RESPONSE OF SOYABEAN (*Glycine max* (L.) Merill) TO INTEGRATED WEED MANAGEMENT IN A FOREST-SAVANNA TRANSITION ECOSYSTEM IN OYO STATE, NIGERIA

BY

Adebare James OGUNJOBI

B.Agric. (UNN), M.Sc. (Ibadan)

A DISSERTATION IN THE DEPARTMENT OF CROP PROTECTION AND ENVIRONMENTAL BIOLOGY SUBMITTED TO THE FACULTY OF AGRICULTURE AND FORESTRY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE

OF

MASTER OF PHILOSOPHY

OF THE

UNIVERSITY OF IBADAN, IBADAN

NIGERIA

MARCH 2012

ABSTRACT

Weed infestation of soyabean field causes 65% yield reduction in the forest-savanna transition ecosystem of Nigeria. Single weed control method is often less effective. However, Integrated Weed Management (IWM), will ensure more effective and environment friendly control. There is little information on IWM application on soyabean field. This study was therefore aimed at investigating response of soyabean to IWM.

Field study was carried out in the 2008 and 2009 planting seasons to asses the effectiveness of the integration of various weed control methods in the production of soyabean (TGx 1414E) at Apapa village, Akinyele local government area, Oyo state. The effects of Tillage (Tilled, Non-tilled), mulching (no mulch, grass, plastic) and herbicides (no herbicides, metolachlor, pendimethalin) on growth and yield of soyabean were assessed in a 2x3x3 factorial experiment arranged in randomized complete block design with four replications and at 0.05x0.6m spacing. Data were collected at 16 weeks after planting on weed diversity and abundance using 0.25m^2 quadrat. The Relative Importance Value (RIV) of each weed was determined using standard procedures. Also ten soyabean plants were assessed per plot for growth and yield parameters (biomass, height, number of pods and grain yield). Data collected were analysed using descriptive statistics and ANOVA at p=0.05.

The most abundant weed was *Spilanthes* sp., with RIV of 58.5%, followed by *Chromolaena odorata* (L.) R.M. King and Robinson with RIV of 7.5%. The highest weed biomass of 136.4±18.5g/m^2 was obtained in non-tilled/pendimethalin/grass treatment, followed by non-tilled/plastic (20.0±5.1g/m^2) and tilled plastic (18.2±3.0g/m^2) but lowest in non-tilled/pendimethelin/plastic (15.4±2.9g/m^2). Tilled/metolachlor/plastic reduced weed biomass yield by 97.5%, tilled/plastic by 97.2%, tilled/grass by 82.6%, control by 72.7%. The plants grown in the control plot had a mean height of 82.0±5.4cm in 2008 and 71.6±3.3cm in 2009. The lowest height of 51.6±5.6cm was recorded in 2008 in the non-tilled/metolachlor/grass treatment and was

50.8±4.6cm in 2009 in the non-tilled/pendimethalin/grass treatment. Plants grown in tilled/metolachlor/plastic had highest pod numbers of 52.4±10.5 in 2008 and 57.3±4.0 in 2009 in tilled/pendimethalin/plastic and the lowest value of 19.0±12.6 in 2008 and 24±0.8 in 2009 in the non-tilled/pendimethalin/grass. The highest grain yield of 3.9±0.3 tons/hectare (2008) and 3.7±0.9 tons/hectare (2009) were recorded in the tilled/pendimethalin/plastic treatment while the lowest value of 1.6±0.3 tons/hectare and 1.7±0.4 tons/hectare was recorded in the non-tilled/pendimethalin/grass treatment in 2008 and 2009 respectively. The treatments are significantly different with regards to weed biomass, and grain yield of soyabean in the two years. However, all plastic combined treatments were not significantly different.

The tilled/plastic treatment ensured best weed suppression and highest grain yield. Adopting it as an integrated weed management alternative may reduce the amount of herbicides and labour input better than other strategies.

Key words: Integrated weed management, Metolachlor, Pendimethalin, Soyabean, *Spilanthes*.

Word count: 452.

ACKNOWLEDGEMENTS

My profound gratitude goes to God for His protection and mercy and to my supervisors, Professor Sola Ogunyemi and Dr. R.O. Awodoyin for their kindness, direction and pieces of advice which led to the successful completion of this work. I appreciate it much. I am indebted to the members of my supervisory committee, Dr Oluwadare of Dept. of Forest Resources Management, and Dr. Cladius-Cole for their constructive criticism and suggestions. I wish to specially thank Dr. R.O. Awodoyin, for always being there when it mattered most. The support of Mr. Sanya Gbonjubola, Abel Enaigbe, and Prof. O.S. Bello is highly appreciated. I acknowledge the good wishes of my parents, Pa. Ogunjobi Gabriel and Mrs. Agnes Ogunjobi, my sister Mrs. Anthonia Ayangbemi. I appreciate the moral and spiritual support of the Taiwos and Pastor Adiguns family (Ibadan) and others who contributed to make this work a success. To God be the glory.

DEDICATION

To the glory of God who illuminates the world and enlightens the human mind, this work is dedicated with love to:

. My dear wife, Joke Bolanle for her patience, perseverance and care.

. My children AdeOluwa, Adebanjo and Adenike.

. My parents whose wish I am pursuing.

CERTIFICATION

I certify that this work was carried out by Mr Adebare James OGUNJOBI in the Department of Crop Protection and Environmental Biology, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan under my supervision.

____

Prof. Sola Ogunyemi

B.Sc. Hons), M. Phil. (Ife), Ph.D. (North Wales, Bangor)

____

Dr. R.O. Awodoyin

B.Sc.(Hons), M.Sc.(Ife) Ph.D. (Ibadan).

TABLE OF CONTENTS

LIST OF TABLES

Table Page

INTRODUCTION

Soyabean belongs to the family Fabaceae, sub-family Faboidea and Genus *Glycine* Willd (PBO, 2000). The cultivated species is *Glycine max* (L.) Merril (Hymowitz and Singh, 2008). It is native to East Asia, and it is the most important grain legume crop and the single largest oil seed produced in the world (Hadley *et al.*,1984; William and Akiko, 2007). Few plants elicit as much enthusiasm as soyabean, largely because of its remarkable nutritional properties. Apart from the seed being processed for human consumption, it is the most important source of edible protein (40% by weight) and edible fats and oil (20%), carbohydrates (32%), minerals (5%) and fibre (3%), together with moisture and trace quantities of other nutrients (IITA, 1990; Li and Burton, 2002; Plahar *et al.*, 2006; Ekeleme *et al.,* 2009). It also helps to improve the health and well-being of rural communities because it has excellent balance of amino-acid compared with other vegetable proteins (Wolf and Cowan, 1975). Soyabean meal is used as a valuable livestock feed (Liu, 1997), and serves as a good source of income to farmers (Wilcox and Shibles, 2001; Raji and Oyekan, 2002). It also plays an important role in soil fertility improvement for cereal-legume based cropping system in the savanna ecosystem (Saginga *et al.*, 2002).

IITA (1990) reported that soyabean can be processed into a wide range of edible product which include soyflour, soymilk, soy vegetable soup, soyogi, soy'akara, soycheese etc. Soyabean is reported to be the most economical source of protein in the world (Spore, 1992). In Nigeria, production was estimated at 465,000 tonnes in 1999 compared to less than 60,000 tonnes in 1984, representing 85% increase (Saginga *et al.*, 2002). Despite these amazing characteristics of soyabean, production is constrained by a number of environmental factors which include, the physical and chemical characteristics of the soil, soil moisture, pests and diseases (Akobundu, 1998).

In the rainforest-savanna transition ecosystem especially in the Akinyele local government area of Oyo state, southwest Nigeria, production decline has been attributed mainly to:

(a) Excessive weed growth leading to farmers abandoning their farmlands.

(b) Weed control methods in use are usually labour intensive and crop yield is generally low due to early weed interference.

(c) Farm labour is both expensive and scarce.

(d) The resource base of the farmers is low.

A weed has been defined as a plant out of place or growing where it is not wanted (Taylor, 1999). Jason and Roy (2000) described weed as a plant considered undesirable, unattractive or troublesome especially one growing where it is not wanted. Merril and Ross (2009) defined weeds as plants that interfere with the growth of desirable plants and are normally persistent. They damage cropping systems and human activities and as such are undesirable. Weeds compete with soyabeans for light, moisture and nutrients with early season competition being the most critical (Ferrell *et al.,* 2008). The detrimental effects of weeds according to Akobundu (1987) exceeds those of all other crop pests, because weed control ties up a proportionate percentage of the country's farming population thereby preventing the country from developing in other areas of the economy. Weed control attracts considerable attention because it is essential to an enhanced economic crop production (Usoroh, 1995).

In Nigeria, yield reduction due to uncontrolled weed growth in field crops in soyabean is 60% or more depending on weed density and species (Akobundu, 1987). Ogunyemi and Ojo (2000) reported 49.1% and 66.8% reduction in cumulative fresh shoot yield in *Solanum macrocapon* L. and *S. aethiopicum* L. respectively due to interference from *Commelina benghalensis* L. In another study, Ogunyemi *et al.* (2001) reported a marketable yield loss of 42% in *Amaranthus cruentus* (L.) Saucer when grown with *Acalypha segetalis* Mull Arg. Yield reduction due to uncontrolled weed growth also caused 40% in maize and 84% in rice (Akobundu 1980a), 20-77% in soyabean (Kurchania *et al.*, 2001), 73-78% in cayenne pepper (Awodoyin and Ogunyemi, 2005) and 65% in tomato (Awodoyin *et al.*, 2007). Other effects of weed infestation include harbouring of diseases and pests, delay in maturity of fruits and competition for light and water (Fourie, 2005). Soyabean yield losses resulting from weed interference and the cost of weed control constitute some of the highest cost involved in the production of the crop and the cost is greater than that for all other pests combined (Shaw, 1978). Bhan (1995) reported that annual weeds of the Poaceae family such as *Eleusine indica,* (L.) Gaertn, *Cyperus* spp., *Setaria barbata (L.) Cynodon dactylon* (L.) Pers, and annual broadleaved weeds such as *Celosia argentea, Euphorbia hirta, Amaranthus viridis,* L. *Phyllantus* spp., *Commelina benghalensis* L. cause maximum damage.

Different methods of weed control used in the management of weed in soyabean according to Ferrell *et al.* (2008) include ;

(a) Cultural method – Hoe weeding, Tillage, mulching, crop rotation, flooding, burning.

(b) Chemical method – use of herbicides

(c) Biological method – use of live mulch, plant canopy manipulation, allelopathy, use of micro and macro-organisms.

(d) Preventive method – use of clean crop seeds for planting, preventing weeds from setting seeds, use of clean machinery, fallowing.

No one method of weed control can adequately meet the needs of any crop all the time. Good weed control in soyabean involves utilizing all methods available and combining them in an integrated weed management (IWM) practice.

Kelner (2005) defined IWM as a strategy that makes use of a combination of different agronomic practices to manage weed, so that the reliance on any one weed control technique is reduced. It is a directed agro-ecological approach to the management and control of weed population to maintain a threshold level that prevents economic damage in the current and future years (Shaw, 1978).

The objective of IWM is to maintain weed densities at manageable levels while preventing shifts in weed populations to more difficult-to-control weeds. Losses caused by weeds will be minimized without reducing income from farm (Bhuler, 2002; Kelner, 2005). In IWM, weeds and crop relationship are manipulated so that growth of crop is favoured over that of the weed (Altieri, 1995). Also IWM aims at maintaining the growth of weed at agronomically, ecologically and economically acceptable levels (Altieri, 1995).

The approaches as recommended by Altieri (1995) include:

- Reduction of plant propagules produced by removing the weed before flowering and seeding,
- Reduction of weed emergence and minimization of weed competition and interference,
- Cropping practices,
- Tillage practices, and
- Crop residue management and herbicide use.

IWM will strengthen the relative competing power of a crop against weed and minimize the weeds harmful effects. A high priority in IWM is the efficient and economical use of resources while minimizing hazards to the environment. IWM is neither a method nor a system of weed control but a philosophy whose goal is to use all available knowledge in weed science and related disciplines to manage weeds to ensure that they do not cause economic loss to farmers and to protect the environment.

OBJECTIVES OF THE STUDY

(a) To develop an IWM strategy that would reduce the drudgery of cultural weed control and at the same time reduce the use of herbicides to protect the environment.

(b) To assess the seed yield potential of soyabean under an integrated weed management strategy.

CHAPTER TWO

LITERATURE REVIEW

2.1 Weed Management in Soyabeans

Weed control refers to actions used to eliminate an existing weed populations. Weed management is more than control of existing weed problems but in addition places greater emphasis on preventing weed reproduction, reducing weed emergence after crop planting, and minimizing weed competition with crops (Buhler, 1995; Zimdahl, 2007). Successful weed control is one of the most important practices for economical soyabean production (Ferrell *et al.,* 2008). Losses due to weeds have been one of the major limiting factors in soyabean production. There are differences among crops in their ability to compete with weeds (Zimdahl, 2004). A key component of weed management is the enhancement of crop competitiveness against weeds. Among several crops studied, wheat was found to be the most competitive (Van Heemest, 1985) but the competitive ability with weeds differs with variety and density (Challaiah *et al.*, 1983). Weed management methods used on soyabean production have included cultural, mechanical, chemical and biological.

In Nigeria, hand weeding which includes practices such as hand pulling, hand slashing and hand hoeing, are the dominant practice in weed management strategies at the small-holder farm level because it is simple and affordable, although laborious. Hand weeding has the effect of either killing or suppressing already established weeds with little or no effects on the un-emerged species. On large farms, the problem of scarcity of labour makes hand weeding a non-viable and inefficient option. For example, hand weeding one hectare of land may require 15-30 man-days, depending on weed density and the cropping system adopted (IITA, 1997). Cultural practice used in control of weeds in soyabean is aimed at managing it to a level that will reduce its effects on the crop. These include land preparation before seed sowing (such as burning and tilling), slashing, cultivation, intercropping, crop rotations, high crop density, hoeing or hand pulling, timely sowing, mulching and fertilizer application to give the crop a competitive edge over the weeds. In the dry forest-savanna transition zone of southwestern Nigeria, melon (*Colocynthis citrullus* L.) alone or in an intercrop with maize is usually used for the suppression of many noxious weeds. Unamma *et al* (1986) observed that in maize/cassava intercrop in Nigeria the economic returns were obtained using high planting densities of low growing cowpea or melon compared with hoe weeding twice. Hoe weeding is laborious and does not provide season-long control of weed (Ayeni, 1991).

Most of the cultural methods of weed control have not been effectively articulated to affect the biology and the resource requirements of most weeds. The methods are basic agronomic practices employed in crop production and have not been properly articulated to optimize the advantages to crops in terms of weed control (Ogunyemi, 1977).

2.2 Soyabean – Weed Interference

Weeds compete with soyabeans for light, moisture and nutrients with early-season competition being the most critical (Ferrell *et al.,* 2008). Weeds may interfere indirectly with soyabean plants through production and release of allelopathic chemicals that inhibit crop growth (Lolas and Coble, 1982). Weeds often serve as alternative hosts for insect pests and plant pathogens that attack soybeans and the physical presence of weed in the crop may interfere with the control of other pests. In addition, the efficiency of operations of harvesting equipment is reduced by the presence of significant numbers of weeds (Nave and Wax, 1971). The quality of harvested crop is directly influenced by weed.

The degree of interference between crops and weed is directly proportional to the density and duration of weed infestation. Ferrell *et al.* (2008) observed that most of the yield reduction due to weed competition occurs during the first six weeks after planting (WAP), therefore, major emphasis on control should be given during this period. However, the critical period of weed interference must be established for each crop in the various agro- ecosystems. Coble and Riters (1978) has shown that a period of 4-6 weeks without weed competition at the beginning of the growing season will allow production of maximum yields under most environmental conditions. Any weeds emerging in the crop after this initial weed free period will not compete effectively with soyabean and will not affect yield potential.

Soyabean yield losses resulting from weed interference and the cost of weed control constitute some of the highest cost involved in the production of the crop, and the cost is greater than that for the control of all other pests combined (Shaw, 1978). Weed competition study at Chequlu in Zimbabwe showed that *Acanthospermum hispidum* reduced soyabean grain yield by 51% (Chivinge *et al.,* 1996). Full competition from Lamb's quatter (*Chenopodium album* L.) also reduced soyabean yield by 20% (Crook and Renner, 1990). Different crops and cultivars can reduce weed biomass from 4 to 83% during a full season competition (Minotti and Sweet, 1981).

Cultivars of common beans and soyabean have been found to differ in their competitive ability against weeds. These differences have been largely attributed to seedling establishment (Burnside, 1979) and canopy development (Legere and Schreiber, 1989).

Various factors affect the severity of crop/weed competition in crop production. The competitiveness of weeds varies with species. Some weeds are more competitive than others either because of their ability to germinate quickly, grow fast and form canopy quickly or their allelopathic characteristics (Akobundu, 1987; Ogunyemi *et al.*, 2001).

