuckbum, T. and Mordue, A. J. (Luntz) (1999). *Azadirachta indica* A. Juss (Neem Tree): In vitro culture, micropropagation and the production of *Azadirachtin* and other secondary metabolites. *Biotec. Agric. For*. 43: 11 – 41.

Anyim, A. (2002). Effect of Planting Dates on the Yield and Control of Major Insect Pests of Soybean in Southern Nigeria. *International Journal of Agricultural and Rural Development* (IJARD Vol. 3 2002: 121 – 126)

Arokoyo, T.J., Onyibe, J.E., Olowoniyan, F., & Chindo, H.J. (1999). Soybean Production and Utilization in Nigeria. *Extensive Bulletin* No. 68, Federal Department of Agriculture, Abuja.

Ascher, K.R.S. (1993). Nonconventional Insecticidal Effects of Pesticides Available from the Neem tree, *Azadirachta indica*. *Arch. Insect Biochem. Physiol*.22;433-449.

Bhatia, H.P., Patel, D.P & Kale, R.K (1983). Catalogue on Soybean. Genetic Resources. National Bureau of Plant Genetic Resources Regional Station, Akola, India.

Boethel, D.J. (2004). Integrated Management of Soybean Insects. In Boerma, H.R. and Specht, J.E (eds) Soybeans: Improvement, Production, and Uses, 3rd Edn. *Agronomy Monograph 16*. American Society of Agronomy, Crop Sciences Society of America, and Soil Sciences Society of America, Madison, Wi, USA, pp 833-882.

Carlson, J.B and Lersten, N.R. (2004). Reproductive Morphology In: Boerma, H.R. and Specht, J.E. (eds) Soybeans: Improvement, Production and Uses, 3rd Edn. *Agronomy Monography 16*. American Society of Agronomy, Crop Sciences

Society of America and Soil Science Society of America, ; Madison, Wi, USA, Pp 59-95.

Chang, R.Z. (1989). Studies on the Origin of Cultivated Soybean *Oil Crop of China* 1:1-6.

Chauhan, G.S and Joshi, O.P. (2005). Soybean (*Glycine max*)- the 21st centaury crop. *Indian Journal of Agricultural Sciences* 75, 461-469.

Chhokar, R.S., Balyan, R.S. and Pahuja, S.S. (1997). Nutrients Removal by Weeds in Soybean (*Glycine max*) Under Integrated Weed Management. *Indian Journal of Agronomy* 42, 138-141.

Chiang, H.S. and Norris, D.M. (1983). Physiological and Anatomical Stem Parameters of Soybean Resistance of Agromyzid Beanflies. *Entomologia experimetalis et Applicata* 33, 203-212.

Christmas, E.P (2008). Plant Populations and Seeding Rates for Soybeans. *Agronomy Guide*, Pardae University, Cooperative Extension Service, West Lafayette, Indiana.

Clark, A.J. and Perry, K.L. (2002). Transmissibility of Field Isolates of Soybean Viruses by *Aphis glycines*. *Plant Disease* 86, 1219-1222.

DeGooyer, T.A., and Browder, J.A. (1994). Grasshoppers in Highleys, L.G. and Boethel, D.J. (eds) Handbook of Soybean Insect Pests. *Enthomological Society of America*, Lanham, MD, USA, Pp. 57-59.

Diebert, E.J., Jeriego, M.D and Olson, R.A (1979). Utilization of 15N Fertilizer by Nodulating and Non-Nodulating Soybean Isolines. *Agronomy Journal* 71, 717-723.

Emosairue, S.O., and Ukeh, D.A. (1996). Field Trials of Neem Products for the Control of Okra Flea Beetles, (*Podagrica spp*) in South Eastern Nigeria, *African J. Plant Protection* 6, 27-33.

Englesham, A.R.J., Hassouna, S. and Seegers, R. (1983). Fertilizer N Effects on N2 fixation by Cowpea and Soybean. *Agronomy Journal* 75, 61-66

Fageria, N.K, Baligor, V.C and Jones, C.A. (1991). Growth and Mineral Nutrition of Field Crops. Marcel Dekkar, Inc. New York, USA.

