PERFORMANCE OF SESAME (*Sesamum indicum* L.) AS AFFECTED BY WEED CONTROL METHODS AND FERTILIZERS IN KANO STATE, NIGERIA

BY

MUSEFIU ADEWALE GANIYU

M.Sc. Agronomy

SPS/15/MAG/00020

A DISSERTATION SUBMITED TO THE DEPARTMENT OF AGRONOMY, FACULTY OF AGRICULTURE BAYERO UNIVERSITY, KANO IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRONOMY

SUPERVISOR

Prof. I. B. MOHAMMED

JUNE, 2019

DECLARATION

I hereby declare that this dissertation titled **Performance of Sesame (*Sesamum indicum* L.) as Affected by Weed Control Methods and Fertilizers in Kano state of Nigeria** is the product of my research efforts undertaken under the supervision of Prof I. B. Muhammad. And no part of the dissertation has been presented anywhere for the award of a master degree or any certificate. All sources have been dully acknowledged.

MUSEFIU ADEWALE GANIYU	…………………..	………………………
SPS/15/MAG/00020	Signature	Date

CERTIFICATION

This to certify that the research work for this dissertation and subsequent write-up titled **Performance of Sesame (*Sesamum indicum* L.) as Affected by Weed Control Methods and Fertilizers in Kano state of Nigeria.** By (**Musefiu Adewale Ganiyu SPS/15/00020)** meets the regulations governing the award of Master of Science in Agronomy at Bayero University, Kano and is approved for its contribution to knowledge and literacy presentation.

Prof I.B. Mohammed	………………………	………………………
Name of Supervisor	Signature	Date

Dr. S.U. Yahaya	……………………….	………………….
Head of Department	Signature	Date

APPROVAL

This thesis titled "Performance of Sesame (*Sesamum indicum* L.) as Affected by Weed Control Methods and Fertilizers in Kano state, Nigeria" by Musefiu Adewale Ganiyu (SPS/15/MAG/00020) has been examined and approved for the award of the Degree of Master of Science in Agronomy.

……………………………	……………………………..
Prof. M. D. Magaji (External Examiner)	Date
……………………………	…………………………….
Prof. A. A. Manga (Internal Examiner)	Date
……………………………	……………………………..
Prof. I.B. Mohammed (Major Supervisor)	Date
……………………………	……………………………..
Dr. S.U. Yahaya (Head, Department of Agronomy)	Date
……………………………	………………………………
Dr. M. U. Dawaki (Faculty Representative of the Board of the School of Postgraduate Studies)	Date

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DEDICATION

This dissertation is dedicated to Almighty God, the everlasting father for His abundant mercy and guidance throughout my years of studies. Special dedication to my noble parents, siblings, and friends.

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ABSTRACT

Field experiments were conducted in 2017 rainy season at the research farm of Bayero University, Kano (lat $11^o\,58^{'}$N and long $8^o\,25^{'}$E and 475m above sea level), and Gurungawa located in Kombotso Local Government Area (lat $11^o\,55^{'}$N and long $8^o\,31^{'}$E and 475m above sea level). The objectives of the study were to evaluate the effects of fertilizers and weed control method of Sesame. The experiment consisted of three levels of cow dung (0t/ha, 3t/ha and 6t/ha) plus NPK. (15:15:15) fertilizer at rates of 50 kg N/ha, 60 kg P/ha, 35 kg K/ha and two levels each of two pre-emergence herbicides (Metolachlor and Pendimethalin) at 2.0 kg a.i. /ha and 2.5 kg a.i. /ha, two hoe weedings at 3 and 6WAS and a weedy check as control. The experiment was laid out in a split plot design with cow dung and NPK applied to the main plot and weed control method to the sub-plot and was replicated three times at both locations. The results of the study indicated that application of NPK at recommended rate increased growth parameters such as plant height, number of leaves, and leaf area index at both sampling period and location. Cow dung at 3 t/ha increased weed control efficiency and NPK at recommended rate increased weed index but fertilizers did not affect weed dry weight. Similarly, NPK at recommended rate and cow dung at 6t/ha significantly increased grain yield, 1000-seed weight and biological yield. Two hoe weedings at 3 and 6WAS increased growth parameters like plant height, number of leaves, leaf area index at both locations. On the other hand, application of Metolachlor and Pendimethalin at the rate of 2.5kg a.i/ha also increased plant height at the research farm of Bayero University, Kano. Both weed dry weight and weed index were increased under weedy check whereas weed control efficiency was increased with two hoe weedings. Consequently, two hoe weedings at 3 and 6WAS significantly increased yield parameters such as grain yield, biological yield and 1000-seed weight. There were highly significant and positive correlations between grain yield, leaf area index, number of leaf, plant height, plant dry weight, 1000-seed weight and weed control efficiency. However, days to 50% flowering, weed dry weight and weed index had negative correlation with yield. It is recommended that NPK (15:15:15) at the rate of 50 kg N/ha, 60 kg P/ha, 35 kg K/ha and cow dung at 6t/ha for the two locations should be used, similarly two hoe weedings and Metolachlor and Pendimethalin at the rate of 2.5kg a.i/ha can also be recommended but depending on the choice of farmer.

CHAPTER ONE

1.0 INTRODUCTION

1.1 ORIGIN AND DISTRIBUTION OF SESAME

Sesame (*Sesamum indicum* L.) also known as beniseed in West Africa and Sim-sim in East Africa, it is an oil crop belonging to the family *Pedaliaceae* grown in both tropical and sub-tropical regions of Africa, Asia, and Latin America. India and Ethiopia have been proposed as sesame centres of origin, but presently, the opinions are more in favor of Ethiopia, because it is believed to have spread from there to other parts of Africa, India, China, Japan, and Europe in very early times (Weiss, 1984). It is the most important crop from which semi-drying vegetable oil is obtained and perhaps the oldest crop cultivated for its oil (Onwueme and Sinha, 1991).

Sesame has high heat and light requirements, but is sensitive to low temperature. Growth and fruiting are favored by temperatures of about $27^{o}C$. It is very drought tolerant, due partly to its extensive root system. However, it requires adequate moisture for germination and early growth but intolerant to water-logging. It requires an annual rainfall of about 500 mm to 600 mm for reasonable yields (Weiss, 1984). Late rainfall in the season prolongs growth, increases shattering losses and reduces seed quality (Onwueme and Sinha, 1991). Initiation of flowering is sensitive to day length and varies among varieties. Short days hasten flowering, while long days delay flowering initiation in sesame (Weiss, 1984). The oil content of the seed tends to increase with the increased photo-period; because protein and oil contents are inversely proportional which means seed with high oil content has less protein content (Weiss, 1984). The crop thrives best in well-drained fertile sandy soil of medium texture and neutral pH with low salt tolerant (Ashri *et al.* 1989).

1. 2 PRODUCTION AND USES

World production of sesame was estimated at 6.2 million tons in the year 2014 led by Tanzania (1,138,290), India (811,000), Sudan (721,000), China (629,900), Myanmar (519,400), and Nigeria (434,990 (FAO, 2014). In Nigeria, sesame is produced mainly in the Sudan and Northern Guinea Savanna ecological zones extensively by small holders using manual labor and limited inputs, and on relatively poor soils thereby resulting in low average yield of 300 kg/ha compared with 1,960 kg/ha in Venezuela, 1083 kg/ha in Saudi Arabia, 517 kg/ha in Ivory Coast and 510kg/ha in Ethiopia (Abubakar *et al.*, 1998). Sesame ranks sixth in the world production of edible oil seeds and twelfth in the world of vegetable oil produced (FAO, 2002).

The crop production in most African countries has been increasing steadily due to the crop short duration cycle and the good liquidity in the global market (Anon, 2004). In Nigeria annual production stood at about 110,000 tons in the year 2007, of which about 50,000 tons was exported (Anon, 2008).

Sesame seed contains approximately 50% oil and 25% protein and is used in baking, candy making and other food industries. Oil from the seed, which contains about 47% oleic and 39% linoleic acid, is used in cooking, salad and in making margarine. Sesame oil and food fried in sesame oil have long a shelf life because the oil contains an antioxidant called sesamol. The oil can be used in the manufacture of soap, paints, perfumes, pharmaceuticals and insecticides. Sesame meal left after oil extraction is an excellent high protein (35 to 50% crude protein), feed for poultry and livestock (Oplinger, 1990)

1.3 PROBLEM STATEMENT

In recent times the high cost of inorganic fertilizers, their poor distribution and manual labor intensive demand have affected sesame availability to resource poor farmers thereby resulting in the use of insufficient quantities at the time of need, hence contributing to low crop yields. In order to find alternative sources of nutrition for sesame production, cow dung can be considered. Raw Materials Research And Development Council (RMRDC, 2004), identified shortages of fertilizers as major problems hindering sesame production in the country. Food production, farm incomes and food prices are vulnerable to inadequacy in supply and high cost of chemical fertilizers in Nigeria (Rahman *et al.,* 2001). Where chemical fertilizers are available, excessive usage increases pollution, decreases soil productivity and leads to nutrient imbalance (Duhoon *et al.,* 2004).