Crop cultivars suppress weed growth by shading through its dense canopy. Swanton and Wiese (1991) cited studies in Ontario where early maturing varieties of soyabean were found to be less competitive with weeds than the tall, late maturing varieties. Increased competitive ability of cultivars has been attributed to early emergence, seedling vigour, rate of leaf expansion and rapid development of dense canopy, increased plant height, early root growth and increased root size (Forcella, 1987). A good stand of soyabean, which emerges rapidly and shade the ridges early is helpful in reducing weed competition. All these are necessary for producing good soyabean yield and is an aid in weed control (Ferrell *et al.,* 2008). The plant that emerges first and grows rapidly is usually the plant that will have competitive advantage therefore everything possible should be done to ensure that the soyabeans, and not the weed, have this competitive edge. The competitive cultivars and more aggressive crops in rotation could complement other integrated weed management measures in suppressing the weeds.

2.3 Crop Density and Row Spacing in Weed Management

Row spacing is often reduced by increasing the seeding rate to hasten canopy closure and thus increase the crops ability to compete with weeds for the incoming photosynthetic active radiations. This shades weeds and prevents the establishment of late weed flushes (Yelverton and Coble, 1991). "The degree of interference between crops and weeds is directly proportional to the density and duration of the weed infestation in the crop plants". Studies by Thurlow and Pitts (1983) have shown an advantage of planting soyabean in row widths 45-50 cm compared to 90-100 cm row widths, and in Northern USA yield increase of 10-12% can be achieved by narrowing row widths to within 17-35 cm. Soyabean yields were increased by 20% when grown in 25 cm row spacing compared to 102 cm spacing, if weeds were controlled (Wax and Pendleton, 1968). Kust and Smith (1969) showed a yield advantage for closely spaced row. He also reported a yield advantage for crops if weeds are controlled in early part of the crop life cycle. The extra shading provided by narrow rows increased competition offered by the crop thus decreasing the weed growth and reducing the amount of cultivation and herbicide required to control weeds.

Eaton *et al.* (1976) reported no yield loss from plots where weeds germinated 20 to 40 days later than soyabeans, whereas where weed seed germinated at the same time as the crop, significant yield loss was obtained. The longer weeds remain, the more competitive and more difficult to control they become.

Malik *et al.* (1993) reported that cultivar, row spacing and seeding density combinations in snap-beans, *Phaseolus vulgaris* maximized leaf area index and reduced weed biomass under medium (75 cm) and narrow (50 cm) rows compared to the traditional wide rows (100 cm or more apart). Manipulating cultivar selection, row spacing and seeding density may provide a non-chemical means of reducing the impact of weed interference on crop yield. Spatial arrangement of crop and plant architecture have a significant influence on weed competition. Rogers *et al.* (1976) observed that the period of weed control required for maximum yield in cotton planted in rows spaced 53 cm apart was 6 weeks as against 14 weeks for those planted in rows spaced 106 cm apart. Bridges *et al.* (1992) observed that peanut yields continue to decline as wild poinsettia

(*Euphorbia heterophylla* L.) density was increased in a competition studies involving wild poinsettia and peanut (*Arachis hypogeal* L.). Yield loss was approximately 55% and 40% in the Georgia and Florida sites respectively when the wild poinsettia density was increased to 32 plants/m^2 of row. Awodoyin (2001) observed that higher sicklepod, *Senna obtusifolia* (L.) Irwin and Barneby, population was able to more successfully smother weeds than lower population densities.

2.4 Crop Canopy and Weed Management

Crop canopies greatly reduce the quantity of light (Pike *et al,* 1979) and canopy development depends partly on species and cultivars (Burnside, 1979). The competitive ability of plant is governed partly by the efficiency with which they intercept light, and by the capacity to suppress the growth and development of other plants (Keely and Thullen, 1978). Studies that demonstrated significant gains in crop yield could result from optimizing light available to crops at the expense of weeds have been cited by Holt (1995). Many traditional methods of cultural weed management are recognized as forms of managing competition to the advantage of the crop, for example, encouraging a dense closed canopy is widely used in a variety of crops to favour the crop and discourage weeds (Aldrich, 1984). Crop cultivar characteristics, plant density, row spacing and timing are often chosen for optimal crop performance, within the constraints imposed by available equipment (Holt, 1995). Shading reduces the amount of photosynthesis produced in the lower portion of a plant canopy thereby putting the plants growing under the taller canopies in a disadvantage (Holt, 1995).

2.5 Tillage for Weed Management in Soyabeans

Tillage destroys weeds by breaking them apart, cutting or tearing them loose from the soil, causing them to dry out (desiccate), smothering tender tissues by cutting off light and air, exhausting stored food reserves, or depleting reserves of seeds and vegetative propagules from the soil (Merril and Ross 2009).

The use of hoe for tillage and for weed control is common in Nigeria in the small farm holdings. The objective being to bury weeds or weed seeds beyond the level at which they can germinate. Tillage practices such as ridging has been recognized by farmers as effective in reducing weed infestation, because weed and their seeds are buried in the mounds thus reducing their germination and pressure on crops (Akobundu, 1987). Ridging gives crops favourable ground for establishment before weed invasion. Tillage as a method of weed control affects the weed environment, weed communities are influenced by tillage through changes in seed distribution in the soil, and on seed predators (Brust and House, 1998; Buhler, 1995).

Tillage for seedbed preparation can be used to reduce densities of annual weed population, especially if planting is delayed, and allows weed seed germination prior to final seed bed preparation (Buhler and Gunsolus, 1996). Post plant tillage also can be part of integrated weed management especially during the production of annual crops. Shallow tillage prior to crop emergence and cultivation between rows after crop establishment are effective in removing annual weeds and inhibiting the growth of perennial weeds when used in combination with rotary hoeing (Buhler and Gunsolus, 1996) or supplemented with broadcast (Steckel *et al.,* 1990), or band applications of herbicides (Buhler *et al.,* 1992).

Tillage following soyabean planting can be an effective weed control tool using rotary hoeing at 7 and 14 days after planting and can also reduce weed density up to 85% (Buhler and Gunsolus, 1996). Hoeing may improve soyabean stands by breaking the soil crust to allow uniform emergence. However, care must be taken when hoeing, as it may expose the hypocotyl at the soil surface which may cause severe injury to soyabean. Generally, shallow cultivation is best to minimize soyabean root pruning and avoid disturbing weed seeds buried deeper in the soil following ploughing (Buhler, 2002). Research on ridge tillage by Buhler (1992) suggests that cultivation improves weed control following herbicide treatment and reduces weed population density in subsequent years by reducing weed population.

Timely, effective tillage is a good means of weed control, good weed control took planning and timely operations of tillage and pre-emergence herbicides. It is important to control weeds early in the development of the soyabean plant before the flowering stage. Since control methods are more effective and economical on small weeds than on large ones, early control is essential (Aldrich and Scott, 1970). No-tillage weed control is an extreme form of conservation tillage, and involves placing seeds or seed transplants directly into the soil without tillage and with only a minimum disturbance of the killed stubble or crop residue. This is widely used in temperate agriculture (Wiese, 1983). A vital requirement of this tillage system is that there shall be present on the soil surface, plant residue mulch to protect the soil from erosion, suppress weed growth and on decay add organic matter to the soil. It has been reported by Sether *et al.* (1971) that no tillage system has reduced the time required for rice land preparation from 15 to 30 days to 6 to 10 days and maintained yields equal to conventional tillage in such tropical countries as Indonesia, India, Malaysia and Sri-Lanka. In Brazil and Argentina, large production of soyabean without tillage has been successful (Burkley, 1980). IITA (1997) has indicated that when weeds are controlled the method of land preparation has little effects on yields. The poor yield from no-till plots was attributable to increased weeds and decreased efficiency of fertilizer use (IITA, 1997).

2.6 Mulching as a weed management strategy

Mulch is a protective cover placed over the soil to retain moisture, reduce erosion, suppress seed germination and weed growth and provide nutrient as they decay (Louise and Brown 1996). Materials used as mulches vary depending on factors such as availability, cost, appearance, the effect on the soil including chemical reactions and pH, durability, combustibility, rate of decomposition and cleaness. Materials used as mulch include grass clippings, leaves, hay, straw, shredded barks, wood chips, saw dust, shells, shredded newspaper, plastic films, etc (Louise and Brown, 1996).

Grass clippings from mowed lawns when mixed with tree leaves provide aeration and are relatively high in nitrate content which are returned to the soil on decay (Patrick, 2004). Louise and Brown (1996) reported that straw mulch or field hay are light, biodegradable and neutral in pH, have good moisture retention and weed control properties. Jackie (2010) noted that mulching with wood chips moderated soil temperature, conserved soil moisture and suppressed weed growth. The decay of freshly produced chips from recently living woody plants consumes nitrates because of the high C:N ratio, which is often offset with light application of nitrate fertilizer in garden crops.

Plant residue mulch can influence weed by suppressing weed seed germination and weed seedlings growth. It has been in use for a very long time to protect the soil and reduce weed growth. Broadly speaking, the general benefits of mulching are those of moisture conservation, protection of soil erosion from erosion, reduction of soil temperature, increasing water infiltration rate, maintenance of soil structure and promotion of microbial activities in the soil (Fernandez and Sanches, 1990; Salau *et al*; 1992). Reports of extensive work done on mulch types have shown that mulch types vary in respect to weed control and soil conservation potential. Asoegwu (1991) showed that wood shavings was better at controlling weed in pinapple than rice husks and saw dust, while grass mulch was better at soil fertility improvement than plastic mulch (Opara-Nadi, 1993). For weed suppression, plastic mulch was shown to be better than other mulch materials (Miller, 1976; IITA, 1985; Awodoyin and Ogunyemi, 2005). Crutchfield (1984) showed that winter wheat straw reduces weed population as straw level increased thereby reducing herbicide rate, and organic residue after decomposition also replenishes the soil organic matter and increases the nutrients levels. He also noted that weeds growing in crop residues are easier to control than weeds where little residues exists because they are not likely to be under drought stress and may even be etiolated. Water loss from the surface is reduced with stubble mulch giving weeds a better chance of surviving disturbance if the soil is cultivated or if rain follows soon after cultivation.

Stapleton and Garza-Lopez (1988) reported that plastic mulch are not economical and practicable on large scale farms for most grain crops. Akobundu (1987) stated that the limitations of mulching include labour intensiveness (when mulch materials have to be transported), interference with seed germination and or seedling growth, especially when placed before seeding; necessity for complete soil coverage, and serving as alternate hosts for animal pests of crop.

Olabode *et al.* (2007) in a study of the response of okra (*Abelmoschus esculentus* (L.) Moench) to weed control by mulching indicated that plants under the grass mulch (*Panicum maximum* Jacq.) had bigger leaves and stem, as well as higher number of branches compared to those of wood shavings and weedy control plots. The plants are also significantly taller and were similar to plants under hand weeded control in these parameters. Yield from grass mulch (6.7 kg/ha) were similar to that of the hand weeding control (6.9 kg/ha) which were significantly higher than those of wood shavings mulch (5.3 kg/ha). Lal (2006) also reported the positive effect of mulching with *P. maximum* on the grain yield of crops. Mulching increased the yield of maize by 10.7%, soyabean 2.2% and groundnut 2.8%. However, he noted that mulching with *Pueraria phaseoloides* straw was more beneficial than that with *P. maximum* and produced 80% of the yields without the addition of chemical fertilizers.

2.7 Chemical method

Herbicides are one of the most effective tools for weed control in soyabeans (Ferrell *et al.,* 2008). Pre-plant or pre-emergence applications ensure that soyabeans have the initial competitive advantage. The advantages of chemical control over mechanical control are that it is often cheap, especially in a stable economy, rapid, and involves less soil disturbance. Also there is less risk of erosion. Herbicides that have been screened for weed control in soyabeans in Southwest Nigeria include Gramoxone (paraquat) for no-till soyabeans, metolachlor, pendimethalin, chloramben, alachlor, bentazon, fluazifo-p-butyl, galex, etc (OGADEP, 2003).

Chemical weed control in soyabean has been superior to hand weeding, but crop yields have been identical (Akobundu, 1987). Pre-emergence application of alachlor, metolachlor and pendimethalin have provided good control of annual grasses such as *Brachiaria lata*

Schumach (Akobundu, 1980b). Chemical weed control receives greater acceptance because it is less laborious in comparison to other weed control methods. Compared to manual and mechanical method, there is lower field labour demand, timeliness in weed control and reduced drudgery. Control of broadleaf weeds has been satisfying with chloramben and metobromuron but will not control wild poinsettia, *Euphorbia heterophylla*. A new herbicide imazaquin is effective on wild poinsettia without injury to soyabean and also has advantage of suppressing tropical spiderworth *Commelina benghalensis* (Poku and Akobundu, 1985). Slight to moderate vigour reduction was reported by Hagwood *et al.* (1980) at early growth stages of soyabean with *chloramben* but not significant yield reduction was observed in any field experiment due to rapid recovery.

In most cases of herbicide use, no single herbicide will selectively control all weeds over an extended period of years. Effective and consistent weed control with herbicides requires that herbicide selection be based on weed species present in the area and the recognition that weed population will adapt to herbicide over time (Gebhardt, 1981). Apart from selectively controlling weeds without injury to crops, pre-emergent herbicides are known to protect crops from adverse effect of early competition.

Moody (1982) stated that herbicide use results in the agro-ecosystem with low species diversity and with new problem weeds appearing. Therefore there is a need for an ecological approach to control weeds instead of relying totally on chemical control methods.

Mahn and Hekmecke (1979) noted that reliance on a single herbicide could result in quantitative changes in the structure of the weed population in as far as five years. As weed population stresses are shifted by herbicides, weeds formerly of secondary importance emerge as primary weed problems, that may be avoided by an integrated system of rotation of crops. Lo (1990) advocated the alternative use of herbicides with different grass control spectra over seasons to prevent the emergence of tolerant weeds.

In Nigeria, when the cost of application is added to the price of the herbicide, the cost return analysis becomes unfavourable, especially to small holder farmers cropping less than three hectare per annum. The herbicides are expensive, unavailable and unaffordable to the subsistence farmer who produces the bulk of the food consumed. This is a source of concern to the farmers, and thus requires an alternative control practices which employ good agronomic practices with lower external input. The notable herbicides used in soyabean production are:

Metolachlor (*2- Chloro –N-(2- ethyl -6- methyl –phenyl)-N-(2-methoxyl -1-methyl ethyl) acetamide).*

Metolachlor (Dual) is an organic compound used as herbicides. It is a derivative of aniline and a member of the chloroacetaline herbicide. It is highly effective in the control of grasses and acts by inhibition of root and shoot elongation. It is used for grass and broadleaf weed control in corn, peanuts, sorghum, and cotton (Kiely *et al*., 2004). It belongs to the large group of the amide herbicides mostly used in the tropics as a pre-emergence herbicide for weed control in maize, cowpea, soyabean and groundnuts. It is available as formulated mixtures with a wide range of herbicides that includes atrazine (metolachlor + primextra) and galex (metolachlor + metobromuron). It is mostly used as a component mixtures in cereal, legumes, root and tuber crops and intercropping systems involving these crops. Broadleaf weeds absorb metolachlor through both roots and shoots, while uptake by grasses is through the shoot (Akobundu, 1987). Mode of action appears to be the inhibition of protein and lipid synthesis. It does not persist in tropical soil even when used in high rates up to 160 kg/ha (Utulu *et al.*, 1986). Studies by Pillae *et al.* (1979) showed that it inhibited photosynthesis in *chlorella* by 33% at high concentration (10^{-4M}). Hamman (1974) reported that metolachlor inhibit weed seed germination and development of germinating seedlings. It inhibits protein synthesis (Duke *et al.*, 1975) and also inhibit gibberrellin induced amylase synthesis in de-embryonated barley seed (Delvin and Cunningham, 1990) which indicates a basic inhibitory effect on one or more metabolic processes upon which germination or early seedling growth depends. Geber *et al.*, (1974) noted that root elongation of soyabean was decreased by 74% by 10^{-4} metolachlor. The inhibitory effect on shoot length and weight are similar to those for roots of the same species. Thus, for grasses metolachlor appeared to enter primarily through the shoot zone or it had its greatest effect when it entered through the shoot zone (Geber *et* al., 1974). He also reported that grass weeds are highly sensitive to low concentration of the herbicide in the shoot zone while much higher concentration in the root zone caused only limited stunting effects.

Pendimethalin **(***-N-(1-ethyl propyl)-3,4 dimethyl-2,6-dinitrobenzenamine).*

Pendimethalin (Stomp or Prowl) is used pre-plant incorporated, pre-emergence and also as a post-emergence herbicides for control of tough grass weed in crops like maize, sorghum, cowpea, soyabean and vegetables. Pendimethalin can be tank mixed with atrazine for use in maize and with metobromuron in cowpea. It is to date a potential solution to *Rottboellia cochinchinensis* problem in maize in the tropics (IITA, 1978). Pendimethalin treatment is most effective when adequate rainfall or irrigation is received within 7 days of application and fits all variety of tillage systems - conventional, minimum or no-till and provides soil active residual weed control. It is a low volatile and low mobile dinitroaniline containing low water solubility properties. Cultivation practices, moisture conditions, soil temperature and soil type influence the herbicide persistence (Street and Lanhan, 2005).