FAO (2009). FAOSTT Food and Agriculture Organization of the United Nations, Rome. Italy http//faostatfao.org.

Fukuda, Y. (1933). Cytogenetical Studies on the Wild and Cultivated Manchurian Soybeans (Glycine L.) *Japanese Journal of Botany* 6, 489-506.

Guard, A.T. (1931). Development of Floral Organs of the Soybean. *Botanical Gazette* 91,97-102.

Guo, W.I. (1993). The History of Soybean Cultivation. Hehai University Press, Nanying, China.

Hajare, T.N., Mandal, D.K. and Challa, O. (2003). Influence of Rainfall on Productivity of Soybean-Saf-Flower Cropping Sequence in Dry Subhumid Condition of Viderbha. *Journal of Maharashtra*. Agricultural University, 28, 89-90.

Hamada, Y., Shaku, I., Sawada, Y. and Kojima, H. (2007). Factors Causing Submergence Damage on Soybean Seedling Emergence Under No-till Culture. *Japanese Journal of Crop science* 76, 212-218.

Hammond, R.B. (1995). Timing of Ploughing and Planting Effects on Seedcorn Maggot populations in Soybean. *Crop Protection* 14,471-477.

Hartman, G.L., Sinclair, J.B., and Rupe, J.C. (1999). Compendium of Soybean Diseases, 4th edn. American Phytopathological Society Press, St Paul MN, USA.

Highley, L.G.and Boethel, D.J. (1994). Soybean Insect Guide "Handbook of Soybean Insect Pests" *Journal of Entomological Society of American.*

Hu, C., Hsoio, C., Huang, S., Fu, S., Hang, T., Chen, H. and Lu, F. (2004). Antioxidant Activity of Fermented soybean Extract. *Journal of Agricultural and Food chemistry* 52. 5735-5739.

Hymowitz, T. (2004). Diversity Within the Perennial *Glycine spp*. In: *Proceedings of World Soybean Research Conference* vii.P. 518-521.

Isman, M. B. (1997). Neem insecticides. *Pest Outlook*: 32 – 38.

Jakai, L.E.N., (1993). The use of Neem in controlling cowpea pests. IITA Research No.7 September, 1993.

Jakai, L.E.N., and Oyediran, O.A. (1991). The Potential of Neem, *Azadirachta indica* for Controlling post flowering pests of cowpea, *Vigna unguiculata* (L.) Walp. 1: The pod borer, *Maruca testulalis* Geyer, Insect Sci. Applc. 12 (1/2/3): 103-109.

Jones, D.R. (2003). Plant Transmitted by White Flies. *European Journal of Plant Pathology* 109, 195-219.

Jones, J.B., Wolf, B. Jr and Mills, H.A. (1991). Plant Analysis Hand Book. Micro-Macro Publishing, Inc., Athens, Greece.

Kogan, M. and Turnipseed, S.G. (1987). Ecology and Management of Soybean Arthropods. *Annual Review of Entomology* 32, 507-538.

Kumudini, S., Pallikondo, P. and Steele, C. (2007). Photo Period and E-genes Directly Influence the Duration of Soybean Reproductive Development. *Crop Science* 47: 1510-1517.

Lersten, N.R. and Carlson, J.B. (2004). Vegetative Morphology In: Boerma, H.R and Specht, J.E, (eds) Soybeans Improvement, Production and Uses, 3rd ed. *Agronomy Monograph* 16. American Society of Agronomy, Crop Sciences Society of America and Soil Science of America, Medison, W. USA, pp. 15-57.

Levings, S.C. and Window, D.M (1985). Litter Anthropods Population in a Tropical Deciduous Forest; Relationship Between Years and Anthrops Groups. *Journal of Animal Ecology*, 8411: 61-68.