Furthermore, application of large quantities of soluble fertilizer to a crop one, two or three times per season mostly supplies the plant with surplus nutrients, stimulating the development of certain noxious weed species and causing nutritional imbalances that leads to disease incidence, insect infestations and poor yield quality (Kuepper and Gegner, 2004). Soluble nutrients, especially nitrate, are prone to leaching, which can cause a number of environmental and health problems (Kuepper and Gegner, 2004).

Organically produced sesame is preferred and given premium in the global market (Duhoo *et al.,* 2004). The use of organic sources of fertilizers will reduce the dependence on chemical fertilizers besides their eco-friendly nature. Broadleaf weeds such as morning glory (*Ipomoea* spp.) and smell melon (*Cucumis melo* L.) affect sesame growth and development. These weeds come up in flushes following rainfall or irrigation and after sesame canopy formation (Grichar *et al.*, 2001); (Grichar *et al.*, 1991). They can continue growing under weak light conditions, climb the sesame plants to the top of the canopy, and when they are exposed to light, they overwhelm the crop. As soon as they reach light, their leaf size increases dramatically. In high populations, these climbing weeds form a mat on top of the sesame and cause problems at harvest because it is difficult to separate adjacent rows of sesame (Langham *et al.*, 2010).

1.4 JUSTIFICATION

Nigeria is one of the developing countries of the world where sesame is produced annually due to its importance as a source of food and vegetable oil (IITA, 2012). The country is facing an increase in population, the demand and consumption of sesame and vegetable oil is increasing rapidly over the years; there is need for the production of more food to meet the increase in population. In fact, many of our daily diets contain vegetable oil either directly or indirectly. The oil is an important ingredient in the production of food of almost all kinds. International food processing companies like Nestle and others purchase it to produce some of the famous cereal-based breakfast brands like Cornflakes, bread and many others.

The cultivated soils of Sudan Savanna of Nigerian are deficient in organic matter and in major plant nutrients such as nitrogen (N), phosphorus (P), potassium (K) and other macro and micro elements. Low crop productivity is the common feature of agriculture under those conditions because of very low organic matter content, poor soil physical condition, coupled with poor weed control methods. Unavailability of fertilizers at proper time and also high cost has also been a matter of serious concern to resource poor farmers thereby resulting in the use of insufficient quantities at the time of need, hence contributing to low crop yields. In order to increase productivity of the crop in Nigeria, cow dung can be considered as an option most especially in the savanna where a high number of livestock population is found, as such large quantity of cow dung is available because even the small scale farmers keep animals. Cow dung is an excellent source of organic matter and restores some essential nutrients depleted by the prevailing cropping practices (Bahman and James, 1999). Mahadi *et al.* (2012) also pointed out that cow dung supplement to chemical fertilizers but may also improve the organic matter status and physico-chemical properties of soil in maize crop, thereby increasing the productivity of the planted crop. To restore and maintain the soil nutrients status for improved crop productivity, cow dung application can be considered as an option provided, if it is applied at the right dosage and time to sesame crop.

Weed control in sesame through the use of herbicides has received little attention in West Africa, and particularly in Nigeria while elsewhere in the world herbicides have shown a great promise in weed management in sesame. Consequently, to identify effective weed control method to boost farmers income and reduce cost of production and effective weed control method is very essential in the production of sesame as the crop is sensitive to weed infestation, chemical weed control will be effective in this regards in view of its low cost as compared to manual hoe weeding which is tedious, labour intensive and time consuming. Pre-emergence herbicides such as pendimethalin, metolachlor have been known to be efficient and effective in sesame and therefore could support economic sesame production ventures at small scale level.

1.5 OBJECTIVES OF THE STUDY

1. To evaluate the effect of fertilizers on the productivity of sesame in Kano State.

2. To evaluate the response of sesame to weed control methods in Kano State of Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of Organic Manure and Inorganic Fertilizers on the Growth and Yield of Sesame

Manure is a key fertilizer in organic and sustainable soil management practices. It contains many of the elements that are needed for the plant growth and development as well as improving soil physical and biological status. The amount and composition of nutrients in poultry dropping, cow dung and sheep manure, vary with the age of the animal, storage, handling and management (Aliyu and Kuchinda, 2002; Anon, 2006). Manure application results in increased water holding capacity and decrease density when used on a long term basis (Anon, 2006). Apart from increasing soil fertility, manure serves as a soil amendment by adding organic matter to the soil. Organic manure has also been reported to greatly improve water holding capacity, soil aeration, soil structure, nutrient retention and microbial activity (Anon, 2007a). Manure application has been shown to improve the solubility and uptake of P from sparingly soluble P compounds in soil and enhances the utilization of P from P containing fertilizers (Zeidan, 2007).

Haruna *et al.* (2012) reported that application of 5.0t/ha of cow dung significantly increased seed yield of sesame compared to application of 2.5t/ha. He also reported that application of 5.0t/ha of cow dung significantly increased the seed weight and biological yield of sesame compared to application of 2.5t/ha of cow dung which produced lightest weight of sesame seed.

According to Mondal *et al.* (1992) and Haruna *et al.* (2012), application of 2.5t/ha of poultry manure and 5.0t/ha of cow dung, increased the number of capsules per sesame plant and sesame seed yield. Alege *et al.* (2009), also reported that application of NPK and organic fertilizer increased plant height and number of leaves of sesame, and concluded that application of NPK brought about the greatest increase in the height of sesame plant.

2.2 Weed – Crop Interaction

Weeds compete with crop plants for nutrients, moisture, light, space, temperature, etc. The degree of competition is dependent on weed flora, time of weed emergence, relative density of crop plants and weeds as well as the duration of competition.

Competition is set in motion when supply or availability of resources is limited for the unrestricted growth of both crop and weeds (Chikoye and Ekeleme, 2001). One key constraint to increasing crop production and improving farmer's life is poor weed control. Weeds are the most universal of all crop pests, proliferating each year on every farm in Africa (Obuo *et al.,* 1997). African soils contain 100 to 300 million buried weed seeds per hectare of which a fraction germinate and emerge each year and the soil seed population in a Nigerian experiment was estimated at 20,130 seeds per square meter, 200 million per hectare (Chikoye *et al.,* 2004). A total of 263 weed species belonging to 38 families were found in crop fields in West Africa; broad leaf weeds (72%) and grasses (24%) dominated the total weed spectrum, whereas sedges (4%) were minor. Mean weed species richness per field was similar across all agro-ecological zones and average about 16% of the field (Chikoye and Ekeleme, 2001).

Weed problems are more severe in African tropical regions than Europe and North America because weeds grow more vigorously and regenerate quicker because of higher heat and light intensity, high humidity, conditions characteristic of sub-Saharan Africa (Akobundu, 1980). Under unweeded conditions, crop losses have been measured for groundnut (80%), cowpea (40-60%), rice (50-100%), maize (55-90%), sesame (70%), wheat (50-80%), sorghum (40-80%), and cassava (90%) (Akobundu, 1980).

Weed competition is most serious when the crop is young; the critical period of crop weed competition is approximately equal to the first one-third to one-half of the life cycle of the crop. Keeping the crop free of weeds in the first one third of its life cycle usually assures near maximum productivity (Dadari *at al.*, 2005).

2.3 Effect of Weeds on Oil Crops

Significant yield loss in oil crops is mainly due to competition, allelopathic effects of weeds and contamination of harvested products. Abdullahi *et al*. (2000) found that full competition from weeds reduced the yield of sunflower (*Helianthus annus*) by 58%. Weeds compete with crops for limited environmental resources and habour diseases and pests that cause significant reduction in yield by interfering with the root system of the crops thereby considerably reducing the efficiency of the roots in carrying out its function of water and nutrients uptake and also increased the cost of production and in certain cases farmers abandon their fields because of weeds (Agoola, 1994). Weed competition is greatest early in the crops life, because weeds have tendency of outgrowing the crop if they are not controlled early in the growth period. Kropff and Spitters (1991) reported that major factor influencing sesame yield in a competitive situation is the ratio between the relative leaf area of the weed and the crop at the time of canopy closure.

Balyan (1993), Gurnah (1974), Singh *et al.* **(**1992), and Upadhyay (1985) reported that weeds induced reductions of sesame yield up to 65% and a need for a critical weed-free period up to 50 days after planting. Apart from reduction in crop yield, weeds reduce both the quality and quantity of harvested products, increase incidence of diseases and insects, and frequently hamper efficient use of equipment which also reduces oil contents in groundnut and sesame as it competes with the crop for all environmental resources that favour the production of oil in the crop (Ahmad *et al.*, 2007).