Ahmad *et al.* (2000) while evaluating the effect of the herbicide on weed control in soyabean field noted that pendimethalin applied at 1.48 kg active ingredient per hectare controlled the weeds and gave 53% higher grain yield (2858 kg/ha) than weedy check (1877 kg/ha) and was at par with weed free treatment (2867kg/ha). Weed density and biomass were also significantly affected with different doses of pendimethalin. The medium doses of the herbicides gave excellent performance. Pod number per plant was significantly different with the different doses of the herbicides. The medium dose gave higher number of pods per plant. In another experiment, Khan *et al.* (1999) recorded lowest weed density and weed biomass in pendimethalin treatment, highest plant height and number of pods per plant were also obtained from weed free treatment. No negative effect on the germination and growth of the crop was observed. In the study, pendimethalin proved to be the best herbicides for weed control in soyabean, applied by soil incorporation method. Highest grain yield (1523kg/ha) was obtained from weed free check followed by pendimethalin (1475kg/ha) while the lowest yield (1127kg/ha) was produced in the weedy control.

2.8 Integrated weed management (IWM) in Soyabean

Integrated weed management is a strategy of weed control which involves the combination of different agronomic practices to manage weed so that reliance on any one weed control is reduced (Kelner, 2005). Weed control in soyabean requires good management practices in all phases of soyabean production. Good soyabean weed control involves utilizing all methods available and combining them in an integrated weed management system (Ferrell *et al.,* 2008). The central objective in IWM is to manipulate the crop weed relationship so that growth of the crop is favoured over that of the weed.

Kelner (2005) identified three main types of agronomic practices that can be used to develop an IWM programme.

- Practices that limit the introduction and spread of weed (prevent weed problem before they start)
- Practices that help the crop compete with weed (help "choke out" weeds)
- Practices that keep weed off balance (make it difficult for weed to adapt).

IWM emphasizes combinations of techniques and knowledge that consider the cause of weed problems rather than react to problem after they occur (Buhler, 2002).

Eplee (2003) stated that prevention is by far the best deterrent against invasive weed plants; once established successful eradication or management of weeds is contigent upon early detection, identification, assessment, development of eradication strategies and a steadfast implementation of that strategy. This involves using measures to forestall the introduction and spread of weed. Preventable means by which weeds can be introduced into new areas include; contaminated crop seed; transport of plant pests and seeds, tillage, harvest, and processing equipment; livestock, manure, irrigation and drainage water, and forage and feed grains (Walker, 1995). Although the concept of prevention is quite simple, success and feasibility are determined by weed species, means of dissemination, farm size, and the amount of effort expended. Preventive weed management programmes are most successful in situations in which humans are the vectors or have direct control over the seed source (Walker, 1995). Mohammed *et al.* (1997) combined pre-sowing irrigation, pre-emergence herbicides and one hand weeding in Northern Sudan and found that total weed population was reduced by 60.5% leading to an over 40% increase in crop grain yield. In combining row, herbicide and cultivation, Gregg *et al.* (1998) reported that cultivation was the single most important variable that reduced the amount of herbicide input by 50% with maize yield comparable to the weed free check.

Crop rotation is often identified as a valuable component of weed management (Liebman and Gallandt, 1997). Liebman and Ohno (1998) in a 25 test crop rotation combination studies found that in 19 cases, weed plant density in rotation was less than in monoculture, higher than monoculture in two cases and equivalent with monoculture in four cases. Rotation is an integrative practice that combines differences in planting dates and growth periods, tillage practices, life cycles, competitive characteristics and weed control practices to disrupt regeneration niches of weed species and prevent the build up of adapted weed species (Buhler, 2002). Schreiber (1992) observed that giant foxtail (*Setaria faberi* Herrm.) was intermediate in weed management in a corn/soyabean rotation, and lowest in a corn/soyabean/winter wheat rotation.

Wax and Pendleton (1968) increased the effectiveness of both cultural and chemical weed control systems in soyabean by manipulating row spacing. This approach was demonstrated to be more effective in weed control and to give better crop yield than when cultivation or herbicide alone was used (Walker and Buchanan, 1982).

Robert *et al.*, (1996) reported that integrating cultivation with herbicides controls a broader spectrum of weeds than cultivation or herbicides alone.

Enhancing the ability of crops to compete with weeds is an attractive component of IWM systems (Pester *et al.,* 1999). This can be accomplished by providing the best possible environment for crop growth combined with practices that reduce the density and vigour of weeds. Practices such as narrow spacing, appropriate time of planting and fertility management are capable of shifting the competitive balance to favour crops over weeds (Buhler and Gunsolus, 1996). Decreasing row spacing has been shown to increase competitiveness of many crops including soyabeans (Teasdale, 1995). In an extensive review of the effects of cultural practices on soyabean-weed interaction, Stroller *et al.* (1987) concluded that soyabean cultivar selections, row spacing, plant density, planting date, crop rotation, tillage and herbicides can all be used to maximize the ability of soyabean to compete with weeds. Characteristics commonly associated with crop competitiveness with weed include rapid seed germination and root development, rapid early vegetative growth and vigour, rapid canopy closure and high leaf area index, profuse tillering or branching, increased leaf duration, greater plant height and allelopathy (Callaway, 1992; Pester *et al.,* 1999).

Weed density is an important factor in crop-weed competition. Findings have shown that crop yield is reduced to zero before maximum weed density is attained (Aldrich, 1984; Akobundu, 1987).

Also, yield losses increase with increase in weed weight. The onset of crop–weed interaction is very significant in crop-weed competition and consequently in yield reduction (Olabode *et al.*, 1999). Apart from the early stages of seedling growth in both weed and crop, when negative interaction has not set in, control of weed should not be delayed longer than when weeds are at the six-leaf stage, or more than three weeks, for most crops in the tropics (Bakut, 1985). Generally, the superior competitive ability of weeds arises from the rapidly spreading canopy and deeply penetrating root system at the early growth stage (Awodoyin, 2001). In competition studies on *Bidens pilosa* L. (blackjack) and *Amaranthus hybridus* L. (pigweed) in *Glycine max* (L.) Merril (soyabean), Chivinge and Schweppenhauser (1995) observed that branching was reduced by 75% in *G. max* while it increased in the weeds. Furthermore, the three plants had their shoot dry weight reduced in the mixture although the weed species had higher growth rate and leaf area index than soyabean. Similarly, the yield parameters of soyabean, including seed weight, pod number per plant and yield per plant were significantly reduced due to competition. Pigweed was more problematic of the two weed species.

Thus, the goals of integrated weed management is to optimize crop production and grower's profit through the concerted use of preventive tactics, scientific knowledge, management skills, monitoring procedures and appropriate use of cultural practices (Buhler, 2002).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study site

The experiment was conducted in 2008 and 2009 at Apapa Village in Akinyele Local Government Area, 16.2 kilometers Northwest of Ibadan, Oyo State, Nigeria. The geo-referencing of the site was done in December 2008 using a global positioning system (GPS; Etrex Legend Garmin, 2008 model). The site is on Latitude 7^0 31.72'N and Longitude 3^0 55.54'E and an altitude of 251m above sea level. The relative humidity in December 2008 was 60.2%. The site is in the transitional zone between the rain forest to the south and derived savanna to the North with mean annual rainfall of 1250mm and temperature of 26.3^{0}C (Palada *et al.*, 1985). The dominant soil type is an Alfisol (Okigbo, 1995). It is an arable land suitable for most cereals crops like maize and sorghum; root crops such as yam and cassava; and legumes such as cowpea, soybean and groundnut (Okigbo, 1995).

The land was abandoned by farmers due to high weed invasion. The common weed at the site at the beginning of the study includes *Setaria barbata* Kunt (Palm grass), *Eleusine indica* L. (Goose grass), *Eragrotis atrovirens* Desf. (wiry love grass), *Cyperus* species – sedges, *Commelina* species (Tropical Spiderworth), *Acanthospermum hispidum* L. (Bristly starburn), *Chromolaena odorata* L. (Siam weed) and *Euphorbia heterophylla* L. (Wild poinsettia).

Soil sampling and analysis.

Samples of soil were collected from the top 0-15cm of the soil using a set of core samplers 10cm in diameter and 15cm high and bulked at the beginning of the study for analysis. The bulked samples were air dried after removing the pebbles in them. The samples were sieved using a 2mm sieve in preparation for physical and chemical analyses. The soil analysis was carried out in the Department of Agronomy, University of Ibadan. The physical properties determined were particle size using the hydrometer method (Bouyoucous, 2007) and the textural class was determined using the USA textural triangle (IITA, 1979). The chemical analyses included:

- Organic matter by dichromate oxidation (Wakley and Black, 2007)
- Total Nitrogen by Microkjedahl method (Jackson, 2004)
- Available phosphorus by Bray P-1 method (Bray and Kurtz, 2003).
- pH using a pH meter.
- Exchangeable bases by displacement with neutral ammonium acetate (IITA, 1979).

3.3 Land preparation

In 2008 the farm site (8 x 23 m) was cleared manually using a machete. It was divided into four blocks each measuring 1 x 23 m. Each block was subdivided into 12 plots (1 x 1 m each), six plots were tilled and six plots untilled. A 1 meter alleyway was maintained between contiguous plots and blocks.

In 2009 the site (15 x 20 m) after clearing were divided into four blocks of 3 x 20 meters and each block subdivided into 18 plots of 1 x 1 m with 9 plots tilled and 9 plots untilled. The tilled plots were slightly opened up into a raised platform 20cm high, the untilled plots were not cultivated but slashed with a machete to minimize soil disturbance and the debris removed.

3.4 Experimental design

The experimental design was factorial in a randomized complete block design (RCBD) with four replications in the two years. In 2008, the herbicides (2) and mulch types (2) were combined to have 4 treatments. These, with the weedy and weed free control treatments (to have 6 treatments), were combined with the two tillage treatments to have 2 x 6=12 treatment combinations.

In **2008** the treatments were

Non-tilled weed free control	(weed free)
Non-tilled weedy control	(weedy)
Non-tilled/grass mulch/metolachlor	T_0MgHm
Non-tilled/grass mulch/pendimethalin	T_0MgHp
Non-tilled/plasticmulch/metolachlor	T_0MpHm
Non-tilled/plastic mulch/pendimethalin	T_0MpHp
Tilled weed free control	(weed free)
Tilled weedy control	(weedy)
Tilled/grass mulch/metolachlor	T_1MgHm
Tilled/grass mulch/pendimethalin	T_1MgHp
Tilled/plastic mulch/metolachlor	T_1MpHm

Tilled/plastic mulch/pendimethalin T_1MpHp

In **2009** the herbicide and mulch types treatments were not lumped together as in 2008 (to bring out the treatment effect on the experimental unit) to have the three treatments as follows;

Tillage (2) - Tilled and non tilled plot).

Mulch types (3) - No mulch control, grass mulch and plastic nylon fabric.

Herbicides (3) - No herbicides, Pendimenthalin, Metolachlor.

These three treatments combined in 2 x 3 x 3 factorial design to have 18 treatment combinations which were;

Non-tilled/no mulch/no herbicide (control)	$T_0M_0H_0$(weed free)
Non-tilled/no mulch/metolachlor	T_0M_0Hm
Non-tilled/no mulch/pendimethalin	T_0M_0Hp
Non-tilled/grass mulch	T_0MgH_0
Non-tilled/grass mulch/metolachlor	T_0MgHm
Non-tilled/grass mulch/pendimethalin	T_0MgHp
Non-tilled/plastic mulch/no herbicides	T_0MpH_0
Non-tilled/plastic mulch/metolachlor	T_0MpHm
Non-tilled/plastic mulch/pendimethalin	T_0MpHp
Tilled/no mulch/no herbicide (control)	$T_1M_0H_0$ (weed free)
Tilled/no mulch/metolachlor	T_1M_0Hm
Tilled/no mulch/pendimethalin	T_1M_0Hp
Tilled/grass mulch/no herbicide	T_1MgH_0
Tilled/grass mulch/metolachlor	T_1MgHm
Tilled/grass mulch/pendimethalin	T_1MgHp

Tilled/plastic mulch/no herbicide	` T_1MpH_0
Tilled/plastic mulch/metolachlor	T_1MpHm
Tilled/plastic mulch/pendimethalin	T_1MpHp

The treatments were completely randomized in each block.

3.4 Planting/Establishment

The seeds of soyabean cultivar TGx 1414E were obtained from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. The soybean cultivar TGx 1414E is recommended for the forest-savanna transition zone of Nigeria where the experiment was carried out. The soyabean seeds were treated before planting with Apron plus (10% metalaxyl + 6% carboxin + 34% furathiocarb) at the rate of 5g/kg of seed to protect them against fungal infections. The seeds were sown in the first week of July in both years at a depth of 1cm and a spacing of 5 cm within the rows and 60 cm between rows to give a plant population of 333,333 plants /ha (IITA, 1990).

3.6 Herbicide application

Each of the herbicides was applied pre-emergence to all plots designated for the treatment using a CP3 knapsack sprayer. Two hundred and ten millilitres (210 mls or 2.5 l/ha) of pendimethalin and fifty millilitres (50 mls or 0.6 l/ha) of metolachlor 960EC was added to 20 litres of water separately and thoroughly mixed. The herbicides were applied to the soil immediately after planting at an average height of 60cm. All the treatments were applied on the respective plot in the two years. The weed free control plot were weeded with a hoe at 3 and 6 weeks after planting (WAP) and no herbicidal treatment nor mulch applied. The weedy control plot were not weeded until maturity and harvest of the soybean.

3.4 Laying of mulch

The grass mulch, sourced from guinea grass (*Panicum maximum* Jacq.*)*, was laid on the plot receiving the treatment (grass and plastic) to a thickness of 5 cm after planting and herbicide application. The plastic fabric (a 0.25µm thick dual surface grey-on-black polyethylene sheet) was cut to the size of each plot (1 x 1m) and laid on the plot receiving the treatment after planting and herbicide application. The plastic fabric was punched at the spot where the seeds were planted and firmly held in place with wooden pegs.

3.6 Weed identification, quantification and harvest

At maturity of the soybean, (16 weeks after planting) weeds were sampled in each plot with a quadrat measuring 0.25 m^2, laid at the centre of each plot in 2008 and 2009. Weed species from each point were identified and number of individuals counted and recorded. The number of each weed species per quadrat was used to determine the density and percentage frequency which also indicate the relative importance of each weed species.

Density= number of each weed species per unit area.

$$\text{Frequency} = \frac{\text{number of each weed species per quadrat}}{\text{Number of quadrat}}$$

Relative important value= $\frac{\text{relative density + relative frequency}}{2}$

The weeds in each plot were harvested at ground level. Weed samples were oven dried at 80^{0}C to constant weight in a Gallenkemp oven. Then the samples were weighed with a digital balance (Metller P1210) and records well kept.

3.5 Data collection

Soyabean

(a) Plant height at maturity – Soyabean height was taken in each plot by measuring ten randomly selected plants at maturity in each experimental year using a meter rule. This is the height (cm) from the ground surface to the top of the main stem.

(b) Number of pods per plant: Mean number of pods per plant was taken by counting number of pods on the 10 plants.

(c) Stem diameter: The diameter of stem was taken on the 10 plants at maturity using a venier caliper. The diameter of each stem was taken at 5cm height.

(d) 100 seed weight: This is the weight in grams of 100 selected seeds from the dried clean seed samples using an electronic top-loading digital balance (Metller P1210).

(e) Grain yield – weight (in tonnes) of clean, dry grain from each plot after harvest. The grain weight was determined by drying harvested samples at 65^{0}C for 48 hours in a

Gallenkemp oven and weighing with an electronic top-loading digital balance (Metller P1210).

3.6 Data analyses

Data collected were analyzed by ANOVA and differences between means compared using the least significant difference (LSD) at 95% levels of significance as appropriate according to Gomez and Gomez (1984) and Wahua (1999).

CHAPTER FOUR

RESULTS

4.0 The physical and chemical properties of the soil

The textural class of the soil was found to be a sandy loam using the United States Department of Agriculture (USDA) textural triangle classification (IITA,1996). The mechanical analyses showed that the soil contains 752 g/kg of sand, 152 g/kg of silt and 96 g/kg of clay. The soil is slightly acidic with a pH of 6.9. The chemical properties of the soil include; a high organic carbon content of 19.8 g/kg, high total nitrogen content of 48 g/kg, available phosphorus 27.53 mg/kg, potassium 0.13 cmol/kg, calcium 1.33 cmol/kg, magnesium 0.64 cmol/kg and cat-ion exchange capacity 2.57 mg/kg (Table 1).

The rainfall distribution in the area was bimodal and had peaks in July and September (Table 2). There was higher rainfall in 2008 than 2009. The distribution over the months was also fair in 2008 with 80 rainy days, but erratic in 2009 with 62 rainy days (Table 2). The minimum and maximum temperature respectively averaged 22.9^{0}C and 31.9^{0}C in 2008 and 23.2^{0}C and 31.6^{0}C in 2009.