Lhuissier, F.G.P., De Ruijter, N.C.A, Sieberer, B.J., Esseling, J.J. and Emons, A.M.C. (2001). Time Course of Cell Biological Events Evoked in Legume Root Hairs by Rhizobium Nod factors. State of the Art. *Annals of Botany* 87, 289-302.

Li, F.S. (1987). Discussion About the Earliest Cultivation Area of Soybean in China. *China seeds* 1,3-4.

Li, F.S. (1994). Study on Origin and Evolution of Soybean. *Soybean Science* 13, 61-66.

Lowcery, D. T. and Smile, M. J. (2000). Toxicity of insecticides to oblique banded leaf roller, christoneura rosaceana, larvae and adults exposed previously to neem seed oil. *Entomol. Exp. Appl.* 95: 201 – 207.

Maas, E.V. (1986). Soil Tolerance of Plants. *Applied Agricultural Research* 1:12-25.

Macedo, T.B., Bastos, C.S., Higley, L.G., Ostilie, K.R. and Madhavan, S. (2003). Photosynthetic Responses of Soybean to Soybean Aphid (*Homoptera aphididae*) Injury. *Journal of Economic Entomology* 96, 188-193.

Marcello, N., Oliviero, M., Tiziana, O., Susanna, M., & Fabio, V. (2012). Neem Tree(*Azadirachta Indica* A. Juss*)* as source of Bioinsecticides, Insecticides-Advances in Integrated Pest Management.

Mclean, E.O. and Brown, J.R. (1984). Crops Responses to Lime in the Midwestern United States In: Adams, F. (ed) Soil Acidity and Liming, 2nd Edition Agronomy Service 12 ASA, CSSA and SSA, Madison USA, P. 167-303.

Oerke, E.C. (2006). Crop Losses to Pests. *Journal of Agricultural Science* 144, 31-43

Okonmah, L.U. (2012). The performance of growth and yield of ten varieties of soybean(Glycine max L Merrill) in two locations of rainforest zones of Delta State. *Global Advanced Research Journal of Biotechnology Vol. 1(1) pp. 001-004*

Parde, S.R., Kamsal, R.T., Jayas, D.S. and White, N. DG. (2002). Mechanical Damage to Soybean Seed during Processing, *Journal of Stored Products Research* 38, 385-394.

PAU (2009). Rackage of Practices for Kharif Crops of Punjabi Punjab Agricultural University, Ludhian India.

Pederson, P. and Laver, J.G. (2003). Soybean; Agronomic Respose to Management system in the Upper Midwest. *Agronomy Journal* 95, 1146-1151.

Pederson, P., Gran, C., Cullen, E and Hill, J. (2007). Potential for Integrated Management of Soybean Virus disease. *Plant Disease* 91, 1255-1259.

Pedigo, L.P (1994). Bean Leaf Beetle. In Higley, L.G. and Boethel D.J. (eds) Handbook of Soybean Insect Pests. *Entomological Society of America, Lanham*, MD, USA, pp57-59.

Perring, T.M., Gruenhagen, N.M. and Farvar, C.A. (1999). Management of Plant Viral Diseases through Chemical Control insect vectors. *Annual Review of Entomology* 44, 457-481.

Piper, C.V. and Morse, W.J. (1923). The Soybean, McGraw Hill, New York, USA.

Reedy, D.D. Sabba Rao, A. and Takkar, P.N. (1999). Phosphate Absorption Behaviour of a Typic Hapluster in Relation to Long Term use of Fertilizer P and Manure under soybean Wheat Nutrition. *Journal of the Indian Society of Soil Sciences* 47:425-430.

Rosolem, C.A. (1980). Mineral Nutrition and Fertilization of Soybean. *Technical Bulletin* 6. Potassium and Phosphate Institute, Piracicaba Brazil.

Saxena, R.C., (1987). Neem seed derivative for management of rice insects pests. A review of recent studies. Pages 81-93: In Natural pesticides from the neem tree and other tropical plants, edited by K. Schmutterer and K. R. S. Ascher. Proceedings 3rd I*nternational neem conference*, 10-15 July 1986, Nairobi Kenya, GTZ Eschborn, Germany.