2.4 Herbicides, Weed Control, and Sesame Tolerance

Several herbicides provide excellent control of weeds with minimal to no damage to sesame. However, in evaluating herbicides, there have been conflicting results, and it is difficult to sort out why some herbicides work in one area and do not work in another. Also, in some cases, at the same location, the herbicides effectively control weeds and little sesame injury is noted in one year; however, the opposite may be true the following year. With most herbicides, dose, formulation, soil texture, pH, moisture, method of incorporation and temperature before and after application are all factors affecting herbicide persistence (Smith, 1989). Since soil organic matter, temperature, and aeration are more favorable for microbial activity in the topsoil than in the subsoil, degradation rates may decrease if a herbicide is leached into the subsoil layers (Smith, 1989). Soil pH can affect degradation directly if the stability of the herbicide is dependent upon acidity or alkalinity, and indirectly via its effects on the absorption of the herbicide to the soil (Smith, 1989). Increased rates of non-biological reactions and biological processes are favored by increasing temperature, thus herbicide degradation rates should increase also. Adequate moisture is also essential for microbiological activity (Smith, 1989). Martin (1995) reported that rainfall amounts during germination and establishment can markedly affect herbicide phytotoxicity to sesame, a possible factor in the reported erratic behavior of many herbicides. Many herbicides will delay sesame maturity while a few herbicides will completely kill the sesame. In many of the studies mentioned below, it will be seen with some herbicides that even with severe stand reduction, sesame yields are good because the plants can compensate for open space by putting out branches with capsules.

In some herbicide studies in some cases where multiple varieties were used, there have been differences in varietal susceptibility. Some of the clues have not been followed up because the moving baselines of new varieties has been fast, and the emphasis has always been placed on the use of the most recent released variety to use in herbicide evaluations.

2.5 Manual Method of Weed Control

This is the oldest method of controlling weeds and it is still a practical and efficient method of weeds control in cropped and non-cropped lands. Hand weeding is the predominant weed control practice of smallholder farmers. Hand weeding consists of hand-pulling, hand slashing and hoeing of weeds. Farmers spend 50-70% of their total labor time on hand weeding (Chikoye *et al., 2004*). Women contribute more than 90% of the hand weeding labor for most crops (Ukeje, 2004), 69% of farmer's children between the ages of 5-14 are forced to leave school and are used in the agriculture sector especially at peak period of weeding (Ishaya *et al.*, 2008). The scarcity of labor and the concurrent rise in the cost of hand weeding make timely removal of weeds by direct labor difficult and expensive (Ishaya *et al.*, 2008).

The sowing time of some crops coincides with periods of heavy rain and wet soil conditions that do not permit efficient hand weeding or hoeing, labor for hand weeding is therefore very scarce and when available too expensive for the average farmer to afford, as a result of that, it is often impossible to carry out timely weeding by hand (Akobundu, 1979). The principal limiting factor to the sizes of farms in Africa is the number of necessary weedings during the period following planting (Kent *et al.,* 2001). Eighty percent of farmers reported that if weeds were fewer problems, they would increase the area of land under cultivation (Aliyu and Lagoke, 2000). According to Sibuga (1997), weeds are underestimated crop pests for which government spending in Africa on training, research and education is minimal and appropriate weed management technologies remain largely unavailable and/or underdeveloped.

2.6 Brief Descriptions of Herbicides in this Study

2.6.1 Metolachlor

Metolachlor, [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl]

Metolachlor herbicides are commonly used in various crops for control of small-seeded broadleaf weeds, some annual grasses, and yellow nutsedge (Grichar *et al.,* 1996). Metolachlor will control small-seeded annual grasses, but provides inconsistent control of large-seeded annual grasses (Grichar *et al.,* 2004a; 2004b). Many growers have reported peanut (Groundnut) stunting when soil applications of metolachlor were followed by rain (Grichar *et al.,* 1996). Grichar *et al.* (1996) reported that post-emergence applications of metolachlor followed by irrigation within 24 hour could be effective for yellow nutsedge control and reduce the chance of peanut injury from soil applications. Combinations of factors, such as herbicide dose, moisture conditions at planting, soil organic matter, and pH may affect peanut injury by chloroacetamide herbicides such as *S*-metolachlor (Cardina & Swann, 1988; Wehtje *et al.,* 1988; Osborne *et al.,* 1995; Mueller *et al.,* 1999). Cardina and Swann (1988) reported that metolachlor often delayed peanut emergence and reduced peanut growth when irrigation followed planting. In many areas of the world, metolachlor has shown similar results as alachlor on sesame and is being used more frequently because it requires lesser active ingredient per hectare to achieve similar results. Commercial pre-emergence uses of metolachlor include the following: in Thailand, a field guide recommends metolachlor at 1.2 to 1.25 l/ha in case of labor shortage (Anonymous, 1997). In Australia, grower guides in the Northern Territories (Bennett, 1998) and in South Burnett (Sapin *et al.*, 2000) recommend the use of metolachlor. In El Salvador, a grower guide recommends 1.4 l/ha of metolachlor (Anonymous, 2007c).

In pre-emergence experiments in the U.S., metolachlor treatments (2.2 kg/ha) had a slight reduction in sesame vigor, provided good broadleaf control initially, but allowed broadleaf weeds to germinate later (St Andre, unpublished data, 1997). Metolachlor applied pre-emergence at 2.1 kg/ha was one of the best overall treatments, but pre-plant incorporation of metolachlor affected early vigor and stunted the sesame (D. Howell, unpublished data, 2000). The premix provided good broadleaf weed control while both metolachlor alone and the premix provided good annual grass control (Hussein *et al.*, 1983). In Nicaragua, metolachlor at 1.1 and 2.2 kg/ha provided good grass control with no injury to sesame, and doubled the yield from that of the untreated check (Soto-Soto and Silva-Vasquez, 1987). In Ethiopia, metolachlor at 1.7 kg/ha provided good grass and broadleaf control, which resulted in a significant yield increase (Zewdie, 1994). In Australia, Martin (1995) reported that metolachlor adequately controlled weeds but caused unacceptable crop injury. Despite that report, farmers use metolachlor for commercial sesame field.

Metolachlor at 0.6, 1.1, 2.2, and 3.4 kg/ha resulted in variable sesame plant populations, had no effect on sesame plant height, resulted in consistent weed control, and provided greater yields than the untreated plots (Grichar *et al.*, 2001a).

2.6.2 Pendimethalin

The dinitroaniline herbicides, such as trifluralin and pendimethalin, are used to reduce weed populations and aid in the establishment and production of many crops including groundnut, soybean, and grain sorghum (Dotray *et al.,* 2004; Grichar and Colburn, 1993; Grichar *et al.,* 2005a, b; Grichar, 2006). Pendimethalin provides excellent control of annual grasses (Buchanan *et al.,* 1982; Chamblee *et al.,* 1982; Wilcut *et al.,* 1995). Uptake of pendimethalin is primarily through roots and emerging shoots (Ashton and Crafts, 1981; Appleby and Valverde, 1989). It is possible that the pendimethalin will be concentrated in the extreme upper portions of the soil profile and weed seed may be able to germinate below the zone where pendimethalin is located (Johnson *et al.,* 2002). In this case, emerging shoots pass through treated soil, whereas developing roots would be below the herbicide treated soil. The dinitroaniline herbicides have very low water solubility and are subject to losses due to photodecomposition and volatilization (Weber, 1990). Therefore, incorporation soon after herbicide application is important for effective weed control. The effectiveness of soil-applied herbicides is dependent upon several factors, including movement of the herbicide into the soil either through water provided by rainfall or irrigation, or by mechanical incorporation (Prostko *et al.,* 2001; Ross and Lembi, 1999). Chenault *et al.* (1992) reported that pendimethalin provided greater than 78% control of barnyardgrass (*Echinochloa crus-galli* (L.) depending on incorporation method. Tolerance to the dinitroaniline herbicides has been evaluated extensively in many crops. Information on absorption and translocation within plants is less clearly defined; however, direct entry into plant tissue is considered limited, and unless the pendimethalin herbicide enters meristematic tissues, the herbicide will have little effect on plant growth (Miller *et al.,* 2003).

Previous research by Grichar *et al.* (2001a; 2009) reported sesame injury following the use of Pendimethalin applied pre-plant incorporated using various incorporation methods. Grichar *et al.* (2001a) reported that ethalfluralin, pendimethalin, and trifluralin reduced sesame stand numbers when compared with the untreated check. In that study the dinitroaniline herbicides were incorporated 2.5 cm deep with a tractor-driven power tiller. In another study, Grichar *et al.* (2009) reported that a spring-tooth harrow, with lack of the ability to adjust incorporation depth, caused similar problems. However, the rolling cultivator mixing wheels, which were set to a depth of less than 2.5 cm, resulted in excellent sesame stands. Therefore, only a shallow incorporation of the pendimethalin must be done when used in sesame to ensure a good stand. They concluded that it was best if the dinitroaniline herbicides were applied pre-emergence. Of the dinitroaniline herbicides, only pendimethalin formulated can be applied pre-emergence (Anonymous, 2004b); however, annual grass control following pendimethalin applied pre-emergence is often poor (Byrd and York, 1987; Culpepper, 1996).