The mean relative humidity was 74% in 2008 and 80% in 2009.

Table 1: The physical and chemical properties of soil in the experimental site at the commencement of the study.

Parameter	Values
pH	6.9
Sand (g/kg)	75
Silt (g/kg)	15
Clay (g/kg)	10
Textural class	Sandy loam
Organic Carbon (g/kg)	1.98
Total Nitrogen (g/kg)	0.48
Available Phosphorus (mg/kg)	27.53
Potasium (cmol/kg)	0.13
Calcium (cmol/kg)	1.33
Magnesium (cmol/kg)	0.64
ExchangeableAcidity(cmol/kg)	0.40
Cation exchange capacity	2.57
Base saturation %	84.44

Table 2: Rainfall distribution in Ibadan, Southwest Nigeria in 2008 and 2009

	Rainfall (mm)		Number of Rainy days	
Month	2008	2009	2008	2009
January	0	0.7	0	1
February	1.5	0	1	0
March	60.3	58.6	8	6
April	42.9	28.8	6	6
May	92.0	107.0	8	7
June	118.7	107.6	7	7
July	128.4	68.9	12	6
August	59.8	48.7	10	8
September	151.7	171.5	11	8
October	124.0	141.2	9	7
November	38.3	37.1	5	4
December	18.7	8.2	3	2
Total	836.3	778.3	80	62

Source: Nigerian Metereological Agency, Samonda, Ibadan, Oyo State.

4.1 Plant height at maturity

The plants grown on tilled/no mulch/no herbicide ($T_1M_0H_0$) plot had the best height (81.95$\pm$5.44cm) and the least (51.60$\pm$5.55cm) was recorded in the non-tilled/grass /metolachlor (T_0MgHm) treatment in 2008. The tilled/grass/pendimethalin (T_1MgHp) had a height of 67.61$\pm$8.39cm while the non-tilled/grass/metolachlor (T_0MgHm) had a height of 51.60$\pm$5.55cm (Table 3). The tilled/ grass/metolachlor (T_1MgHm) and tilled/plastic/metolachlor (T_1MpHm) treatment are significantly different ($p<0.05$) from the non-tilled/grass/metolachlor (T_0MgHm) and non-tilled/plastic/metolachlor (T_0MpHm) in 2008. Tillage and weed control treatment effect were significant ($p<0.05$) on the plant height in 2008.

In 2009 the plants grown on tilled/no mulch/no herbicide ($T_1M_0H_0$) also had the best height (71.63$\pm$3.33cm) and the lowest was recorded in the non-tilled/grass/pendimethalin (T_0MgHp) treatment (50.77$\pm$4-61cm). The mean plant height of the treatment does not follow the trend as recorded in 2008 (Table 5). The tilled/plastic/metolachlor (T_1MpHm) treatment had a height of 60.14$\pm$2.78cm compared to the tilled/plastic/pendimethalin T_1MpHp (52.29$\pm$2.70cm) which are significantly different ($p<0.05$). The main effect of mulch, herbicide and the interaction between the two were significant ($p<0.05$) on plant height.

Table 3: Means of growth and yield parameters of soyabean in an integrated weed management in Apapa village, Ibadan in 2008.

Weed Control		Plant height (cm)	Pod No.	Stem diameter (mm)	100 Seed weight (gm)	Weed dry shoot biomass (g/m)	Grain yield (t/ha)
No-till/plastic/pendimathalin	T_0MpHp	61.16 (5.19)	51.65 (15.45)	8.52 (0.52)	13.55 (0.68)	11.33 (2.69)	3.29 (0.31)
No-till/plastic/metolachlor	T_0MpHm	59.90 (7.82)	39.95 (8.77)	7.74 (0.67)	13.99 (0.32)	13.25 (2.64)	2.14 (0.95)
No-till/grass/pendimethalin	T_0MgHp	51.99 (1.56)	19.00 (12.63)	8.05 (0.46)	14.04 (0.82)	66.23 (11.78)	1.64 (0.28)
No-till/grass/metholachlor	T_0MgHm	51.60 (5.55)	23.60 (12.28)	7.18 (1.03)	14.04 (0.43)	78.48 (43.39)	1.70 (0.61)
Nn-till weed free	$T_0M_0H_0$	66.07 (9.36)	45.55 (9.93)	7.59 (0.84)	13.47 (0.49)	74.49 (38.67)	3.31 (0.86)
No-till weedy	$T_0M_0H_0$	66.65 (5.86)	21.67 (5.86)	7.03 (1.29)	13.01 (0.61)	426.8 (179.35)	1.32 (0.40)
Tilledplasticpendimethalin	T_1MpHp	55.75(2.82)	50.32(8.47)	8.12(0.33)	13.86(0.19)	11.73(1.80)	3.90(0.27)
Tilled/plastic/metolachlor	T_1MpHm	60.12(11.13)	52.40(10.47)	8.71(0.64)	13.85(0.55)	13.33(2.84)	3.12(0.43)
Tilled/grass/pendimethalin	T_1MgHp	67.61(8.39)	49.70(9.66)	8.77(1.00)	14.25(0.77)	61.83(10.52)	2.25(0.48)
Tilled/grass/metolachlor	T_1MgHm	64.83(8.39)	50.37(9.16)	8.63(0.74)	14.13(0.33)	99.48(29.94)	2.94(0.48
Tilled weed free	weed free	81.95(5.44)	52.30(18.26)	8.13(1.01)	14.03(0.22)	66.18(23.28)	3.77(1.26)
Tilled weedy	weedy	75.74(2.03)	33.37(10.30)	8.31(0.76)	13.38(0.21)	425.83(79.50)	1.92(0.86)
LSD 0.05		5.67	16.75	1.17	0.73	165.79	0.63

LSD 0.05 = Least Significant difference at 95% level of probability

Values are means with standard deviations in parenthesis (n=10)

Table 4: Means of growth and yield parameters of soyabean in an integrated weed management in Apapa Village, Ibadan in 2009

Weed Control		Plant height (cm)	Pod No.	Stem diameter (mm)	100 Seed weight (gm)	Weed dry shoot biomass (g/m^2)	Grain yield (t/ha)
Non-till/plasticpendimethalin	T_0MpHp	52.06(2.39)	45.20(6.80)	7.48(0.36)	12.81(0.51)	19.53(3.20)	3.27(0.54)
Non-till/plastic metolachlor	T_0MpHm	59.20(1.78)	34.08(10.86)	7.07(0.36)	12.94(0.43)	22.56(7.33)	2.80(1.11)
Non-till/grass/pendimethalin	T_0MgHp	50.77(4.61)	24.08(10.63)	7.54(0.37)	12.95(0.64)	136.41(18.50)	1.73(0.41)
Non-till/grass/metholachlor	T_0MgHm	54.41(1.63)	28.01(7.22)	6.81(0.60)	13.10(0.09)	117.07(4.41)	2.45(0.37)
Non-till/plastics	T_0MpH_0	54.05(2.56)	39.36(7.66)	6.97(1.03)	12.95(0.31)	19.97(5.12)	3.19(0.52)
Non-till/grass	T_0MgH_0	54.14(4.90)	24.82(7.86)	7.09(0.38)	12.90(0.32)	122.11(7.47)	2.65(0.84)
Non-till/pendimethalin	T_0M_0Hp	52.04(1.29)	27.81(8.06)	7.25(0.33)	13.07(0.44)	131.06(37.48)	2.51(0.27)
Non-till/metolachlor	T_0M_0Hm	56.73(3.38)	31.21(5.36)	7.49(0.31)	13.10(0.36)	101.13(15.43)	2.21(1.28)
Non-till weedfree	$T_0M_0H_0$	67.86(5.80)	41.68(6.51)	7.54(0.35	13.29(0.66)	77.41(12.47)	3.35(0.56)
Tilled/plastic/pendimethalin	T_1MpHp	52.29(2.70)	57.30(4.01)	8.03(0.53)	12.93(0.29)	22.49(7.98)	3.67(0.88)
Tilled/plastic/metolachlor	T_1MpHm	60.14(2.78)	50.14(5.47)	7.97(5.47)	12.83(0.45)	18.20(2.48)	2.91(0.57)
Tilled/grass pendimethalin	T_1MgHp	54.93(5.98)	36.25(3.98)	7.63(0.20)	13.01(0.36)	122.89(13.73)	2.07(0.38)
Tilled/grass metolachlor	T_1MgHm	54.29(2,12)	42.19(5.60)	7.43(0.45)	13.04(0.24)	83.14(13.32)	2.73(0.53)
Tilled/plastic	T_1MpH_0	55.82(6.83)	44.30(9.35)	7.42(1.73)	13.00(0.47)	18.24(3.03)	3.61(0.90)
Tilled/grass	T_1MgH_0	53.81(4.14)	27.53(10.57)	7.03(0.58)	13.18(0.15)	118.18(14.94)	2.61(0.32)
Tilled/pendimethalin	T_1M_0Hp	53.74(3.07)	31.25(12.73)	7.45(0.69)	13.15(0.43)	89.50(7.41)	2.77(0.93)
Tilled/metolachlor	T_1M_0Hm	54.54(3.50)	27.70(8.60)	8.02(0.47)	13.11(0.24)	119.65(12.07)	2.50(0.90)
Tilled weedfree	$T_1M_0H_0$	71.63(3.33)	57.80(13.76)	8.48(0.26)	13.20(0.22)	49.50(11.61)	3.57(0.85)
LSD 0.05		5.28	8.77	0.75	0.54	20.47	1.05

LSD 0.05 = List Significant difference at 95% level of probability
Values are means with standard deviations in parenthesis (n=10)

4.2. Pod number per plant

The tilled/plastic/metolachlor (T_1MpHm) treatment had more pod numbers (52.40±10.47) in 2008, the lowest being 19.00±12.63 from the non-tilled/grass/pendimethalin (T_0MgHp) treatment. The tilled/plastic/metolachlor (T_1MpHm) differs significantly ($p<0.05$) from non-tilled/grass/metholachlor, T_0MgHm (23.60±10.28). The interaction of tillage and weed control strategies were not significant ($p<0.05$) on pod numbers. In 2009, the largest mean pod number (57.80±13.76) was recorded in the tilled/no-mulch/no-herbicides ($T_1M_0H_0$) while the non-tilled/no mulch/penndimethalin (T_0M_0Hp) had the lowest (27.81±8.06). The tilled/plastic/pendimethalin (T_1MpHp) with a mean pod number of 57.30±4.01 differs significantly ($p<0.05$) from non-tilled-grass/pendimethalin (T_0MgHp) (24.08±10.63). However, the main effect of tillage, mulch and the interaction between tillage, mulch and herbicide were significant ($p<0.05$).

4.3 The stem diameter

The best stem diameter (8.77±1.00mm) was recorded in the tilled/grass/pendimethalin (T_1MgHp) treatment in 2008, the lowest being 7.03±1.29mm in the weedy plot. The tilled/grass/pendimethalin (T_1MgHp) differ significantly ($p<0.05$) from non-till/grass-mulch/metolachlor, T_0MgHm (7.18±1.03mm). The effect of tillage on stem diameter was significant ($p<0.05$) in 2008. In 2009 the tilled weed free control ($T_1M_0H_0$) had the best stem diameter (8.48±0.26mm), the lowest being 6.81±0.66mm in the non-tilled/grass/metolachlor (T_0MgHm) treatment. Tillage, mulch and the interaction between mulch and herbicide were significant ($p<0.05$) on the stem diameter.

4.4 100 Seed Weight

The highest mean 100-seed weight of 14.25$\pm$0.77g was recorded in the tilled/grass/pendimethalin (T_1MgHp) treatment and the lowest mean weight of 13.01$\pm$0.61g was recorded in the (non-till weedy plot) in 2008. The non-till weedy control were significantly different. However in 2009, the tilled weed free ($T_1M_0H_0$) and non-till weed free ($T_0M_0H_0$) recorded the highest mean (100-seed weight) of 13.29$\pm$0.22g and 13.29$\pm$0.66g respectively. The lowest mean 100-seed weight of 12.90$\pm$0.32g was obtained in the (non-tilled/ grass) T_0MgH_0 treatment. The integrated weed management does not produce any significant effect on 100-seed weight in 2009.

4.5 Soyabean grain yield

The integration of tillage/plastic/pendimethalin (T_1MpHp) produced the highest mean yield of 3.90$\pm$0.27 t/ha, comparable result were obtained in the control tilled hand weeded plot, $T_1M_0H_0$ (3.77$\pm$1.26t/ha). The grain yield was in the order tilled/plastic/pendimethalin (T_1MpHp) > Tilled weed free ($T_1M_0H_0$) > Non-tilled weed free ($T_0M_0H_0$) > Non-tilled/plastic/pendimethalin (T_0MpHp) > Tilled/plastic/metolachlor (T_1MpHm). The tilled/plastic/pendimenthalin (T_1MpHp) differ significantly ($p<0.05$) from tilled/plastic/metolachlor (T_1MgHm) in 2008. The main effect of tillage and weed control produced the observed significant ($p<0.05$) difference.

In 2009 the highest soyabean grain yield was also recorded in the tilled/plastic/pendimethalin T_1MpHp ($3.67\underline{+}0.88$t/ha) integration. This was closely followed by the tilled/plastic T_1MpH_0 ($3.61\underline{+}0.89$t/ha) treatment. The grain yield was in the order; tilled/plastic/pendimenthalin (T_1MpHp) > tilled/plastic (T_1MpH_0) > tilled weed free ($T_1M_0H_0$) > non-tilled weed free ($T_0M_0H_0$) > non-tilled/plastic/pendimethalin (T_0MpHp). The main effect of mulch and herbicides were significant ($p<0.05$) on the grain yield. The lowest grain seed yield of $1.64\underline{+}0.28$t/ha and $1.73\underline{+}0.41$t/ha was recorded from the non-tilled/grass/pendimethalin (T_0MgHp) treatment in 2008 and 2009 respectively

Weed density

The weed spectrum in the treatment plot indicated the Asteraceae family to be the dominant weed species. Others include Poaceae, Commelinaceae, Cyperaceae and Euphorbiaceae. The common weed species on the treatment plot in the two years were *Spilanthes* species, *Ageratum conzyoides* L., *Synedrella nodiflora* Gaertn, *Chromolaena odorata* L., *Tridax procumbens* L., *Poulzolzia guineensis* Benth, *Commelina* species, *Euphorbia heterophylla* L., *Eragrotis atrovirens* Desf. Trin.Ex steud, *Cyperus rotundus* L. and *Digitaria horizontalis* Willd (Table 5).

In 2008 *Spilanthes* species made up 33.37% of the weed species present in the non-tilled weed free ($T_0M_0H_0$) plot at harvest, 31.63% in tilled weed free ($T_1M_0H_0$), 31% in tilled/grass/pendimethalin (T_1MgHp), 23.53% in non-tilled/grass/metholaclor (T_0MgHm), 21.37% in non-tilled/grass/pendimethalin (T_0MgHp) and 19.48% in non-tilled/grass/metholachlor (T_0MgHm). The plastic mulched plots had no noticeable weed species owing to the total covering of the soil (Table 6).

However, in 2009, there was an upsurge of *Spilanthes* species in the treatment plots as follows: non-tilled/grass (T_0MgH_0) had 90.63%, tilled weed free ($T_0M_0H_0$) had 80.43%, tilled/grass/metholachlor (T_1MgHm) had 71.43%, non-tilled/grass/pendimethalin (T_0MgHp) had 69.57%, tilled weed free ($T_1M_0H_0$) had 66.66%, tilled/pendimethalin (T_1M_0Hp) had 64.44%, non-tilled/metolachlor (T_0M_0Hm) 64.29%, tilled/grass/metolachlor (T_1MgHm) had 56.25%, tilled/metolachlor

(T_1M_0Hm) had 54.55% non-tilled weed free ($T_0M_0H_0$) had 40.30%, tilled/grass/pendimethalin (T_1MgHp) had 36.36% (Table 7). *Spilanthes*, due to its aggressivity suppressed other weed species present on the treatment plots. There was also a shift in the weed flora to mainly broadleaf weeds. The grasses and *Chromolaena odorata* L. which were noticed at the time of clearing the plot gave way to *Spilanthes* species which dominated the treatment plot (Table7).

Table 5: The weed spectrum in the soyabean integrated weed management at harvest of the crop

Species	Family
Spilanthes species	Asteraceae
Synedrella nodiflora Gaertn.	Asteraceae
*Chromolaena odorata (*L.*)* R.M. King & Robinson	Asteraceae
Tridax procumbens L.	Asteraceae
Ageratum conyzoides L.	Asteraceae
Poulzolzia guineensis Benth.	Urticaeae
Spigelia anthelmia L.	Loganiaceae
Euphorbia heterophylla L.	Euphorbiaceae
Euphorbia hirta L.	Euphorbiaceae
Commelina benghalensis L.	Commelinaceae
Commelina diffusa J. K. Morton.	Commelinaceae
Eragrotis atrovirens Desf.	Poaceae
Digitaria horizontalis Willd.	Poaceae
Setaria barbata L. Kunth.	Poaceae
Cyperus rotundus L.	Cyperaceae
Mimosa pudica L.	Mimosoideae

Source: Field survey 2008 & 2009

Table 6: Mean weed density (number/m²) under an integrated weed management in 2008.