Schmutterer,H., (1995). The Neem tree. Source of Unique Natural Products for Integrated Pest Management, Medicine, Industry and other purposes. Weinheim, New York, Basel, Cambridge, Tokyo.

Sinclair, J.B., Kogan, M. and McGlamery, M.D. (1997). Guildelines for the Integrated Management of Soybean Pests Research Laboratory Publication No. 2, College of Agricultural Consumer and Environmental Sciences, University of Illinois at Urbana-Champaign Urbana, Il, USA.

Singh, .G. (2010) .The Soybean: Botany, Production and Uses: CAB International Nosworthy way, Wallingfood, Oxfordshire, OX108DE. UK.

Small, H.G., Jr and Ohlrogge, A.J. (1973). Plant Analysis and an Aid in Fertilizing Soybeans and Peanuts. In: Walsh, L.M. and Beaton, J.D (eds0 Soil Testing and plant Analysis, *Soil Science Society of America*, Madison, W1, USA, pp 315-327.

Talekar, N.S. (1989). Characteristics of Melanagromyza Sojae (Diptera, Agromyzidae) Damage in soybean. *Journal of Economic Entomology* 82, 584-588.

Tandan, H.L.S (1989). Secondary and Micronutrients Recommendations for soils and Crops- A Guide Book. Fertilizer Development and Consultation Organisation, New Delh: Indi.

Timmers, A.C.J. (2008). The Role of the Plant Cytoskeleton in the Interaction Between Legumes and Rhizobia. *Journal of Microscopy* 231, 247-256.

Turnipseed, S.G. and Kogan, M. (1976). Soybean Entomology. *Annual review of Entomology* 21, 247-282.

Van den Berg, H., Shephard, B.M and Nasikin (1998b). Response of Soybean to Attack by Stemfly Melanagromyza Sojae in Farmers' Fields in Indonesia. *Journal of Applied Ecology* 35, 514-522.

Varma, A. and Malathi, V.G. (2003). Emerging Geminivirus Problems: A Serious threat to Crop Protection. *Annals of Applied Biology* 142, 145-164.

Verden Berg, H., Shephard, B.M. and Nasikin (1998a). Damage Incidence by *Etiella zinckenella* in Soybean in East Java, Indonesia, *International Journal of Pest Management* 44, 153-159.

Wang .L.Z. (1985). The Origin Evolution and Distribution of Soybean. *Soybean Science* 1,1-6.

Wang, Q.R.; Li S.F., Yang, Z.Y., Zhou, LL., Gao, H., Xu, B.H., Fang, Z.L., Gang, S.L., Gao, J., Wu, Y.M. Cai, M.Y., Shi, W.Y. & Ge, C.H. (2004). The Effects of Soybean Peptides Supplementation on Serum Biomarkers in Distance runners. *Chinese Journal of Sports Medicine* 1.33-37.

Whigham, D.K. (1983). Soybean. In: Productivity of Field Crops under Different Environments. *International Rice Research Institute*, Los Banos, Philippines Pp. 205-225.

White, N.D.G (2001). Protection of Farm-stored Grains Oilseeds and Pulses from Insects, Mites, and Moulds. In white, N.D.G. (ed) Protection of Farm Stored Grains Oil seeds and Pulses from Insects, *Canada Publication 1851* (E) Revised, Cereal Research Centre, Winnipeg, MB, Canada Pp. 5-53.

Xie, Y.S., Fields, P.G. & Isman, M.B. (1995). Repellency and Toxicity of Azadirachtin and Neem Concentrates to three Stored-Product Beetles. *J. Econ. Entomol.* 88; 1024-1031

Yaduraju, N.T. and Mishra, J.S. (2004). Integrated Weed Management in Soybean (*Glycine max* L.) *Jnkvv Research Journal* 38,1-12.

Zehnder, G. & Warthen, J. D. (1988). Feeding Inhibition and Mortality Effects of Neem-Seed Extract on the Colorado Potato Beetle. *J. Econ Entomol*.81: 1040-1044.