On the other hand, it controlled annual grasses and increased the yield over the weedy check by 45%. Schrodter and Rawson (1984) reported that pendimethalin at 1.5 and 3.0 kg/ha and trifluralin at 0.84 kg/ha reduced sesame plant populations. Plant selectivity by herbicide placement is influenced greatly by the movement of the herbicide in soils (Ennis, 1964). If the dinitroaniline herbicides move, they may come into contact with the absorptive sites of sesame and cause sesame injury (Grichar *et al.,* 2001a). In India, Shukla (1984) found that pendimethalin was toxic to sesame. In Korea, Kim *et al.* (1986) found that pendimethalin provided effective weed control using 1.27 kg/ha, but caused crop damage and yield reductions. In Egypt, Ibrahim *et al.* (1988) found that the best weed control and significantly greater seed yields and seed and yield components resulted from treatment with pendimethalin alone or in tank mixtures with linuron or diuron. In Somalia, Malik and Muhammed-Ramzak (1992) reported that pendimethalin at 3.7 l/ha provided the greatest weed control and significantly higher yield over the weedy check with no phytotoxic effects on sesame. Grichar *et al.* (2001a) reported yield increases over the untreated check with pendimethalin and trifluralin. They concluded that lack of yield differences among herbicide treatments which injured or reduced sesame stands could be attributed to the ability of the sesame plant to compensate for reduced stands.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITES

The experiment was conducted at two locations during 2017 rainy season at Teaching and Research Farm of Bayero University Kano (lat 11^{o} $58^{'}$N, long 8^{o} $25^{'}$E and 475m above sea level), and Gurungawa located in Kumbotso Local Government Area (lat 11^{o} $55^{'}$N and long 8^{o} $31^{'}$E and 475m above sea level) both in the Sudan savanna ecological zone of Nigeria.

3.2 SOIL AND METEOROLOGICAL DATA

Composite soil samples of each of the experimental sites were taken from 0-15 and 15-20cm depth using soil auger. The samples were air-dried, sieved using a 2mm wire mesh sieve and analyzed for physical and chemical properties using standard procedures (Black, 1965).

Data on rainfall, temperature, relative humidity and solar radiation were collected from the automatic weather station of Faculty of Agriculture, Bayero University, Kano and that of Gurungawa were collected from IITA weather station, Tarauni Local Government Area, Kano State.

3.3 COW DUNG ANALYSIS

The cow dung used was analyzed for its various properties including moisture content, N, P, K, Ca. Mg, Na, total organic carbon, organic matter as well as other micro elements as described by Peterson and Calvin (1986).

3.4 TREATMENTS AND EXPERIMENTAL DESIGN

The experiment consisted of three levels of cow dung (0t/ha, 3t/ha and 6t/ha) plus NPK. (15:15:15) fertilizer at rate of 50 kg N/ha, 60 kg P/ha, 35 kg K/ha and two levels of each of two pre-emergence herbicides (Metolachlor and Pendimethalin) at 2.0 kg a.i. /ha and 2.5 kg a.i. /ha, two hoe weeding at 3 and 6WAS and weedy check as control. The experiment was laid out in a split plots design with cow dung and NPK applied to the main plot and weed control method to the sub-plots and was replicated three times at the two locations.

3.5 DESCRIPTION OF THE TEST CROP USED

Ex- sudan was used as a test crop, a short duration variety maturing under 90 days. The seed colour is white and contains about 50% oil. This variety is capable of yielding up to 1,200kg/ha and 1000 seeds of this variety weighed 3.0 - 3.5g. The variety was source from agro-allied shop in Kano State.

3.6 PLOT SIZE

The gross plot size was 3.0m x 2.0m ($6m^2$), consisting of four ridges each 2m in length and spaced 0.75m apart. The net plot size was $3m^2$ consisting of the two innermost ridges while the two border rows were used for sampling. A gap of 0.5m was left between plots and 1m between replicates.

3.7 CULTURAL PRACTICES

3.7.1 Land preparation

The experimental area was harrowed to a fine tilth, followed by ridging at 75cm apart between rows and the field was marked into plots and replications.

3.7.2 Sowing

Seeds were mixed with river sand at a spacing of 20 x 75cm at a depth of about 2.5cm on each ridge and were covered with light soil.

3.7.3 Fertilizer application

The three levels of cow dung and recommended rate of NPK fertilizer were incorporated into the plots as per the treatments, cow dung was applied two weeks before sowing for it to decompose.

3.7.4 Weed control

Weeding was done as per the treatments, some plots were weeded while others were treated with herbicides and the weed check plots were un-weeded throughout the conduct of the study

3.7.5 Pest and disease control

During the course of the studies, Sesame pest identified was Leaf webber/Roller and Capsule borer (*Antigastra catalaunalis*). Chemical used to controlled the pest was Imi-Force (Imidacloprid 200/L SL), at the rate of 0.25-0.5ml/L and volume of water is 600-700L/ha. It is an excellent, systemic foliar and soil agricultural insecticide act as contact and system poison in various crops.

3.7.6 Harvesting

Harvesting was done when about 70% of the foliage and capsules turned yellow and started to dry as an indication of maturity. The plants were cut from the ground level and later allowed to sun-dry on the field.

3.8 DATA COLLECTED

3.8.1 Number of leaves per plant

The number of leaves was determined by counting the total number of leaves from five randomly selected plants. Mean values were computed and recorded at 4 and 8WAS.

3.8.2 Plant height (cm)

The average plant height was determined by measuring the height of five randomly tagged plants from the sampling rows of each plot at 4, and 8WAS and the average values were computed and recorded for each plot. Each plant was measured from the ground level to the tip of the last leaf

3.8.3 Leaf area index (LAI)

Leaf area index was calculated from leaf area and were obtained at 4 and 8WAS sampling periods as per the formula given by Sestak *et al.* (1971), after obtaining leaf area values used length x breadth x correction factor (0.70) as described by Chen and Black (1992).

$$LAI = \frac{\text{leaf area}}{\text{Ground area}} \ (cm^2)$$

3.8.4 Crop growth rate (CGR (g/m^2/week)

The crop growth rate expresses the dry matter increment of plant material per area of land per unit time. The CGR was computed at 4 and 8WAS using the below formula as suggested by Watson (1995). Thus:-

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where, w_1 = dry weight of plant/m^2 recorded at time t_1, w_2 = dry weight of plant/m^2 recorded at time t_2. T_1 and T_2 were the interval of time, respectively and it is expressed in g/m^2/time

3.8.5 Days to 50% flowering

The number of days from planting to the date when 50% of the plants have flowered in each plot was counted and recorded.

3.8.6 1000-seed weight (g)

The weight of 1000 seeds of sesame from each of the plots was measured and recorded.

3.8.7 Grain yield (kg/ha)

The grain weight of each net plot area was measured and recorded after allowing the capsules to dry properly on the field.

3.8.8 Biological yield (kg/ha)

The biological yield was calculated using the following relation as described by Rana and Kumar (2014).

$$\text{Biological yield (kg/ha)} = \frac{\text{Yield of crop in net plot (kg)} + \text{ stalk in net plot(kg)}}{\text{Net plot harvested area}} \times 10{,}000\text{m}^2$$

3.8.9 Harvest index (%)

Harvest index was calculated as described below by Nadeem *et al.* (2008).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.9 WEED DATA

3.9.1 Weed dry weight (g m^{-2}) at 75DAS

Dry weight of weeds was recorded at harvest; the weeds were removed from an area of $0.5m^2$ and were oven-dried at a constant temperature of 75^0C until a uniform weight of the weeds was obtained and then expressed in kg/ha.

3.9.2 Weed control efficiency (%)

Weed control efficiency was determined at physiological maturity of the crop using the following relation as described by Mani *et al*. (1976),

$$\text{WCE (\%)} = \frac{\text{weed dry weight in unweeded control} - \text{weed dry weight in treatment in}}{\text{weed dry weight in unweeded control}} \text{x } 100$$

3.9.3 Weed index (WI)

Weed index is the relationship between yields from weed free plot and that of the treatment using the relationship as described by Rana and Kumar (2014):

$$\text{WI} = \frac{\text{Yield from weed free plot} - \text{Yield from the treatment plot}}{\text{Yield from the free plot}} \text{ x } 100$$

3.10 DATA ANALYSIS

The data collected were subjected to statistical analysis of variance (ANOVA) (GENSTAT) to test for significant difference among the means as described by Snedecor and Cochran (1994). Means were compared using Students Newman-Keuls Test (SNK). The magnitude type and relationship between the characters examined were assessed using correlation analysis as described by Little and Hills (1978).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Physical and Chemical Properties of Soil of the Experimental Sites

The results of the soil analysis are shown in Table 1. The soil at BUK was loamy sand, the particles size distribution of sand, clay and silt were (86.0%), (5.44%) and (8.56%) respectively. The soil nutrient statuses were (4.321 g/kg) organic carbon, (1.4 g/kg) total nitrogen, (5. 887 mg/kg) of available phosphorus. Exchangeable bases were (5.781 cmol/kg Ca), (2.729 cmol/kg mg), (0.087 cmol/kg K) and (0.079 cmol/kg Na) as well as CEC of (9.009 cmol/kg), EC of (0.037 ds/m) and E.A of (0.334 cmol/kg) while the pH of the soil were (6.56 H_20) and (5.74 KCl).