Weed Species	TGP	NGP	TPP	NPP	TMG	NGM	TPM	NPM	TWF	NWF	TW	NW
Spilanthes species	16.6	16	_	_	13.6	24	4	_	26	24.6	37.2	22.8
Ageratum conyzoides Linn.	8	6	_	_	5.2	6.4	_	_	4	4	8	4
Synedrella nodiflora Gaertn	6	6	_	_	6.8	6	_	_	4	_	4	8
Chromolaena odorata (L.) R. M. King & Robinson	7	15	4	_	5	13.6	_	_	15	14	10.4	9.6
Tridax procumbens Linn.	_	13.2	4	_	8	4	_	_	5.2	5.2	9.2	16
Spigelia anthelmia Linn.	_	_	_	_	5.2	8	_	_	4	6	10	6
Poulzolzia guineensis Benth.	4	4	4	_	4	4	_	_	8	_	10.8	8
Commelina species J.K. Morton	4	6.7	_	4	8	4	_	_	4	_	4	4
Euphorbia hirta Linn.	_	4	_	4	4	4	_	4	_	4	4	4
Euphorbiaheterophylla Linn.	_	4	_	4	4	14	_	_	_	4	12	_
Eragrotis atrovirens Desf.Trin Ex steud.	4	_	_	_	6	4	_	_	_	_	_	_
Setaria barbata Kunt	_	_	_	_	_	_	_	_	_	12	_	8
Cyperus rotundus Linn.	4	_	4	_	_	10	4	4	14	_	8	11

Source: Field survey 2008.

Key: TGP= Tilled/ grass/pendimethalin NGP= Non-tilled/grass/pendimethalin
TPP = Tilled/plastic/pendimethalin NPP = Non-tilled/pastic/pendimethalin
TGM= Tilled/grass/metholachlor NGM=Non-tilled/grass/metolachlor
TPM = Tilled/plastic/metolachlor NPM=Non-tilled/plastic/metolachlor
TWF = Tilled weed free NWF=Non-tilled weed free
TW = Tilled weedy NW=Non-tilled weedy

Table 7: Mean weed density (number /m²) under an integrated weed management in 2009

Weed Species	TGP	NGP	TPP	NPP	TGM	NGM	TPM	NPM	Twf	TP	NP	TPe	NPe	TGr	NGr	Tme	Nme	Nwf
Spilanthes species	12	16	1	1	27	40	1	1	36	1	1	29	27	20	29	24	36	37
Agerathumconyzoides Linn.	4	_	_	_	4	3	_	_	_	_	_	5	_	_	_	_	_	_
Chromolaena odorata (L.) R. M. King & Robinson	4	_	_	_	_	_	_	_	4	_	_	_	_	4	_	_	_	_
Synederella nodiflora Gaertn	4	2	1	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
Tridax procumbens Linn.	4	_	_	_	4	5	_	_	7	_	_	_	8	4	_	5	9	1
Poulzolzia guineensis Benth	_	_	_	_	4	4	_	_	_	_	_	_	4	_	_	_	_	_
Commelina species J.K.Morton.	4	5	_	_	4	_	_	1	4	_	2	_	_	_	1	_	_	_
Eragrotis atrovirens Desf. Trin. Ex steud	1	_	_	_	3	4	_	_	2	_	_	1	7	4	_	4	5	8
Digitaria horizontalis Willd	_	_	_	_	_	_	_	_	1	4	1.5	_	9	9	_	6	6	_
Cyperus rotundus Linn.	_	_	4.5	2	1	_	3	1	_	_	_	10	12	_	_	5	_	_
Euphorbiaheterophylla Linn.	_	_	_	_	1	_	_	_	_	_	_	_	_	_	2	_	_	_
Mimosa pudica Linn	_	_	_	_	_	_	_	_	_	_	3	_	_	_	_	_	_	_
Brachiaria deflexa (Schumach)	_	_	_	_	1	_	_	_	1	_	_	_	1	1	1	_	_	1

***Source*:** Field survey 2009.

Key: TGP=Tilled/grass/pendimethalin, TPP=Tilled/plastic/pendimethalin, TGM=Tilled/grass/metholachlor, TPM=Tilled/plastic/metol-achlor, TP=Tilled/plastic, TPe=Tilled/pendimethalin, TGr=Tilled/grass, TMe=Tilled/metolachlor. Twf=Tilled/weed free. NGP=Non-tilled/grass/pendimethalin, NPP=Non-tilled/plastic/pendimethalin, NGM=Non-tilled/grass/metholahlor, NPM=Non-tilled/plastic/metolachlor, NP=Tilled/plastic, NPe=Non-tilled/pendimethalin, NGr=Non-tilled/grass, NMe=Non-tilled/metolachlor, Nwf=Non=tilled/wee dfree

4.7 Weed dry shoot biomass

The weed dry shoot biomass was lowest in the non-tilled/plastic/pendimethalin (T_0MpHp) treated plot (11.33$\pm$2.69 g/m^2) in 2008. The tilled/plastic/pendimethalin (T_1MpHp) plot had 11.73$\pm$1.80 g/m^2, non-tilled/plastic/metolachlor (T_0MpHm) had 13.25$\pm$2.64g/m, and tilled/plastic/metolachlor (T_1MpHm) had 15.33$\pm$2.84 g/m^2. The grass mulched plots had higher weed dry shoot biomass (Tilled/grass/pendimethalin (T_1MgHp), 61.83$\pm$10.52 g/m^2 and tilled/grass/metolachlor (T_1MgHm), 99.48$\pm$29.94 g/m^2). The highest weed dry shoot biomass was recorded on the control weedy plot ($T_0M_0H_0$, 425.83$\pm$79.5g/m^2). The plastic mulch reduced the weed dry shoot biomass yield by 96.18% while the grass mulch reduced the biomass by 77.32%. The tilled weed free plot ($T_1M_0H_0$) reduced weed dry shoot biomass by 90.08% (Table 8).

In 2009, the effect of tillage, mulch, and herbicide was significant ($p<0.05$) on the weed dry shoot biomass yield. Also the interaction between mulch and herbicides was significant ($p<0.05$). The treatment with the plastic mulch also resulted in lower weed dry shoot biomass (20.17 g/m^2), the grass mulch had 116.63 g/m^2, the herbicide pendimethalin had 86.98 g/m^2 and metolachlor had 81.85 g/m^2 (Table 9). The integration of tillage, plastic mulch with herbicides was better than the integration with grass mulch.

The weed free control treatment reduced the weed dry biomass by 90.63%. The T_0MgHp (Non-tilled/grass/pendimethalin) treatment produced the highest weed dry shoot biomass of 136.41 ± 18.5 g/m^2, while the T_1MpHm (Tilled plastic/metolachlor) treatment had the lowest weed biomass, 18.2 ± 2.4g/m^2. The plastic mulch covering imposed on the soil significantly reduced the weed dry shoot biomass.

Table 8: The mean main effect of tillage, mulch and herbicides on growth parameters of soybean in 2008

Factor	Plant Height (cm)	Pod number	Stem diameter (mm)	100 Seed weight (g)	Grain yield t/ha	Weed dry shoot biomass (g/m^2)	Weed reduction (%)
Tillage	67.67	48.08	8.45	13.75	2.98	113.47	49.62
No-Tillage	59.56	33.57	7.68	13.68	2.24	111.75	50.38
SE	2.49	3.17	0.16	0.13	2.45	41.36	-
Herbicides							
Pendimethalin	59.13	42.67	8.37	13.93	2.76	37.78	88.82
Metolachlor 960EC	59.11	41.58	8.06	13.75	2.49	51.64	84.68
SE	1.90	4.46	0.18	0.15	0.26	11.83	-
Mulch							
Nylon Plastic	59.23	48.58	8.27	13.56	3.11	12.91	96.18
Grass	59.01	35.67	8.16	14.12	2.14	76.51	77.32
SE	1.90	4.46	0.18	0.15	0.26	11.83	-
Control							
Hand weeded	74.01	48.93	7.86	13.76	3.54	70.29	90.08
Weedy	71.2	27.52	7.67	13.20	1.62	426.3	39.95
S.E.	3.31	5.86	0.27	0.37	0.50	88.72	-

S.E.=Standard error of the means.

Table 9: Mean main effect of tillage, mulch and herbicides on growth parameters of soybean in 2009.

Factor	**Plant Height (cm)**	**Pod number**	**Stem diameter (mm)**	**100 Seed weight (g)**	**Grain yield t/ha**	**Weed dry shoot biomass (g/m^2)**	**Weed reduction (%)**
Tillage	56.81	41.61	7.73	13.06	2.94	71.24	52.67
No-Tillage	55.69	32.92	7.25	13.01	2.68	79.87	47.33
SE	1.25	2.44	0.10	0.03	0.14	10.64	-
Herbicides							
Pendimethalin	52.65	36.99	7.58	12.98	2.67	86.98	63.96
Metolachlor 960EC	56.55	35.56	7.47	13.02	2.60	81.95	65.97
SE	1.05	2.85	0.10	0.03	0.04	13.22	-
Mulch							
Nylon Plastic	55.59	45.07	7.49	12.91	3.24	20.17	91.07
Grass	53.73	30.48	7.26	13.03	2.37	116.63	76.06
SE	0.75	2.92	0.11	0.03	0.16	14.32	-
Control							
Hand weeded	69.75	50.24	7.52	13.2	3.46	254.01	90.63
SE	1.33	5.71	0.48	0.06	0.08	9.92	-

***S.E.** = Standard error of the means.

4.8 Soyabean grain yield versus weed dry shoot biomass

In 2008 experiment soyabean grain yield was highest in the tilled/ plastic/pendimethalin (T_1MpHp) treatment plot, this treatment also had lowest weed dry shoot biomass (3.90t/ha/11.73g/m^2). There was a significant weed control ($p<0.05$) which was translated to highest (3.90 t/ha) soyabean grain yield in the T_1MpHp plot. The lowest soyabean grain yield was recorded in the Non-till/ grass/pendimethalin (T_0MgHp) treatment (1.64 t/ha). Similar trend was observed in 2009 in the T_1MpHp treatment (3.67t/ha and 22.49g/m^2 . The lowest grain yield of 1.73t/ha and 136.41g/m^2 of weed dry shoot biomass was recorded in the Non-tilled/grass/pendimethalin (T_0MgHp) treatment. The tilled weed free ($T_1M_0H_0$) and non-tilled weed free ($T_0M_0H_0$) control produced 3.77t/ha and 3.31t/ha of grain yield and 66.18g/m^2 and 74.48 g/m^2 of weed dry shoot biomass in 2008 while 3.57t/ha and 3.35t/ha of grain yield and 49.50g/m^2 and 77.41g/m^2 of weed dry shoot biomass was recorded in 2009. The effect of the integrated weed control was significant.

No significant interaction was found for tillage and weed control on the soyabean grain yield and weed dry shoot biomass in 2008. In 2009 the main effect of mulch and herbicides was significant on the grain yield. The main effect of tillage, mulch, herbicides and interaction between mulch and herbicides was significant ($p<0.05$) on dry shoot weed biomass in 2009. When the main effect of tillage, mulch and herbicides were compared to the integrated effect it was discovered that the integration of the control strategies produced more grain yield than the main effect of the control strategies. The integrated approach was also more effective in reducing the weed biomass (Table10).

Table 10: Combined effect of integrated weed management strategies on soybean growth and yield parameters in 2009.

Integrated Weed Control		Plant Height (cm)	Pod Number	Stem Diameter	100 Seed Weight	Grain yield (t/ha)	Weed dry shoot biomass (g/m²)	Weed reduction (%)
No till grass pendimethalin	T_0MgHp	51.38	21.54	7.80	13.50	1.68	101.32	85.50
No till plastic pendimethalin	T_0MpHp	56.61	48.46	8.00	13.18	3.28	15.43	97.43
No till grass metolachlor	T_0MgHm	53.01	25.81	7.00	13.57	2.11	97.78	85.95
No till plastic metolachlor	T_0MpHm	59.55	37.02	7.41	13.47	2.47	17.91	97.43
No till plastic	T_0MpH_0	54.05	39.36	6.97	12.90	3.19	19.97	97.23
No till grass	T_0MgH_0	54.14	24.82	7.09	12.95	2.65	122.11	82.89
No till pendimethalin	T_0M_0Hp	52.04	27.81	7.25	13.07	2.50	131.06	86.35
No till metolachlor	T_0M_0Hm	56.73	31.21	7.49	13.10	2.10	101.13	85.83
No till hand weeded	$T_0M_0H_0$	66.86	36.30	7.39	13.26	2.66	164.01	71.46
Tilled grass pendimethalin	T_1MgHp	61.27	42.98	8.20	13.63	2.15	92.36	85.88
Tilled plastic pendimethalin	T_1MpHp	54.02	53.81	8.03	13.39	3.78	17.11	97.38
Tilled grass metholachlor	T_1MgHm	59.56	46.28	8.03	13.59	2.84	91.31	86.17
Tilled plastic metolachlor	T_1MpHm	60.13	51.27	8.34	13.34	3.01	16.76	97.45
Tilled plastics	T_1MpH_0	55.82	44.30	7.42	12.99	3.61	18.24	97.16
Tilled grass	T_1MgH_0	53.81	27.53	7.03	13.18	2.61	118.18	81.57
Tilled pendimethalin	T_1MpH_0	53.82	31.26	7.54	13.15	2.77	89.50	86.04
Tilled metolachlor	T_1M_0Hm	59.54	27.70	8.02	13.11	2.50	119.65	81.45
Tilled hand weeded	$T_0M_0H_0$	76.44	47.82	8.31	13.57	3.09	147.78	72.66
S.E.		1.44	2.40	0.11	0.06	0.13	10.77	-

S.E.= Standard error of the means

CHAPTER FIVE

DISCUSSION

Food production is the primary human activity and weed control is an integral part of this business. Weed management constitutes one of the greatest problem in the rainforest and humid savanna agro-ecosystem of Nigeria. The presence of weed in farms is regarded as an evidence of laziness and poverty on the part of the farmers. In the traditional agricultural set up, weeding is responsible for large family size as the population provides family labour for farm various farming activities of which weeding is the major one. Several methods of weed control (cultural, chemical and biological) have evolved but no single method has proved to have solved the menace of weed invasion without its associated environmental effects (Akobundu and Ekeleme, 2000). Udensi (2005) observed that to reduce food scarcity arising from shortage of labour for farm production especially weeding in this agro-ecology there is the need to incorporate strategies of weed management to meet the goals of the farmers. Weed management therefore remains imperative in food security because of its suppressive effects on crop performance (Olaniyan *et al.*, 2008).

Strategies for weed management in soyabean in the rainforest/savanna transition ecosystem of 0yo state, Nigeria, where this study was conducted include hand weeding, tillage, burning, crop rotation (cultural), use of herbicides (chemical) and preventive by fallow management and rouging of isolated weeds. One management strategy that could be adopted for weed control in the production of soyabean is the integrated approach, which forms the centre point of this study. The results from the adopted integrated weed management strategies showed that tillage, mulch and herbicides when combined appropriately had significant effect in suppressing the growth of weeds thereby increasing soyabean grain yield, reduced weed biomass and may reduce damage to the environment. The results are in agreement with previous studies which highlighted the effectiveness of tillage and herbicides for weed management in soyabean (Buhler, 2002; Ferrell *et al.*, 2008).

Combination of the three control options gave a better control of weeds than the main effects of a single option. The combination of tillage/ plastic/pendimethalin produced the most effective weed management strategy which also reflected in the highest soyabean grain yield obtained in this study. The integration of tillage and plastic mulch produced a soyabean grain yield that is above the main effect of the three factors stated above. The tilled/grass mulch treatment does not produce a comparable soyabean grain seed yield. The only comparable treatment is the tilled hoe weeded control method. The effect of this mulch integration with herbicides in suppressing weed growth and increasing yield agrees with the report of Colleen (2010) which states that mulch inhibits weed growth by thoroughly covering the soil thus depriving the weed seeds the ability of emergence and also prevents them from gaining foothold in the soil, most weeds will never be able to come in contact with the soil, the result of which is transferred to crop yield. The mulch treatment were significantly more effective at weed suppression than no treatment. The inorganic (nylon plastic) mulch had been reported to increase crop yield more than other mulch materials (IITA,1985; Compos De Araujo *et al.*, 1992; Nkeki, 1996) through increased soil temperature and nutrient contents, water conservation and weed control (Stapleton and Garza-Lopez, 1988; Opara-Nadi, 1993). Increased water conservation, intense heat production under the plastic mulch could be responsible for the high soyabean grain yield above the other weed management strategy (panicum mulch, hoe weeding).