At Gurungawa, the soil was characterized as sandy loam with a particles size distribution of (68%) of sand, (3.44%) clay and (28.56%) of silt. The organic carbon was (3.184 g/kg), (1.05 g/kg) of total nitrogen and available phosphorus was (3.925 mg/kg) while the exchangeable bases were (1.198 cmol/kg Ca), (1.641 cmol/kg mg), (0.054 cmol/kg K) and (0.094 cmol/kg Na). CEC of (3.654 cmol/kg), EC of (0.015 ds/m) and EA of (0.668 cmol/kg) as well as soil pH of (6.35 H_20) and (5.45 KCl)

4.1.2 Chemical Properties of the Cow dung used during Experiment

The chemical composition of cow dung used is presented in Table 2. The cow dung nutrient composition showed (0.3%) nitrogen, (1370.97 mg/kg) of phosphorus. (7875.10 mg/kg) of calcium, (565.86 mg/kg) of magnesium, (66.33 mg/kg) of sodium, (1139.24 mg/kg) of potassium as well as MC of (1.03%) and (955.2 mg/kg) of iron

Table 1: Physical and Chemical Properties of Soil at BUK and Gurungawa 2017 rainy season

Properties	BUK	Gurungawa
Physical (%)		
Sand	86.00	68.00
Clay	5.40	3.40
Silt	8.60	28.60
Textural Class	Loamy sand	Sandy loam
Chemical Composition		
pH in water	6.60	6.40
pH in KCl	5.70	5.50
Organic carbon (g/kg)	4.30	3.20
Total nitrogen (g/kg)	1.40	1.10
Available phosphorus (mg/kg)	5.90	3.90
Exchangeable Bases		
Ca++	5.80	1.20
Mg++	2.70	1.60
K+	0.10	0.10
Na+	0.10	0.10
CEC (cmol/kg)	9.00	3.70
EC (ds/m)	0.03	0.01
E.A (cmol/kg)	0.30	0.70

Table 2: Chemical Composition of Cow Dung at BUK and Gurungawa, 2017 rainy season

Chemical Composition	Analytical Values
Total Nitrogen (%)	0.30
Total phosphorus (ppm)	1370.90
Calcium (mg/kg)	7875.10
Magnesium (mg/kg)	565.90
Sodium (mg/kg)	66.30
Potassium (mg/kg)	1139.20
Iron (mg/kg)	955.20
Moisture content (%)	1.03

4.1.3 Plant Height (cm)

The effect of NPK, cow dung and weed control method on plant height of sesame is presented in Table 3, with both factors having significant effects at both locations. The results showed that application of NPK (50:60:35) produced significantly taller plants across the sampling periods and locations, followed by application of cow dung at 6 and 3 tons/ha while the shortest plants were produced by 0 tons/ha of cow dung.

The effect of weed control method on plant height of sesame indicated that hoe weeding at 3 and 6WAS produced the tallest plants at both locations and across the sampling stages, except that the values were statistically at par with the application of Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha at 4WAS at BUK. Application of Pendimethalin at 2.0 kg a.i./ha and Metolachlor at 2.0 kg a.i./ha produced plants with similar height, while the weedy check had the shortest plants at both locations and across the sampling period. At BUK, application of Metolachlor at 2.5 kg a.i./ha had taller plants compared with Pendimethalin at 2.5 kg a.i./ha. At Gurungawa, the effect of weed control method exhibited a similar trend at both sampling periods with Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha recording similar plant heights followed by application of both herbicides at 2.0 kg a.i /ha while the weedy check recorded the shortest plants.

The interaction between NPK, cow dung and weed control method on plant height at 8WAS at both locations presented in Table 4 indicated that application of recommended rate of NPK fertilizer with two hoe weedings at 3 and 6WAS resulted taller plants than any other weed control method, while the shortest plants were recorded when no cow dung was applied at the weedy check.

Table 3: Effect of NPK, Cow dung and Weed control Method on Plant height of sesame at BUK and Gurungawa, 2017 rainy season.

Treatments	Plant height			
	BUK		Gurungawa	
	4 WAS	8 WAS	4 WAS	8 WAS
Cow dung (t/ha)				
0	14.10c	57.60d	14.10d	55.70d
3	14.90c	68.60c	14.90c	64.50c
6	16.60b	72.50b	16.60b	68.60b
NPK	18.20a	78.70a	17.90a	76.30a
SE+	0.310	0.370	0.240	0.360
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	15.90b	67.50d	15.60c	64.40c
Pendimethalin 2.0 kg a.i/ha	15.80b	66.80e	15.60c	63.60c
Metolachlor 2.5 kg a.i/ha	16.30a	73.40b	16.20b	70.10b
Pendimethalin 2.5 kg a.i/ha	16.30a	72.10c	16.20b	69.20b
Hoe weeding 3 and 6WAS	16.80a	80.50a	16.90a	77.40a
Weedy check	14.90c	55.70f	14.70d	53.20d
SE+	0.131	0.250	0.102	0.451
Interaction				
CD*WCM	NS	**	NS	**

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance
CD= cow dung, WCM= weed control method

Table 4: Interaction between NPK, Cow dung and Weed control Method on Plant height at 8WAS at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	55.10m	51.18n	61.23j	59.42k	69.39gh	48.25o
3	68.32hi	67.38i	71.41fg	72.52f	77.13d	55.32m
6	71.80f	71.84f	77.43d	75.20e	81.58c	57.63l
NPK	74.39e	75.81de	83.09b	82.16c	93.34a	62.06j
SE±			0.601			
			Gurungawa 2017			
0	53.54hi	50.9j	58.25fg	56.19gh	67.47d	48.04k
3	63.12e	62.81e	67.66d	68.49d	72.86c	52.34ij
6	68.35d	67.76d	72.62c	71.04c	79.68b	52.38ij
NPK	72.97c	72.83c	81.98b	81.23b	89.46a	59.48f
SE±			0.901			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance. M= metolachlor P= Pendimethalin HW= hoe weeding, WC= weedy check

4.1.4 Number of Leaves

Table 5 shows the effect of NPK, cow dung and weed control method on number of leaves of sesame. At BUK, application of cow dung from 0 to 6tons/ha resulted in progressive increase in number of leaves of sesame. However, application of NPK at recommended rate produced the highest values at both 4 and 8WAS. At Gurungawa, application of NPK at recommended rate resulted in significantly higher number of leaves at 4 and 8WAS followed by application of cow dung at 6tons/ha and 3tons/ha while cow dung at 0tons/ha had the lowest values in the two sampling stages. However, at 4WAS, the difference between NPK and cow dung at 6tons/ha was not significant.

The effect of weed control method on number of leaves of sesame indicated that across the two locations and the sampling stages, the two hoe weedings at 3 and 6WAS resulted in higher number of leaves while significantly lower values were recorded under the weedy check.

At 4 WAS at BUK all the herbicide applications, irrespective of rates had similar numbers of leaves. At 8WAS in both locations the results showed that application of Metolachlor at 2.5 kg a.i /ha resulted in higher number of leaves compared with the application of Pendimethalin at the same rate while both herbicides at 2.0 kg a.i /ha had the lowest values. However, at Gurungawa, the effects of the two herbicides were similar under the same rates.

The interaction between NPK, cow dung and weed control method on number of leaves at 8WAS at BUK and Gurungawa 2017 (Table 6) indicated that application of recommended rate of NPK fertilizer with two hoe weedings at 3 and 6WAS highly

Table 5: Effect of NPK, Cow dung and weed control Method on Number of leave of sesame at BUK and Gurungawa, 2017 rainy season.

Treatments	Number of leave			
	BUK		Guringawa	
	4 WAS	8 WAS	4 WAS	8 WAS
Cow dung (t/ha)				
0	8.21d	34.62d	7.84b	32.80d
3	9.22c	42.33c	9.04b	39.30c
6	11.33b	47.30b	10.83a	43.82b
NPK	12.83a	51.70a	11.93a	48.54a
SE+	0.281	0.325	0.381	0.450
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	10.33b	40.69d	9.67c	37.98d
Pendimethalin 2.0 kg a.i/ha	10.34b	40.51d	9.47c	37.85d
Metolachlor 2.5 kg a.i/ha	10.41b	47.70b	10.33b	44.31b
Pendimethalin 2.5 kg a.i/ha	10.51b	46.83c	10.33b	43.31c
Hoe weeding 3 and 6WAS	11.73a	53.70a	11.34a	50.13a
Weedy check	9.24c	34.95e	8.51d	33.19e
SE+	0.141	0.22 2	0.132	0.353
Interaction				
CD*WCM	NS	**	NS	**

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

significant produced the highest number of leaves than any other weed control methods, while the least numbers of leaves than any other weed control methods, while the least numbers of leaves were observed plants when no cow dung for weedy check were applied.

4.1.5 Leaf Area Index (LAI)

The effect of NPK, cow dung and weed control methods on leave area index of sesame is presented in Table 7. The results showed that application of NPK produced higher leaf area index across the sampling periods and locations, followed by application of cow dung at the rate of 6 and 3tons/ha while the lowest leaf area index were produced by 0tons/ha.