Water is very critical in soyabean production (Ekeleme *et al.*, 2009). Awodoyin (2001) had reported higher water content under plastic and wood shavings. This high water content under plastic mulch and lack of competition for growth factors might have influenced the higher grain yield obtained under plastic mulch/herbicide integration in this study. The control weed free plots were significantly comparable to plastic mulch integration because there was no soyabean-weed competition for growth resources. However, care must be taken to avoid root disturbance when hoeing. The plastic mulch/herbicides integration were slightly better than the hoe weeded treatment. This may be due to the higher water conservation for crop use under the mulch/herbicide treatment than the hoe-weeded plot (Salau *et al.*, 1992), better soil coverage and solarisation effect under the plastic mulch (Adetunji, 1990; Nkeki, 1996) which prevented and reflected solar radiation needed for photo-induction of weed seed germination, and mechanical hindrance created by the film to seedling growth. Prolong intense heating under the plastic mulch (solarisation) could also lead to loss of viability in the weed seeds (Stapleton,1990).

The total coverage of the soil by plastic mulch does not allow any weed emergence except the Cyperaceae family that pierced through the nylon or at points where the nylon was torn for crop seed emergence. The grass mulch owing to decay and termite invasion allows weed to grow under the soyabean plant thereby competing with growth resources.

In the weedy plot in 2008 where the above ground competition for space was uncontrolled, soyabean had the least grain yield and highest weed biomass. Thus, Awodoyin (2001) had shown that higher water loss from the soil occurs through water transpiration rather than through evaporation. As such the plants on the weedy plots have moisture stress to contend with in addition to the above ground competition. The grass mulch due to decay encourages soil fertility improvement Opara-Nadi (1993) and rapid growth of weeds which reflected in the lower grain and higher weed biomass.

The plant height was significantly highest in both years in the weed free control closely followed by the tilled/plastic/metolachlor. This result is in agreement with the work of Kamalabi and Nanjappa (2000) who observed a significant plant height in a weed free soyabean plant closely followed by metholachor and cultural practices treatment. There are indications that herbicides inhibited photosynthetic activity in plants (Ashton and Crafts, 1981; Merril and Ross, 2009). The growth of the soyabean seedlings in the treatment plot might have been affected by the inhibitory role of the herbicides. The soyabean plant in the hoe-weeded plot was able to harness the environmental factors of growth due to lack of inhibition from any herbicide. Radosevich *et al.* (2007) stated that the effect of weed on crop yield depends on the various factors influencing the competitive ability of the crop against the weed, thus the weed that would have been a strong force affecting the plant were suppressed by the integrated management strategies.

The better pod yield obtained from the tilled mulch herbicide integration over the non-tilled treatment was as a result of the good soil tilth which enables the soyabean to access the soil nutrients and convert into assimilates which were partitioned into pod yield. Spitters (1983) and Olabode (2004) had observed that better pod yield obtained from sole okra resulted from better nutrient supply to individual okra due to reduced number of competitors.

The result also showed that tillage and pendimethalin alone when integrated in this ecology produced higher pod number and grain yields than the integration of metolachlor. The tilled/pendimethalin (T_1MpH_0) treatment is more sustainable than the other combined strategies, this in agreement with Ahmad *et al.* (2000) in which pendimethalin treatment gave highest soyabean grain and lowest weed biomass yield. The tilled/metolachlor/grass (T_1MgHm) combination produced a better result than the tilled/grass/pendimethalin (T_1MgHp) treatment. The T_1MgHp produced the lowest grain seed yield. The tillage method adopted also produced a significant grain seed yield, the main effect of tilled and no-till treatment are almost equal in terms of percentage weed reduction. The main effect of each of these tillage method is greater than the main effect of the grass mulch on grain seed yield. The result is in agreement with Akobundu (2000) which noted that reducing or eliminating tillage altogether and combining them with good management of ground cover could help to reduce weed pressure, conserve tropical soil, and make it possible to utilize tropical soils more intensively on a sustained basis.

Tillage as a method of weed control had turned over the weed seeds under the soil and those exposed were either desiccated by sunlight or shaded by the mulch or by the canopy of soyabean plant after germination. Tillage also contributes to the reduction of the weed biomass by about 50% in both years. The relatively higher weed biomass in the weed free plots compared to the grass and plastic mulch may be due partly to absence of any physical hindrance to weed emergence and partly to the weed emergence from continuously disturbed topsoil. Akobundu (1987) had observed that tillage encourages seedling emergence from the apparently inexhaustible seed bank in the soil in a similar manner to hoeing.

The common weed flora at the site, *Spilanthes* species accounted for 25.84%, *Chromolaena odorata* L. for 13.1%, *Tridax procumbens* L. for 9.1%, *Cyperus rotundus* L. for 8.2%, *Poulzolzia guineensis* Benth for 6.5%, and *Eragrotis atrovirens* Desf. for 2.1% in 2008. However, in 2009 there was an upsurge of *Spilanthes* species which accounted for 58.5%, *Tridax procumbens* L. for 8.3%, *Cyperus rotundus* L. for 6.6%, *Eragrotis atrovirens* Desf. for 6.7%, and *Chromolaena odorata* L. for 2.1%. The aggressive nature of the weed and the numerous light-seed produced resulted into this rapid invasion. Significantly, high weed population density was noticed in the weedy control in 2008 (426.8g/m^2).

Across all treatments in 2009 the plant species identification put *Spilanthes* far above the other weed species. The density notwithstanding, the soyabean plant had passed the critical stage of weed interference (3 to 6 weeks) before the weed growth becomes noticeable.

The weed dry shoot biomass in the plastic integration produced the lowest weed biomass and reduction in the weed density/population of 96.2% in 2008 and 91.1% in 2009. The result obtained is in agreement with the reports by Kamalabai and Nanjappa (2000), and Awodoyin *et al.* (2007) which showed that mulch treatment were significantly more effective at weed suppression than was no treatment at the 99% confidence level. In the same vein the reduction in the shoot weed biomass was attributable to the total covering of the soil by the plastic mulch and lack of exposure of the weed seeds buried deep down in the soil to solar radiation.

The herbicides had equally killed the weed seeds in the soil, as of the time the weed seeds which survived the herbicidal effect were to germinate at 6 week after planting, the soybean plants have shaded the soil thereby exhibiting effective competition. Kamalabi and Nanjapa (2000), Upadhyah (2002) observed that at harvest of soyabean, significantly lowest weed biomass was noticed in metolachlor coupled with cultural practices integration.

The weed biomass yield were higher in the tilled and the non-till integrated with grass mulch treatment with or without herbicides. The collective characteristics of weed groups such as aggressivity, spontaneous vegetative growth, and growth in undesirable location is responsible for the higher weed biomass yield. This observation was agreed to by Merrill and Ross (2009). The grass mulch and herbicide integration does not reduce the weed biomass as much as the plastic mulch and herbicide due to the rapid decay of the grass mulch which has been attributed to low C:N ratio in grass clippings (Awodoyin, 2001). The rapid decay of grass mulch resulted in rapid loss of mechanical hindrance which exposed the soil to sun radiation which may promote weed seed germination and survival of weed seedlings. The improvement of soil structure and organic matter may account for the improved crop performance and weed intensity is not high, nonetheless the soyabean grain yield obtained from each of these treatments are above the economic threshold level. The herbicides on the other hand might have leached down the soil profile. The higher weed biomass in the tilled/grass (T_1MgH_0) treatment plot did not result in significant grain yield losses because the weed became established after the critical period of weed interference of soyabean. The result obtained from this study shows that tillage, mulch and herbicide integration reduced weed dry shoot biomass by 83.4%, tillage and mulch by 77.0%, tillage and herbicides by 63.6%, and control by 77.9%.

The 100 seed weight recorded (130.6mg) falls within the range of 120-280mg observed by Asian Vegetable Research and Development Centre (AVRDC 2004). The soyabean plant response to herbicide and mulch shows a retardation of growth compared to the control. The control was observed to have produced the tallest plants due to less weed competition and no herbicide treatment. Merril and Ross (2009) stressed that plant responds to herbicides in ways that range from stimulated growth, through temporary retardation and loss of vigour from which the plant usually recovers, to irreversible growth and final death. This assertion seems to have confirmed the result obtained in the height of the plant. The height of the soyabean plant is not an index of more pod production and subsequent grain yield as evidenced from this study, but the proportion of the assimilates that is partitioned for the pod-seed-fill. The significant pod number produced as a result of the main effect of tillage and mulch and the interaction between tillage, mulch and herbicides resulted in higher grain yield. The tilled/grass/pendimethalin (T_1MgHp) treatment with the lowest pod number (21.54) also had the lowest grain yield of 1.68 t/ha.

The density of the soyabean plant 333,333 plants/ha encouraged rapid canopy closure which provided a shading effect on the weed species and subsequent weed suppression as obtained in this study. According to Futch and Singh (2008), the use of cover crops for weed control is promising as it has advantages such as reduction in soil erosion, sand blasting during dry conditions and addition of nutrients to the soil through decomposition of leaf fall, mineralization and nitrogen fixation by nodulating leguminous cover crops. Murphy *et al.* (1996) had shown that narrow crop rows reduced the biomass of late emerging weeds. The result obtained in this study showed that an integrated weed management strategies if well manipulated would ensure lasting suppression of weeds and subsequent increase in soyabean crop yield.

CHAPTER SIX

SUMMARY AND CONCLUSION

The integration of different weed management strategies in soyabean showed that:

(a) Tillage/plastic mulch/pendimethalin produced higher grain yield (3.78 t/ha) than the result obtained from other integrated weed management strategy. Tillage integrated with pendimethalin is however more practicable considering the availability of the nylon plastic.

(b) Tillage/plastic mulch/herbicide treatment resulted in greater reduction (96.4%) in the weed density and lowest weed biomass (16.6g/m^2) than other treatments.

(c) The control weed free method gave a high soyabean grain yield (3.5 t/ha) and good control of annual weed comparable with the best integrated weed management strategy above. When weed are controlled, better grain yield could be obtained whether the soil is tilled or untilled.

(d) The common weed species (*Spilanthes)* constituted 25.84% and 58.45% of the weed flora in 2008 and 2009 respectively. It is a secondary invasive plant, there is the need for further studies on the bio-ecology of the weed species and its effect on food production.

The overall result indicated that an integrated weed management strategy, if well utilized, would ensure lasting weed suppression without constituting any environmental hazard. Information on weed management systems is therefore needed so that producers can develop systems that minimize the environmental impacts of weed control without sacrificing profitability of crop production. The development of sustainable integrated weed management system such as conservation tillage, ground cover, narrow spacing, competitive cultivars, herbicide use, as highlighted in this study is required to exploit the benefit of each practice to maximize weed control, and minimize herbicide input and protect the environment.

REFERENCES

Adetunji, I. A. (1990). Effect of mulching and Irrigation on growth and yield of lettuce in semi-arid region. *Biotronic*, 19: 93-98.

Ahmad, M; Sha, S.M; Mirza, M.Y. and Ali, N. (2000). Evaluation of pre-emergence herbicides in autumn. *PARC Scientist* 3. 144-146.

Akobundu, I.O. (1980a). Weed science research at the IITA and research needs of Africa, *Weed Science* 28: 439-445.

Akobundu, I.O. (1980b). Economics of weed control in African tropics and sub-tropics. *Proc. 1980 British Crop Protection Conf- Weeds*. vol. 3 pp. 911-920

Akobundu, I.O. (1987).Weed Science in the Tropics. Principles and Practices. John Wiley & Sons, New York. 522pp.

Akobundu, I.O. (1998). Basic elements for improved weed management in the developing world. In: Report of the expert Consultation on Weed Ecology and Management pp.93-101. FAO.Rome.

Akobundu, I.O. and Ekeleme, F. (2000). Effect of method of *Imperata cylindrica* management on maize grain yield in the derived savanna of South-western Nigeria. *Weed Research*. 40: 323-334.

Aldrich, R.J. (1970). Weed-crop Ecology: Principles in Weed Management. Breton Publishers, North Situate. 465 pp.

Aldrich, S. A. and Scott, W. O. (1984) Modern soyabean production. S and A Publications, Champain, IL.

Altieri, M. A. (1995). Agro-ecology. The Science of Sustainable Agriculture. West View Press (IT Publication).pp 346

Ashton, F. M. and A.S. Crafts (1981). Mode of Action of Herbicides. 2nd ed. S. Wiley & Sons, New York, 525 pp.

Asoegwu, S.H. (1991).Effects of cover ,mulching and planting time on some soil physical properties and soil loss in pineapple plots. *Agricultural Mechanization in Asia, Africa and Latin America* 21: 39-43

AVRDC (2004). Progress Report for (2002). Shanhua, Taiwan: *Asian Vegetable Research and Development Centre.*

Awodoyin, R.O. (2001).Biology of sickle pod (*Senna obtusifolia* (L.) Irwin and Barneby) and its potentials as inter-row mulch plant in weed control. Ph.D Thesis, University of Ibadan, Ibadan, Nigeria. 233pp.

Awodoyin, R.O. and Sola Ogunyemi (2005). Use of sicklepod, *Senna obtusifolia* (L.) Irwin and Berneby, as mulch interplant in cayenne pepper, *Capsicum frutescenes* L., production. *Emirate Journal of Agricultural Science (Al-Ain)* 17(1): 10-22

Awodoyin, R.O; Ogbeide, F.I. and Oluwole, O. (2007). Effects of three mulch types on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) and weed suppression in Ibadan, rainforest-savanna transition zone of Nigeria. *Tropical Agricultural Research and Extension* 10: 53-60.

Ayeni, A. O. (1991). Hand/Mechanical weed management as an option in Nigerian agriculture. *Nigerian Journal of Weed Science* 4: 71-77.

Bakut, H.B. (1985). Effects of weed competition and chemical weed control on mixtures of maize and chilly pepper. M.Sc Thesis, Faculty of Agriculture, Ahmadu Bello University, Zaria Nigeria. 125pp.

Bhan, V. M. (1995). Weeds associated with soyabean and their control. In: Soyabean production, protection and utilization. Whighan, D.K., ed., *Int. Soy Service 6*. University of Illinois, Champaign-Urbana 147.

Bouyoucous, G.H. (2007).*Agronomy Journal* 43: 434-438.

Bray, K. (2003). Soil Test for Plant Available Phosphorus, College of food Agric and Environmental Science Publication, Osu Extension, ATI, OARDC 22pp.

Bridges, D.C; Barry, J.B. and Barbour, J.C. (1992). Wild poinsettia (*Euphorbia heterophylla)* interference with peanut *(Arachis hypogea).*Weed Science 40: 37-42.

Brust, G.E. and G. J. House (1998). Weed seed destruction by arthropods and rodents in low-input soyabean agro-ecosystem. *American Journal of Alternative Agriculture.* 3: 19-25.

Buhler, D. D. (1992). Population dynamics and control of annual weeds in corn (*Zea mays)* as influenced by tillage systems. *Weed Science* 40: 241-248.

Buhler, D. D. (1995). Influence of tillage systems on weed population dynamics and management in corn and soyabean in central. USA *Crop Science* 35: 1247-1258

Buhler, D. D. (2002). Challenges and opportunities for integrated weed management. *Weed Science* 50: 273-280.

Buhler, D. D. and Gunsolus, J. L. (1996). Effect of date of pre-plant tillage and planting on weed population and mechanical weed control in soyabean (*Glycine max (L.*). *Weed Science* 44: 373-379.

Burkley, N. G. (1980). No tillage weed control in the tropics. In: I. O. Akobundu (ed.) Weeds and their control in the humid and sub-humid tropics, Ibadan, Nigeria. IITA Proceeding Series 3, 12-21.

Burnside, O.C. (1979). Tolerance of soyabean cultivar to weed competition and herbicide. Weed Science 20: 294-297.

Callaway, M. B. (1992). A Compendium of crop varietal tolerance to weeds. *American Journal of Alternative Agriculture* 7: 169-180.

Challaiah, R. E; Ramsel, G.A; Wicks, O. C; Burnside O.C. and Johnson, V.A. (1983). Evaluation of the weed competitive ability of winter wheat cultivars. Proceedings of North Central Weed Control Conference, pp 85-91. North Central Weed Control Conference, Columbus, Ohio.

Chivinge, O.A. and Schweppenhauser, M.A.(1995). Competition of Soyabean *Glycine max (L.)* Merril with Blackjack *Bidens pilosa* L. and Pigweed *Amaranthus hybridus* L. *African Crop Science Journal* 3(1): 73-82.

Chivinge, O. A; Mashingaidze, A. B. and Mutsvairo, M. (1996). Upright starburn weed competition with soyabean. *African Crop Science Journal* 4: 63-70.

Coble, H. D. and R. L. Riter (1978). Pennsylvania smartweed influence in soyabean. *Weed Science* 26: 556-559.

Colleen, V. 2010. Mulch for weed control and soil health *http://organic gardening.about.*com/*od/organimaintenance/almulch.htm*.

Compos De Aranujo, J.A; Samparo, A.C; Durigan, J.F. and Campus De Araujo, S.M. (1992). The effects of mulching on the development of pineapple (*Annas comosus* (L.) Merril. C.V. Smoth Cayene). Proceedings of a conference held in Grenada, Spain, 3-8 May, 1992 (eds. Bados, N.C. and Rodriquez, J.H.).