The effect of weed control method on leaf area index of sesame indicated that hoe weeding at 3 and 6WAS produced the highest leaf area index at both locations and across the sampling stages while significantly lower values were recorded under the weedy check. At 4WAS at BUK all the herbicide applications irrespective of rates had different leaf area indexes. At 8WAS at both locations the results showed that application of Metolachlor at 2.5 kg a.i /ha resulted in higher leaf area index compared with the application of Pendimethalin at the same rate, while both herbicides at 2.0 kg a.i /ha had the lowest values. However, at Gurungawa, the effects of the two herbicides were similar at the same rates.

4.1.6 Crop Growth Rate (CGR) g/m^2/time

Effect of NPK, cow dung and weed control methods on crop growth rate of sesame are presented in Table 8. Application of cow dung significantly affected crop growth rate at both BUK and Gurungawa at 8 WAS during all sampling periods. Application of NPK at recommended rate resulted in statistically higher crop rates across all locations compare with other treatments. Lower mean values were recorded with control plots across all locations.

Table 6: Interaction between NPK, Cow dung and Weed control Method on Number of leave at 8 WAS at BUK and Gurungawa 2017 raining season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	31.71nb	32.33n	36.40m	36.67m	41.30j	29.71o
3	39.33kl	39.20l	47.73h	45.90i	50.73ef	32.53n
6	43.37i	42.30j	51.67e	50.70fg	57.67b	37.70m
NPK	49.50g	48.77gh	55.71c	53.32d	62.87a	40.78jk
SE±			0.512			
			Gurungawa 2017			
0	30.34k	30.60k	33.35j	34.06j	40.80i	29.10k
3	35.33j	35.53j	43.06gh	42.31h	47.33de	30.57k
6	39.31i	39.37i	49.06cd	47.07ef	54.04b	34.80j
NPK	46.33efn	45.50fgn	52.05 b	50.02c	59.50a	38.67i
SE±			0.77			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance, M= Metolachlor, P= Pendimenthalin, HW= hoe weeding
WC=weedycheck

Table 7: Effect of NPK, Cow dung and Weed control Method on Leaf area index (LAI) of sesame at BUK and Gurungawa, 2017 rainy season.

Treatments	Leaf area index			
	BUK		Gurungawa	
	`4 WAS	8 WAS	4 WAS	8 WAS
Cow dung (t/ha)				
0	0.24d	0.79d	0.23c	0.79d
3	0.43c	1.04c	0.31b	0.99c
6	0.57b	1.08b	0.48a	1.03b
NPK	0.63a	1.35a	0.53a	1.22a
SE±	0.012	0.042	0.021	0.031
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	0.36d	0.80d	0.32d	0.80d
Pendimethalin 2.0	0.39c	0.82d	0.33d	0.78e
Metolachlor 2.5 kg a.i/ha	0.75b	0.92b	0.68b	0.83b
Pendimethalin 2.5kg a.i/ha	0.65b	0.89c	0.50c	0.70c
Hoe weeding 3 and 6WAS	0.89a	1.34a	0.78a	1.21a
Weedy check	0.28e	0.78e	0.26e	0.69f
SE±	0.012	0.042	0.022	0.041
Interaction				
CD*WCM	NS	NS	NS	NS

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method.

Table 8: Effect of NPK, Cow dung and Weed control Method on Crop growth rate (CGR) of sesame at BUK and Gurungawa, 2017 rainy season.

Treatments	Crop growth rate			
	BUK		Gurungawa	
	4 WAS	8 WAS	4 WAS	8 WAS
Cow dung (t/ha)				
0	1.40	4.87e	1.40d	4.87d
3	1.52	5.63c	1.52c	5.54c
6	1.70	6.20b	1.70b	6.10b
NPK	1.73	6.80a	1.90a	6.50a
SE+	0.160	0.160	0.020	0.040
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	1.40b	5.80cd	1.50d	5.70d
Pendimethalin 2.0 kg a.i/ha	1.51b	5.60d	1.51c	5.50e
Metolachlor 2.5 kg a.i/ha	1.82a	6.32b	1.91b	6.12b
Pendimethalin 2.5 kg a.i/ha	1.91a	5.90c	1.90b	5.90c
Hoe weeding 3 and 6WAS	1.80b	6.90a	1.90a	6.70a
Weedy check	0.90c	4.50e	0.90e	4.40f
SE+	0.08 0	0.070	0.020	0.040
Interaction				
CD*WCM	NS	**	NS	**

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

The effect of weed control method on crop growth rate showed that application of Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha at 4WAS at BUK were statistically at similar followed by application of two hoe weedings at 3 and 6WAS statistically at par with application of Pendimethalin at 2.0 kg a.i./ha and Metolachlor at 2.0 kg a.i./ha, but at 8WAS at BUK the results were different; application of two hoe weeding produced highest crop growth rate followed by application Metolachlor at 2.5 kg a.i./ha. At Gurungawa, application of two hoe weeding produced higher crop growth rate at both sampling period, while application Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha at 4WAS at 4WAS at BUK were statistically similar. The least crop growth rate were observed when applied cow dung at 0tons/ha at both sampling period and locations.

Table 9 shows the interaction between NPK, cow dung and weed control method on crop growth rate of sesame at 8WAS at both locations. Application of NPK fertilizer at recommended rate with two hoe weedings at 3 and 6 WAS resulted in highly significant while the least crop growth rates were observed at the free weedy check with cow dung at 0t/ha.

4.1.7 Days to 50% flowering

Table 10 presents the effect of NPK, cow dung and weed control methods on number of days to 50% flowering of sesame. The results showed that application of NPK fertilizer at recommended rate flowered earlier across the locations than application of cow dung at 3tons/ha which was statistically at par with application of cow dung at 6tons/ha while plots treated with 0tons/ha of cow dung took smaller number of days to flower in both locations.

The effect of weed control method showed that two hoe weedings at 3 and 6WAS flowered earlier across the locations followed by application of Pendimethalin at 2.5 kg a.i/ha

Table 9: Interaction between NPK, cow dung and Weed control Method on Crop growth rate at 8 WAS at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	4.60oqr	4.70oqr	5.10m-p	5.10n-q	5.90g-k	3.70s
3	5.71i-m	5.52l-n	5.93f-j	5.83g-l	6.21d-h	4.35rs
6	6.04e-i	5.80g-m	6.60c-f	6.60cd	7.40b	4.90n-r
NPK	7.10bc	6.60cde	7.40b	6.30d-g	8.40a	5.10l-o
SE±			0.211			
			Gurungawa 2017			
0	4.50m	4.60m	5.09k	4.90kl	5.80ghi	3.68o
3	5.72i	5.40j	5.90gh	5.80ghi	6.28f	4.23n
6	5.94g	5.74hi	6.57de	6.30ef	7.13b	4.88i
NPK	6.59de	6.33ef	6.89c	6.60cd	7.70a	5.05kl
SE±			0.081			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance, M= metolachlor, P= Pendimethalin, HW= hoe weeding
WC= weedy check

Table 10: Effect of NPK, Cow dung and Weed control method on Days to 50% flowering and Biological yield (kg/ha) of sesame at BUK and Gurungawa, 2017 rainy season.

	Days to 50%		Biological yield	
Treatments	BUK	Gurungawa	BUK	Gurungawa
Cow dung (t/ha)				
0	47.60a	47.60a	3881d	3811d
3	46.20b	45.90b	4853c	4746c
6	44.60c	44.61c	5553b	5439b
NPK	42.90d	42.90d	6298a	6210a
SE±	0.080	0.080	63.701	34.801
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	46.10c	46.20c	4583d	4467d
Pendimethalin 2.0 kg a.i/ha	46.41b	46.41b	4315e	4312e
Metolachlor 2.5 kg a.i/ha	44.32e	44.32d	5936b	5817b
Pendimethalin 2.5 kg a.i/ha	44.60d	44.50d	5734c	5620c
Hoe weeding 3 and 6WAS	42.42f	42.41e	6633a	6521a
Weedy check	48.10a	48.10a	3677e	3572e
SE±	0.111	0.122	43.101	31.201
Interaction				
CD*WCM	*	*	**	* *

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

and Metolachlor at 2.5 kg a.i./ha across the locations, while the weed check plots took longer period to flowered at both locations.

Table 11 presents the interaction between cow dung and weed control method on days to 50% flowering of sesame at BUK and Gurungawa in 2017 rainy season. The results showed that application of NPK fertilizer at recommended rate with two hoe weedings resulted in early flowering followed by application of Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha with NPK fertilizer at recommended rate while plots with no cow dung and weedy check recorded longer days to flowering.

4.1.8 Biological yield (kg/ha)

The effect of NPK, cow dung and weed control method on biological yield of sesame is presented in Table 10, with both factors having significant effects at both locations. The result showed that application of NPK produced high biological yield across the two locations, followed by application of cow dung at the rate of 6 and 3tons/ha while the least biological yield were produced by 0tons/ha.

The effect of weed control methods on biological yield of sesame indicated that hoe weeding at 3 and 6WAS produced the high of biological yield at both locations follow by application of Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha at both locations while the weedy check produced the least biological yield at both locations.

The interaction between cow dung and weed control method on biological yield of sesame (Table 12), the results indicated that application of NPK and two hoes weeding at 3 and 6WAS resulted in high biological yield that were at par with the other weed control methods while the least biological yield were observed with 0t/ha cow dung and weedy check treatment though statistically similar with some other treatments.

4.1.9 Grain yield (kg/ha)

The effect of NPK, cow dung and weed control method on grain yield of sesame is presented in Table 13, with both factors having significant effects at both locations. The result showed that application of NPK (50:60:35) produced high grain yield of across the locations, followed by application of cow dung at the rate of 6 and 3 tons/ha while the lowest grain yield were produced by 0 tons/ha.

The effect of weed control method on grain yield of sesame indicated that hoe weeding at 3 and 6WAS produced the high grain yield at both locations follow by the application of Pendimethalin at 2.5 kg a.i./ha and Metolachlor at 2.5 kg a.i./ha at both locations while the weedy check yielded the lowest grain yield at both locations.

The interaction between NPK, cow dung and weed control method on sesame (Table 14), the result indicated that application of NPK and two hoes weeding at 3 and 6WAS resulted in high grain yield that were at par with all other weed control method, the least grain yield were observed when 0t/ha cow dung for weedy check and statistically similar with some other treatments.

4.1.10 1000-Seed Weight (g)

Table 13 shows the effect of NPK, cow dung and weed control method on 1000-seed weight of sesame. The results showed that application of NPK at recommended rate recorded highest weight across at both locations followed by application of cow dung at

Table 11: Interaction between NPK, Cow dung and Weed control method on Days to 50% flowering at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	48.10cd	48.37b	47.20e	47.10e	45.10g	50.20a
3	47.10e	47.10e	45.10g	45.10g	43.27ij	48.23bc
6	45.01g	45.71f	43.32j	44.03hi	42.30k	47.72d
NPK	44.10hi	44.13h	42.10k	42.13k	39.01l	46.01f
SE±			0.222			
			Gurungawa 2017			
0	48.10bc	48.17b	47.10d	47.10d	45.10g	50.10a
3	47.10d	47.10d	45.10g	44.17gh	43.17jkl	48.13b
6	45.10g	45.17ef	43.13jl	44.10ij	42.10m	47.17c
NPK	44.01ijk	44.13hi	42.10m	42.13m	39.10n	46.10e
SE±			0.231			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance, M= metolachlor, P= Pendimenthalin, HW= hoe weeding, WC= weedy check

Table 12: Interaction between NPK, Cow dung and Weed control Method on Biological Yield at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	3437l	3307l	4508hi	4396hij	5059g	2583m
3	4340ij	4186jk	5617e	5374ef	6149d	3451l
6	4973g	4648h	6489c	6208d	6976b	4023k
NPK	5582e	5121fg	7129b	6957b	8348a	4651h
SE±			101.201			
			Gurungawa 2017			
0	3334n	3331n	4423ij	4307jk	4973h	2496o
3	4226kl	4068lm	5528f	5284g	6062e	3310n
6	4867h	4544i	6293d	6062e	6927bc	3938m
NPK	5440fg	5303g	7022b	6827c	8122a	4544i
SE±			66.801			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, M= Metolachlor, P= Pendimethalin, HW= hoe weeding, WC= weedy check

Table 13: Effect of NPK, Cow dung and Weed control Method on Grain yield (kg/ha) and 1000-seeds weight (g) of sesame at BUK and Gurungawa, 2017 rainy season.

	Grain yield (kg/ha)		1000 seeds weight (g)	
Treatments	BUK	Gurungawa	BUK	Gurungawa
Cow dung (t/ha)				
0	617d	607d	2.4d	2.3d
3	780c	760c	2.8c	2.7c
6	908b	889b	3.5b	3.4b
NPK	1049a	1034a	3.8a	3.6a
SE±	23.620	12.270	0.01	0.04
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	755d	733d	3.1e	2.9d
Pendimethalin 2.0 kg a.i/ha	694e	700e	3.0d	3.1d
Metolachlor 2.5 kg a.i/ha	946b	930b	3.4b	3.2b
Pen 2.5 kg a.i/ha	912c	891c	3.3c	3.2c
Hoe weeding 3 and 6WAS	1072a	1048a	3.6a	3.5a
Weedy check	652f	633f	2.6d	2.4e
SE±	13.740	8.770	0.021	0.041
Interaction				
CD*WCM	**	**	**	**

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

6t/ha across the in both location while plots with no cow dung recorded lightest weight of seed.

The effect of weed control method indicated that weeding at 3 and 6WAS significantly recorded highest 1000 seeds weight across the locations follow by application of Pendimethalin at 2.5 kg a.i. /ha and metolachlor at 2.5 kg a.i. /ha at both locations; the weedy check statistically recorded lightest seed weight of across location that were at par with the other weed control methods.

Table 15 presents the interaction between NPK, cow dung and weed control method at both locations, application of NPK combined with two hoe weeding at 3 and 6 WAS produced heavier weight that were at par with all other weed control method while lighter weight were recorded at cow dung at 0t/ha with weedy check plots.

4.1.11 Harvest Index (%)

Effect of NPK, cow dung and weed control method on harvest index of sesame is presented in Table 16. The results showed that all the cow dung rates and NPK at recommended rate were statistically similar at both locations except at Gurungawa, in which all the cow dung rate were superior to the NPK fertilizer.

Effect of weed control method on harvest indices of sesame indicated that application of Pendimethalin at 2.0 and 2.5 kg a.i/ha, metolachlor at 2.5 kg a.i/ha and hoe weedings at 3 and 6 WAS recorded higher harvest indices compared with metolachlor at 2.0 kg a.i/ha followed by the weedy check at BUK 2017 rainy season.

At Gurungawa, application of Pendimethalin at 2.5 kg a.i /ha produced highest harvest index followed by application of Metolachlor at 2.5 kg a.i /ha and two hoe weedings at 3 and 6WAS which were statistically similar while the least harvest index was observed when no cow

Table 14: Interaction between NPK, cow dung and weed control Method on Grain Yield at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	566n	536n	694kl	672lm	778hij	458o
3	717jkl	686kl	886fg	833gh	957de	603mn
6	821gh	748ijk	1032c	996cd	1141b	708jkl
NPK	917ef	808hi	1173b	1148b	1413a	838gh
SE±			34.460			
			Gurungawa 2017			
0	548k	548k	680j	657j	762gh	444l
3	694ij	663i	868e	818f	939d	579k
6	801fg	728hi	1016c	968d	1131b	692j
NPK	890e	861e	1156b	1121b	1361a	818f
SE±			30.550			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test

NS= Not significant at 5% level of significance, M= Metolachlor, P= Pendimethalin, HW= hoe weeding, WC= weedy check

Table 15: Interaction between NPK, cow dung and weed control Method on 1000-Seed weight at BUK and Gurungawa 2017 rainy season.

Treatments	Weed control method					
Cow dung (t/ha)	M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	2.40p	2.21q	2.61n	2.51o	2.70m	2.11r
3	2.71mn	2.61n	3.10k	2.90l	3.30i	2.51o
6	3.51g	3.41h	3.81de	3.71e	3.91c	2.71mn
NPK	3.80e	3.61f	4.11b	3.90cd	4.50a	3.21j
SE±			0.031			
			Gurungawa 2017			
0	2.21lm	2.21lm	2.50jk	2.41kl	2.60hij	2.10m
3	2.50jk	2.41jk	2.90g	2.80gh	3.11f	2.41kl
6	3.30ef	3.20f	3.60d	3.60d	3.91b	2.51ijk
NPK	3.60d	3.51de	3.90bc	3.70cd	4.31a	2.71ghi
SE±			0.081			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance, M= metolachlor, P= Pendimethalin, HW= hoe weeding, WC=weedycheck

Table 16: Effect of NPK, cow dung and Weed control Methods on Harvest index (%) and Weed control efficiency (%) of sesame at BUK and Gurungawa location, 2017 rainy season.

Treatments	Harvest index (%)		Weed control efficiency (%)	
	BUK	Gurungawa	BUK	Gurungawa
Cow dung (t/ha)				
0	57.11	57.01a	27.40	28.10
3	56.70	56.91a	27.9 0	28.31
6	56.21	56.21a	27.72	27.92
NPK	55.51	55.42b	27.71	27.71
SE±	0.381	0.211	1.310	1.091
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	56.10b	56.20d	29.60c	29.90c
Pendimethalin 2.0 kg a.i/ha	57.11a	56.60c	27.41d	27.31d
Metolachlor 2.5 kg a.i/ha	57.60a	57.51b	33.81d	34.41b
Pendimethalin 2.5 kg a.i/ha	57.17a	57.91a	32.11d	32.19b
Hoe weeding 3 and 6WAS	57.12a	57.14b	43.01a	43.13a
Weedy check	52.17c	52.17e	0.00e	0.00e
SE±	0.210	0.101	0.740	0.750
Interaction				
CD*WCM	NS	NS	NS	NS

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

dung was applied

4.1.12 Weed Control Efficiency (%)

Effect of NPK, cow dung and weed control method on weed control efficiency of sesame is presented in Table 16. Both factors were not significant at both locations. At BUK, the result showed that all the fertilizers application were statistically similar at both locations; highest weed control efficiency were obtained with application cow dung at 3t/ha in both locations, follow by application of NPK at recommended rate which was at par with the application of cow dung at 6tons/ha.