Crook, T. M., and Renner, K. A. (1990). Common Lambsquatter *(Chenopodium album L*) competition and time of removal in soyabean (*Glycine max*). *Weed Science* 38: 358-364.

Crutchfield, D. A. (1984). Effect of wheat mulch on weed control and weed growth. Ph.D dissertation, University of Nebraska, Lincoln.

Delvin, R.M. and R.P. Cunningham (1970). The inhibition of gibberrellin acid induction of amylase activity in barley endosperm by certain herbicides. *Weed Res.* 10: 316-320.

Duke, W.B; F.W. Slife; J.B. Hanson and A.S. Butler (1975). An investigation of mechanism of action of propaclor. Weed Science. 23: 142-147.

Eaton, B. J; Russ, O. G. and Feltner, K. G. (1976). Competition of velvet leaf, prickly sida and Venice mallow in soyabean. *Weed Science* 24: 224-228.

Ekeleme, F., Omoigui, L.O., Dugje, I. Y., Lavaikumar P.L., Kamara, A. Y., and Bandyopadhyay, R. (2009). Farmers' guide to soyabean production in Northern Nigeria. *http:/www.erudit.org/2009*. pp 18.

Eplee, R.E. (2003). Overview of the invasive plant problem-rationale for weed prevention. Invasive plants in Natural and managed system. Linking science and management and the 7th International Conference on the Ecosystem and management of the Alien Plant invasion, co-sponsored by the Ecological Society of America and Weed Science Society of America, *Abstract*, pp 27.

Fernandez, E.C.M. and Sanches, P.A. (1990). The role of organic inputs and soil organic matter for nutrient cycling in tropical soils. In: organic matter and tillage in humid and sub-humid Africa. Bangkok,, Thailand IBSRAM

Ferrell, J. A; MacDonald G.E. and B.J. Brecke, (2008). Weed Management in Soyabean. US Department of Agriculture, Co-operative extension service, University of Florida. pp 24.

Forcella, F. (1987). Characteristics associated with highly competitive soyabean. *Agronomy abstract,* 1987: 111

Fourie, J.C. (2005). Cover crop management in the vineyards of the Lower Region, South Africa:1. Performance of grass and broad leaf species *South Africa. Journal Enol. Vitic. 25(2):* 140-146.

Futch, S.H. and Singh, M. (2008). 2008 Florida Citrus Pest Management Guide: Weeds. U.S department of Agriculture, Cooperative Extension service, University of Florida. Pp 1-20. www.edis.ifas.ufl.edu.

Gerber, H.R; G. Muller and L. Ebner (1974). A new grass killer herbicides. Proc. Br. Weed Conf. 12: 787-794.

Gerbhardt, M. R. (1981). Cultural and chemical weed control system in soyabean (*Glycine max L*) *Weed Science* 29: 133-138.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. John Wiley & Sons. New York, USA 680pp.

Gregg, A. J; Hoverstad, T. R. and Greenwald, R. E. (1998). Integrated weed management using narrow maize row spacing, herbicides and cultivation. *Agronomy Journal* 90: 40-46.

Hadley, P.E; E.H. Roberts; R.J. Summerfield and F.R. Michin. (1984). Effects of temperature and photoperiod on flowering in Soyabean (*Glycne max* (L.) Merril. A Quantitative model. *Annals of Botany 53: 669-681*.

Hagwood, E.J; Baunaan, T.T; William, J.L. Jr. and Screiber, M.M. (1980). Growth analysis of soyabean *G.max* in competition with velvet (*Abutilon theophrasti*). *Weed Science*. 28: 729-734.

Hamman, P.C. (1974). Discovery, development and current status of the chloroacetamide herbicides. *Weed Science* 25: 541-545.

Holt, J. S. (1995). Plant response to light: A potential tool for weed management. *Weed Science* 43: 473-482.

Hymowitz, T. and Singh, R.J. (2008). Taxonomy and speciation. In Soyabean improvement, production and uses. 2nd Ed. pp 23-33.

IITA (1978). Annual report, IITA, Ibadan, Nigeria, 78pp.

IITA (1979). Annual report, IITA, Ibadan, Nigeria.

IITA (1985). Annual report for IITA for 1984, IITA, Ibadan, Nigeria.

IITA (1990). Soyabean for good health, Annual report for 1989, IITA, Ibadan, -Nigeria, 23pp

IITA (1997). Annual report for IITA for 1996, IITA, Ibadan Nigeria.

Jackie, T. (2010). Edible forest gardening, Wikkipedia vol 1.

Jackson, M. L. (2004). Soil chemical analysis. Prentice Hall Inc. Eaglewood Cliffs N. J.

Jason, VanDriesche and Roy VanDriesche (2000). Nature out of place. Biological invasion in the global-age. Washington DC. Island Press.

Kamalabai, B.A. and Nanjappa, (2000), Economics of different weed control treatment in sunflower. *Kamataka Journal of Agric. Sciences*, 13: 427-429.

Keely, P. E. and Thullen, R. J. (1978). Light requirement of yellow nut-sedge (*Cyperus esculentus*) and light interception by crops. *Weed Science* 26: 10-16.

Kelner, D. (2005). Integrated weed management: Making it work in your farm. Manitoba Agriculture; Saskatchewan Agriculture and food and Doug Derksen, Agriculture and Agri-Food Canada.

Khan, M.A; Shah, S.M; and Mirza, M.Y. (1999). Evalation of pre-emergence herbicides and their application methods for weed control in soyabean. *Parc Scientists* 2(4): 1296-1298.

Kiely, T; D. Donaldson and A. Grube (2004). Pesticide industry, sales and usage: US EPA. office of pesticide programme, Washinton D.C.

Kurchania, S.P; Bhella, C.S; Tiwari J.P. and Paraki, N.R. (2001). Bio-efficiency of feroxy-a-prop-ethyl and lactofern for weed control in soyabean. Indian Journal of Weed Science 31: 25-28.

Kust, C.A. and Smith, R.R. (1969). Interaction of linuron and row spacing for control of yellow foxtail and barnyard grass in soyabean. *Weed Science* 17 : 489-491.

Lal, R. (2006). Tillage systems in the tropics: Management options and sustainability. *Technology and Engineering* 256pp.

Legere, A. and Schreiber, M. M. (1989). Competition and canopy architecture as affected by soyabean (*Glycine max*) row width and density of redroot pigweed (*Amaranthus retroflexus*). *Weed Science* 37: 84-92.

Li, H. and J.W. Burton (2002). Selecting increased seed and density to increase indirectly Soyabean seed protein concentration. *Crop Science* 42: 393-398.

Liebman, M. and Gallandt, E.R. (1997). Many little hammers: ecological management of crop-weed interactions. pp 291-343. In L. E. Jackson, ed; *Ecology in Agriculture*. San Diego, CA; Academic Press.

Liebman, M. and Ohno, T. (1998). Crop rotation and legume residue effects on weed emergence and growth: applications for weed management, pp 181-221. In J. L. Hartfield, D.D. Buhler and Stewata, B.A. ed. Integrated weed and soil management. Chelsea, MI: Ann Arbar Press.

Liu, K. (1977). Soyabean chemistry, technology, and utilization. Chapman and Hall, New York, USA.

Lo, N.P. (1990). Control of *Ischaemum rugosum* and other grasses in direct seeded rice. In. Abstract, 3rd International Conference on pH protection in the Tropics. Genting Highland, Malaysia pp 44.

Lolas, P. C. and Coble N. D. (1982). Non-Competitive effect of Johnson grass (*Sorghum halopense*) on soyabean (*Glycine max L.*) *Weed Science* 30: 588-593.

Louise, B. and Brown, J. (1996). American garden book, New York, Macmillan US, 768pp.

Mahn, E. G. and Helmecke, K. (1979). Effect of herbicide treatment on the structure and functioning of the agro-ecosystems, In: Structural changes in the plant community after the application of herbicide over several years. *Agro ecosystem* 5: 159-179.

Malik, V. S; Swanton, C. J. and Michaels, T. E. (1993). Interaction of white bean (*Phaseolus vulgaris L.*) cultivars, row spacing and seeding density with annual weeds. *Weed Science* 41:62-68.

Merril, A. and Ross, C. (2009). Applied weed science: Including the ecology and management of invasive plants. 3rd ed. John Wiley and Sons. New York. 359pp.

Miller, P. M. (1976). Plastic and hay mulches for tropical fruit crops. *Biological agriculture and horticulture*, 6: 221-227.

Minotti, P. L. and Sweet, R. D. (1981). Role of crop competition in limiting losses from weeds Pp. 351-367. In. D. Pimental ed. CRC Handbook of Pest Management in Agriculture, Vol. 11 CRC Press, Boca Paton, FL, USA.

Mohammed, E. S; Nourai, A. H; Mohammed, G. E; Mohammed, M. I. and Saxena, M. C. (1997). Weeds and Weed Management in Irrigated lentil in Northern Sudan. *Weed Research* 37: 211-218.

Moody, K. (1982). Weeds and shifting cultivation. FAO soils bulletin, 24:155.

Murphy, S.D; Yakubu, Y; Wiese, S.F. and Swanton, C. J. (1996). Effect of planting pattern and inter-row cultivation on competition between maize (*Zea mays*) and late emerging weeds. *Weed Science* 44: 856-370.

Nave, W. R. and Wax, L. M. (1971). Effect of weeds on soybean yield and harvesting efficiency. *Weed Science* 19: 533-535.

Nkeki, K. (1996). Effects of some mulch materials on growth and yield of tomato in the semi-arid region of Borno state. M.Sc. University of Maiduguri, Nigeria 98pp.

OGADEP (2003). Ogun State Agricultural Development Programme. *Field diary for Village/Block Extension Agents*

Ogunyemi, S. (1977). The distribution of some weeds of arable crops in Southwestern Nigeria. In: Proceedings Seventh Conference of the Weed Science Society of Nigeria.

Ogunyemi, S. and Ojo, O.I. (2000). Interference of *Commelina benghalensis L.* with the performance of *Solanum macrocarpon* and *S. aethiopicum*. *Nigerian Journal of Ecology* 2: 38-40.

Ogunyemi, S; Awodoyin, R.O; Osunkoya, O.O; Olabode O.S. and Wewe, O.F. (2001). Response of *Vigna unguiculata (L.)* Walp. and *Amaranthus cruentus (L.*) Sauer Thell. to interference from *Acalypha segetalis* Mull. Arg. on marginal lands in South Western Nigeria. *African Crop Science Proc.* Vol.5 pp 1-10.

Okigbo, B.N. (1995). Major farming systems of the lowland savanna of sub-sahara Africa and the potential for improvement. In: Moist savanna of Africa: Potentials and constraints, for crop production. B.T. Keng, I. O. Akobundu, V. M. Manyong, R. J. Carsky, N. Saginga and E. A. Kueneman, eds. Proceedings of the International Workshop held in Cotonou, Republic of Benin, 19-23 September 1994. pp 31-48. Produced by IITA, Ibadan, Nigeria.

Olabode, O.S; Ogunyemi, S. and Awodoyin, R.O. (1999). Critical period for the removal of *Tithonia diversifolia* Hemsl. A. Gray. In maize (*Zea mays)* plots. *Annals of Agric Science (*1*):* 11-14.

Olabode, O.S. (2004). Agronomic uses, influence, and control of *Tithonia diversifolia* (Helms) A. Gray in *Abelmoschus esculentus* (L,) (Moench) and *Citrullus lunatus* (Thumb.) Mansfd cropping system. Ph.D Thesis, University of Ibadan.Ibadan Nigeria.181pp.

Olabode, O. S; Ogunyemi, S. and Adesina, G.O. (2007). Response of Okra (*Abelmoschus esculentus* (L.) to weed control by mulching. *Journal of Food Agriculture and Environment* 5(3&4): 324-326.

Olaniyan, A.A; Okafor, B.N; Awodoyin, R.O; Lawal, I.O. and Alli, M. (2008). Cover crops for weed management in a mature Citrus Orchard. In: Organic agriculture and the millennium development goals. Proc. Of the 1st West African Summit and 4th National conference on Organic Agriculture. pp 160-163.

Opara-Nadi, O. A. (1993). Effect of Elephant grass and plastic mulch on soil properties and cowpea yield In: Mulongoy, K. and Mercky; R. (eds.) Soil organic matter dynamics and sustainability of tropical agriculture IITA/Ku Lerwen. John Wiley and Sons New York. pp 357-360.

Palada, M. C; Vogew, W. O. and Mutsaers, M. J. (1985). Exploratory survey of Ijaye Area, Oyo State, Nigeria. *On Farm Research Bulletin* No. *2*. IITA, Ibadan. Nigeria.

Patrick, W. (2004). The Earth Care Manual. Permanent publications ISBN 978-1856230216.

PBO, Plant Bio-safety office (2000). The biology of Glycine max (L) Merril. In: A companion document to directive 94-08 (Dir-94-08). Assessment criteria for determining environmental safety of plant and novel traits. Canadian Food Inspection Agency, Ottawa, Ontario, Canada.

Pester, T. A; Burnside, O.C. and Orf, J. H. (1999). Increasing crop competiveness to weeds through breeding. *Journal of Crop Production* 2: 31-58.

Pike, D. R; Stroller, E. W. and Wax, L. M. (1979). Modeling Soyabean growth and Canopy apportionment in Weed-soyabean (*Glycine max*) Competition. *Weed Science* 38: 522-527.

Pillae, P; Davis, D.E. and Truelove, B. (1990). Effects of metolachlor on germination growth, leucine uptake and protein synthesis. *Weed Science* 27: 634-636.

Plahar, M. A; Y.C. Hung and K.H. Mcwatten. (2006). Improving the nutritional quality and maintaining consumption quality of akara using curdlan and composite flour. *International Journal of Food Science and Technology* 41: 962-972.

Poku, J. A. and Akobundu I. O. (1985). Weed management designed for small-holdings. In: Singh, S. R. and Rachie, H.O. (eds.) Cowpea, Research, Production and utilization, chichester, John Wiley and Sons. 327-334.

Radosevich, S; Holt, J. and Ghersa, C. (2007). Ecology of weeds and invasive plants: Relationship to Agriculture and Natural Resource management; 3rd ed. Wiley-Inter Science, Hoboken, NJ.

Raji, J.A. and P.O. Oyekan. (2002). The agronomic assessment of the nutrient production potentials of Soyabean/Sorghum intercrop in peasant farming system. *Crop Research.* Hisar 24(2): 242-246.

Robert, N. K; Wicks, G. A. and Wilson, R. G. (1996). Ridge-till an integrated weed management system. *Weed Science* 44: 417-422.

Rogers, N.K; Buchanan, G.A. and Johnson, W.C. (1976). Influence of row spacing on weed competition with cotton. *Weed science* 24: 410-413.

Saginga, N; J. Okogun; B. Vaanlanwe and K. Danshiel (2002). The concentration of nitrogen by promiscuous Soyabean to maize-based cropping in the moist Savanna of Nigeria. *Journal of Plant and Soil* 24(2): 223-231.

Salau, O.A; Opara-Nadi, O.A. and Swennen, R. (1992). Effects of mulching on soil properties, growth and yield of plantain on a tropical ultisol in South Eastern Nigeria. *Soil Tillage Res* 23: 73-93.

Schreiber, M. M. (1992). Influence of tillage, crop rotation and weed management on giant foxtail (*Setaria faberi*) population dynamics and crop yield. *Weed Science* 40: 645-653.

Sether, A. K; Khau, C. H. and Fua, J. M. (1971). Minimum and Zero tillage techniques and post planting weed control in rice. *Proceedings* 3rd *Asian Pacific Weed Science Conference* pp. 188-189.

Shaw, W. C. (1978). Herbicides: The Cost-benefit ratio: The public view. Proceedings South. *Weed Science Society* 31: 28-43.

Spitters, C.J.T. (1983). An alternative approach to the analysis of mied croppiig experiments. In: Estimation of competition effects. *Netherlands Journal of Agric Science* 31: 1-11.

Spore, C.T.A. (1992). Bimonthly bulletin of the technical centre for agricultural and rural cooperative No. 39.

Stapleton, J. J. and Garza-Lopez, J.G. (1988). Mulching of soils with transparent and black polyethylene films to increase growth of annual and perennial crops in Southern Mexico. *Tropical Agric.* (*Trinidad*). 65: 29-33.

Stapleton, J.J. (1990).Thermal inactivation of crop pests and pathogen and other soil changes caused by solarisation. Proc. 1st intern. Conf. Soil solarisation, Amman, Jordan, 19-25 Feb,1990.(Eds. Devay, J.E; Stapleton J.J. and Elmore, C.L.), 220-228.

Steckel, L.E; Defelice, M. S. and Sims B. D. (1990). Integrating reduced rates of post emergence herbicides and cultivation for broad leaf weed control in soyabean (*Glycine max*). *Weed Science* 38: 541-545.

Sreet, J.E. and Lanhan, D.J. (2005). Pendimethalin as a delayed pre-emergence herbicide in rice. Dowagro services LLC

Stroller, E.W; Harrison, S.K; Wax, L.M; Regner E. E. and Nafzinger E.D. (1987). Weed interference in soyabeans (*Glycine max*) Rev. *Weed Science* 3: 155-181.

Swanton, C. J. and Wiese, S. F. (1991). Integrated weed management: the rationale and approach. *Weed Technology* 5: 651-663.

Taylor, T.A. (1999). Crop Pests and Diseases. Oxford Univ. Press. 70pp.

Teasdale, J. R. (1995). Influence of narrow/high population corn (*Zea mays*) on weed control and light transmission. *Weed Technology* 9: 113-118.

Thurlow, D. L. and Pitts, J. H. (1983). Planting date and row spacing affect growth and yield of soyabeans. *Highlights Agric Res* 30(3): 12.

Udensi, E.U. (2005). Interference and management of Spear grass *(Imperata cylindrica* (L.) Raeuschel) in Maize (*Zea mays* L.) in Oyo State,Nigeria. Ph.D Thesis University of Ibadan, Ibadan. Nigeria. 246pp.

Unamma, R.P.A; Ene, L.S.O; Odumkwe, S.O. and Enyinnia, T.E. (1986). Integrated weed management for cassava intercropped with maize. *Weed Research* 26: 9-17.

Upadhyah, V.B. (2002). Effect of sowing dates and weed control methods on weed management and productivity of pigeon pea. In M.P. *India Journal of Weed Science*. 34: 301-302.

Usoroh, N.J. (1995). Effective weed control strategies for fruit and vegetable production in Nigeria. *Acta Horticulture* 123: 299-304.

Utulu, S.N., I.O. Akobundu and A. A. A. Fayemi (1986). Persistence and downward movement of some selected herbicides in the humid and sub humid tropics. Crop Prot., 5. 129-136

Van Heemest, H.D.J. (1985). The influence of weed competition on crop yield. *Agricultural systems*. 18: 81-93.

Wahua T.A.T. (1999). Applied Statistics for Scientific Studies. African links books 356 pp.

Walker, R.H. 1995). Preventive weed management. In A.E. Smith, ed. Handbook of weed management systems pp 35-50. New York: Mariel Dekker.

Walker, R.H. and Buchanan, G.A. (1982). Crop manipulation in integrated weed management systems. *Weed Science* 30 : 17-24.

Walkley, A. and Black, L.A. (2007). *Soil Science Journal* 37: 29-38

Wax L. M. and Pendleton, J. W. (1968). Effect of row spacing on weed control in soyabeans. *Weed Science* 16: 462-465.

Wiese, A. F. (1983). No tillage crop production in Temperate Agriculture. In I. O. Akobundu and A. F. Deutsch (eds.), No tillage crop production in the Tropics. IPPC, Oregon State University, IPPC Doc. 46-13-83.

Wilcox, J.R. and R.M. Shibbles (2001). Interrelationships among seed quality attributes in Soybean. *Crop Science Society of America*. 41: 11-14

William, S. and Akiko, A. (2007). History of soyabeans and soyfoods: 1100 BC to the 1980's. A special report on the history of soyabeans and soyfoods around the world.

Wolf, W.J. and J.C. Cowan (1975). Soyabean as a food source. Revised edition. CRC Press, Cleveland, Ohio USA.

Yelverton, F.H. and Coble, H. D. (1991). Narrow spacing and canopy formation reduces weed resurgence in soyabean (*Glycine max*). *Weed Technology* 5: 169-174.

Zimdahl, R. L. (2004). Weed Competition. A Review, 2nd ed; Blackwell Publishing Professional Ames I.A.

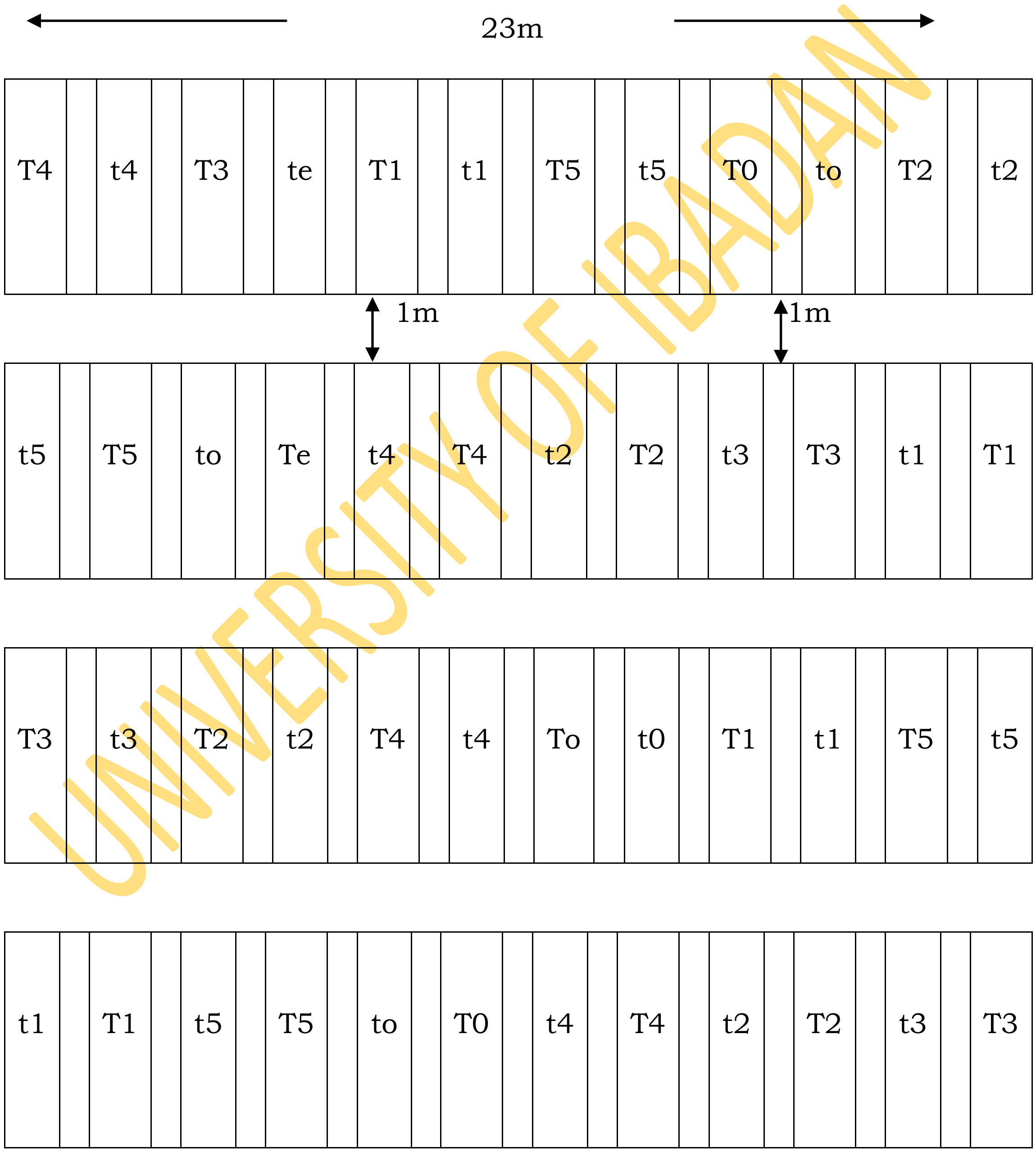
Zimdahl, R. L. (2007). Fundamentals of Weed Science, 3rd. ed. Academic Press, San Diego. C. A.

APPENDICES

APPENDIX I

Experiment field layout (a) 2 x 6 factorial (b) 2 x 3 x 3 factorial of an integrated weed management strategy in Apapa, Oyo State in (a) 2008 and (b) 2009

(a)



(b)

T6	t4	t2	t5	T7	t8	T1	t9	t3
t6	T4	t2	T5	t7	T8	t1	t9	t3

t2	T6	t4	t5	T3	t9	T7	t1	T8
T2	T6	T4	T5	t3	T9	t7	T1	t8

t8	T1	T7	t6	T5	T2	t9	t3	T4
T8	t1	t7	T6	t5	t2	T9	T3	T4

T4	t9	T5	t2	T1	t6	T3	t8	T7
t4	T9	t5	T2	t1	T6	t3	T8	t7

To & to = Tilled and Non-till weedy control

T1 & t1 = Tilled and Non-till weed free control

T2 & t2 = Tilled and Non-till grass/metolachlor

T3 & t3 = Tilled and Non-till grass/pendimethalin

T4 & t4 = Tilled and Non-till plastic/metolachlor

T5 & t5 = Tilled and Non-till plastic/pendimethalin

T6& t6 = Tilled and Non-till pendimethalin

T7 & t7 = Tilled and Non-till metolachlor

T8 & t8 = Tilled and Non-till plastic mulch

T9 & t9 = Tilled and Non-till grass mulch.

APPENDIX 2

Summary of Climatic Data for Ibadan (07 26' N, 03 54'E) 2008-2009.

Month	Total Rainfall (mm)	Ambient Temperature ^0C			Relative Humidity %			No of Rainy Days
	-	Min	Max	Mean	2008	2009	Mean	-
Jan	0.4	22.2	33.2	27.7	42	70	55	1
Feb	0.8	23.9	34.2	29.1	57	81	69	1
March	59.5	24.4	34.3	29.4	65	64	69	7
April	35.9	23.5	32.5	28.0	78	82	80	6
May	99.5	22.8	31.8	27.3	79	82	81	8
June	113.2	22.8	30.5	26.7	85	83	84	7
July	98.6	22.6	30.4	26.5	88	87	88	9
Aug	54.3	22.1	28.4	25.3	88	90	89	9
Sept	161.5	22.5	29.5	26.0	86	86	86	10
Oct	132.6	22.7	30.9	26.8	83	86	85	8
Nov	37.7	23.7	32.9	28.3	75	71	73	5
Dec	13.5	22.4	33.8	28.1	62	78	70	3
Total	807.5	_	_	_	_	_	_	74
Average	_	23.0	31.9	27.4	74	80	77	_

Adapted from the Nigerian Meteorological Agency, State Office, Ibadan. Oyo State.

Appendix 3: ANOVA of Mean squares for main effects and interaction of growth parameters of soyabean in 2008.

Source of variation	Degree of freedom	Plant height	Pod number	Stem Diameter	100 seed weight	Grain yield	Weed dry shoot biomass yield
Tillage (T)	1	956.73*	2257.76*	7.78*	0.67ns	6.50*	1842.65ns
Weed control (W)	5	451.45*	647.99*	0.61ns	0.94*	5.34*	193183.66*
Tillage x weed control (T x w)	5	108.46ns	240.25ns	0.66ns	0.12ns	0.15ns	1265.45ns
Error	33	62.07	134.51	0.65	0.27	0.19	3295.46

* = significant at P< 0.05; ns = not significant

Appendix 4: ANOVA of Mean Squares for main effects and interactions of growth parameters of soyabean in 2009

Source of variation	Degree of freedom	Plant height	Pod number	Stem diameter	100- seed weight	Grain yield	Weed dry shoot biomass yield
Tillage (A)	1	22.31ns	1357.47*	4.16*	0.04ns	1.18ns	1166.37*
Mulch (B)	2	203.68*	1296.46*	1.29*	0.41ns	4.49*	59239.84*
Herbicides (C)	2	287.39*	83.27ns	0.16ns	0.09ns	2.27*	1185.38*
A x B	2	0.10ns	52.66ns	0.31ns	0.01ns	0.02ns	407.48ns
B x C	4	242.36*	700.62*	0.95*	0.05ns	1.31ns	2544.73*
A x C	2	11.21ns	2.75ns	0.21ns	0.2ns	0.04ns	44.06ns
A x B x C	4	10.59ns	116.92*	0.18ns	0.02ns	0.06ns	390.14ns
Error	51	13.53	37.65	0.27	0.14	0.54	192.49

* = Significant at P< 0.05; ns = Not significant

APPENDIX 5

Analysis of variance of plant height for soybean integrated weed management strategies in 2008 ,

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	37.65	0.61	3.29
Tillage	1	956.73	15.56*	4.54
Weed Control	5	451.45	7.27*	2.90
TXW	5	108.46	1.75	2.90
Error	33	62.07	-	-

.* Significant at p=0.05.

APPENDIX 6

Analysis of variance of pod numbers per plant for soybean integrated weed management strategies in 2008

Source	Df	Ms	Fcal	P-value(.05)
Replication	3	32.35	0.24	3.29
Tillage	1	2257.76	16.79*	4.54
Weed Control	5	647.99	4.62*	2.90
TXW	5	240.25	1.79	2.90
Error	3	134.51	-	

* Significant at p=0.05

APPENDIX 7

Analysis of variance of stem diameter for soybean integrated weed management strategies in 2008

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.6	0.92	3.29
Tillage	1	7.78	11.94*	4.54
Weed Control	5	0.61	0.93	2.90
TXW	5	0.66	1.02	2.90
Error	33	0.65	-	

* Significant at p=0.05.

APPENDIX 8

Analysis of variance of 100 weed weight for soybean integrated weed management strategies in 2008

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.36	0.01	3.29
Tillage	1	0.67	2.61	4.54
Weed Control	5	0.94	3.68*	2.90
TXW	5	0.12	0.47	2.90
Error	33	0.26	-	

* Significant at p=0.05.

APPENDIX 9

Analysis of variance of grain seed yield for soybean integrated weed management strategies in 2008

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.19	1.00	3.29
Tillage	1	6.50	33.96*	4.54
Weed Control	5	5.33	27.86*	2.90
TXW	5	0.15	0.80	2.90
Error	33	0.19		

* Significant at p=0.05.

APPENDIX 10

Analysis of variance of dry shoot weed biomass yield for soybean integrated weed management strategies in 2008

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	3916.29	1.19	3.29
Tillage	1	1842.65	0.56	4.54
Weed Control	5	193183.66	58.61*	2.90
TXW	5	1265.45	0.38	2.90
Error	33	3295.96	-	

* Significant at p=0.05.

APPENDIX 11

Analysis of variance of plant height for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	18.07	1.34	2.74
Tillage (A)	1	22.31	1.65	3.98
Mulch (B)	2	203.68	15.05*	3.13
Herbicides (C)	2	287.39	21.24*	3.13
A x B	2	0.095	0.07	3.13
B x C	4	242.36	17.91*	2.50
A x C	2	11.21	0.83	3.13
A x B x C	4	10.59	0.78	2.50
Error	51	13.53	-	

* Significant at p=0.05.

APPENDIX 12

Analysis of variance of pod numbers for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	81.52	2.17	2.74
Tillage (A)	1	1357.47	36.06*	3.98
Mulch (B)	2	1296.46	34.44*	3.13
Herbicides (C)	2	83.265	2.21	3.13
A x B	2	52.656	1.40	3.13
B x C	4	700.62	18.61*	2.50
A x C	2	2.75	0.07	3.13
A x B x C	4	116.92	4.43*	2.50
Error	51	37.6488	-	

* Significant at p=0.05

APPENDIX 13

Analysis of variance of stem diameter for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.63	2.28	2.74
Tillage (A)	1	4.16	15.15*	3.98
Mulch (B)	2	1.29	4.70*	3.13
Herbicides (C)	2	0.16	0.58	3.13
A x B	2	0.31	1.14	3.13
B x C	4	0.95	3.46*	2.50
A x C	2	0.21	0.77	3.13
A x B x C	4	0.18	0.66	2.50
Error	51	0.27	-	

* Significant at p=0.05.

APPENDIX 14

Analysis of variance of 100 seed weight for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.055	0.39	2.74
Tillage (A)	1	0.04	0.27	3.98
Mulch (B)	2	0.41	2.90	3.13
Herbicides (C)	2	0.09	0.61	3.13
A x B	2	0.01	0.07	3.13
B x C	4	0.05	0.33	2.50
A x C	2	0.02	0.17	3.13
A x B x C	4	0.02	0.15	2.50

Error	51	0.14	-	

* Significant at p=0.05.

APPENDIX 15

Analysis of variance of grain seed yield for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	0.92	1.70	2.74
Tillage (A)	1	1.18	2.18	3.98
Mulch (B)	2	4.49	8.31*	3.13
Herbicides (C)	2	2.27	4.19*	3.13
A x B	2	0.02	0.03	3.13
B x C	4	1.31	2.43	2.50
A x C	2	0.04	0.07	3.13
A x B x C	4	0.06	0.11	2.50
Error	51	0.54	-	

* Significant at p=0.05.

APPENDIX 16

Analysis of variance of dry shoot for soybean integrated weed management strategies in 2009

Source	Df	Ms	Fcal	p-value(.05)
Replication	3	416.10	2.16	2.74
Tillage(A)	1	1166.37	6.06*	3.98
Mulch(B)	2	59239.84	307.75*	3.13
Herbicides (C)	2	1185.38	6.16*	3.13
A x B	2	407.48	2.12	3.13

B x C	4	2544.73	13.22*	2.50
A x C	2	44.06	0.23	3.13
A x B x C	4	390.14	2.03	2.50
Error	51	192.49	-	

* Significant at p=0.05.