At Gurungawa in 2017, application of cow dung at 3tons/ha was statistically similar with the application of cow dung at 0ton/ha which recorded the highest weed control efficiency while the lowest weed control efficiency was observed with application of cow dung at 0ton/ha and application of NPK fertilizer at BUK and Gurungawa 2017 respectively. Effect of weed control method on weed dry weight of sesame indicated that application of hoe weeding at 3 and 6WAS produced the highest weed control efficiency at both locations followed by the application of Pendimenthalin and Metolachlor at 2.5 kg a.i /ha and at both location while free weedy check produced the lowest weed control efficiency at both locations.

4.1.13 Weed Dry Weight (kg/ha)

Effect of NPK, cow dung and weed control method on weed dry weight of sesame is presented in Table 17. The result showed that weed dry weight was not affected by the different cow dung rates and NPK at recommended rate at both locations.

Table 17: Effect of NPK, Cow dung and Weed control Method on weed Dry weight (kg/ha) and Weed index (%) of sesame at BUK and Gurungawa, 2017 rainy season.

	Weed dry weight (kg/ha)		Weed index (%)	
Treatment	BUK	Gurungawa	BUK	Gurungawa
Cow dung (t/ha)				
0	477.11	468.71	18.31b	19.01
3	485.90	482.10	20.51b	20.32
6	478.80	478.41	20.52b	21.42
NPK	493.11	488.91	25.72a	23.92
SE±	9.071	8.780	0.701	1.050
Weed control method (WCM)				
Metolachlor 2.0 kg a.i/ha	470.81b	466.62c	28.82c	29.42c
Pendimethalin 2.0 kg a.i/ha	485.21b	484.21b	34.12b	32.42b
Metolachlor 2.5 kg a.i/ha	442.42c	436.22d	11.11e	10.90e
Pendimethalin 2.5 kg a.i/ha	453.62c	446.81d	14.41d	14.71d
Hoe weeding 3 and 6WAS	381.32d	377.32e	0.00f	0.00f
Weedy check	669.11a	666.22a	39.11a	39.72a
SE±	5.322	5.361	0.790	0.711
Interaction				
CD*WCM	NS	NS	*	*

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test, NS= Not significant at 5% level of significance, CD= Cow Dung
WCM= Weed Control Method

Effect of weed control methods on weed dry weight of sesame indicated that free weedy check produced the highest weed dry weight at both locations, follow by applications of Pendimethalin and Metolachlor at 2.0 kg a.i /ha and then the two herbicides at 2.5 kg a.i/ha which were at par while two hoe weeding at 3 and 6 WAS recorded the lowest weed dry weight.

At Gurungawa, application of Pendimethalin and Metolachlor at 2.5 kg a.i /ha were statistically similar, while two hoe weeding recorded lightest weed dry weight.

4.1.14 Weed Index (%)

Effect of NPK, cow dung and weed control method on weed index of sesame is presented in Table 17. The results showed that all the fertilizers application were statistically similar but having different value at both locations except NPK fertilizer. At BUK, highest weed index were recorded with application of NPK fertilizer followed by application of cow dung at 6tons/ha which was statistically similar to the other fertilizer while the least weed index was observed when no cow dung were applied. At Gurungawa, all the fertilizer applications were statistically similar but having different values. Application of NPK fertilizer recorded highest weed index followed by application of cow dung at 6tons/ha while the lowest weed index were observed with application of cow dung at 0tons/ha.

Effect of weed control method on weed index of sesame indicated that free weedy check produced the highest weed index at both locations, followed by applications of Pendimethalin and Metolachlor at 2.0 and 2.5 kg a.i /ha which were statistically similar at locations. At Gurungawa, application of Pendimethalin and Metolachlor at 2.5 kg a.i /ha were statistically similar while application of hoe weedings at 3 and 6WAS produced the lowest weed index at both locations.

Table 18 presents the interaction between NPK, cow dung and weed control method at both locations indicated that application of 0ton/ha of cow dung with free weedy check, Pendimethalin at 2.0 kg a.i. /ha and Metolachlor at 2.0 kg a.i. /ha produced higher weed index that were at par with all other weed control method except application of NPK fertilizer in combination with two hoe weedings at 3 and 6WAS that were recorded lowest weed index.

Table 18: Interaction between NPK, Cow dung and Weed control Method on Weed index at BUK and Gurungawa 2017 rainy season.

Treatments Cow dung (t/ha)	Weed control method M2.0	P2.0	M2.5	P2.5	HW	WC
			BUK 2017			
0	26.90ef	30.90de	10.61ij	13.52hi	0.00k	42.91a
3	24.91f	28.2ef	7.43j	12.71hi	0.00k	36.60bc
6	28.11ef	34.50cd	9.60ij	12.81hi	0.00k	37.90bc
NPK	35.11cd	40.90ab	16.90gh	18.70g	0.00k	40.70ab
SE±			1.611			
			Gurungawa 2017			
0	27.91d	27.81d	10.71f-i	13.70e-h	0.00j	41.71a
3	25.90d	29.41d	7.62i	12.91e-h	0.00j	38.14abc
6	29.22d	35.80bc	10.20fhi	14.50efg	0.00j	38.81abc
NPK	34.62c	36.61bc	15.02ef	17.16e	0.00j	39.90ab
SE±			1.671			

Means followed by the same letter(s) in column and row differ significantly at 5% level using Student-Keul Test
NS= Not significant at 5% level of significance, M= Metolachlor, P= Pendimenthalin, HW= hoe weeding, WC= weedy check

4.1.15 Correlation Analysis

The relationship between grain yield, growth and weed parameters of sesame at BUK 2017 rainy season is presented in Table 19. There were highly significant and positive correlations between grain yield, leaf area index, number of leaf, plant height, plant dry weight, crop growth weight, 1000-seed weight and weed control efficiency. However, days to 50% flowering, weed dry weight and weed index had negative correlation with yield. Leaf area index was positively related to number of leaf, plant height, plant dry weight, crop growth rate, 1000-seed weight and weed control efficiency. However, days to 50% flowering, harvest index, weed dry weight and weed index were negatively related with leaf area index. Weight of 1000 seeds and weed control efficiency had a positive correlation with all the parameters except days to 50% flowering in which the relationship was negative.

Table 20 shows the relationship between grain yield, growth and weed parameters of sesame at Gurungawa 2017 rainy season. There were highly significant and positive correlations between grain yield, leaf area index, number of leave, plant height and plant dry weight, consequently, crop growth rate, 1000-seed weight, harvest index and weed control efficiency showed positive correlations with grain yield. However, days to 50% flowering, weed dry weight and weed index had negative correlation with yield. Leaf area index was highly significant positive with number of leave, plant height, plant dry weight, crop growth rate, 1000-seed weight and weed control efficiency. However, days to 50% flowering, harvest index, weed dry weight and weed index were negatively related with leaf area index.

Table 19: Matrix of Correlation coefficient between Grain yield, Growth and Weeds parameter at BUK 2017 rainy season.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.922**	1.000										
3	0.955**	0.929**	1.000									
4	0.923**	0.884**	0.962**	1.000								
5	0.731**	0.634**	0.743**	0.763**	1.000							
6	0.887**	0.867**	0.925**	0.922**	0.552**	1.000						
7	-0.965**	-0.915**	-0.968**	-0.959**	-0.775**	-0.911**	1.000					
8	0.917**	0.943**	0.945**	0.919**	0.651**	0.896**	-0.930**	1.000				
9	0.052	-0.003	0.196	0.274	0.432**	0.232*	-0.213	0.077	1.000			
10	0.523**	0.407**	0.589**	0.654**	0.736**	0.605**	-0.623**	0.447**	0.730**	1.000		
11	-0.475**	-0.362*	-0.546**	-0.611**	-0.711**	-0.572**	0.577**	-0.404**	-0.754**	-0.981**	1.000	
12	-0.577**	-0.314	-0.538**	-0.537**	-0.664**	-0.493**	0.581**	-0.343*	-0.509**	-0.761**	0.769**	1.000

1= Grain Yield (kg/ha), 2=Leaf area index, 3=Number of leaf, 4=Plant height, 5=Plant dry weight, 6=Crop growth rate, 7=Days to 50%
Flowering, 8=1000 seeds weight, 9=Harvest index, 10=Weed control efficiency, 11=Weed dry weight, 12=Weed index, *=Significant at 5% level, **=Highly significant (at 1%)

Table 20: Matrix of Correlation coefficient between Grain yield, Growth and Weeds parameter at Gurungawa 2017 rainy season

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.759**	1.000										
3	0.888**	0.525**	1.000									
4	0.915**	0.736**	0.898**	1.000								
5	0.906**	0.713**	0.825**	0.914**	1.000							
6	0.017	0.561**	-0.339*	0.009	0.086	1.000						
7	-0.965**	-0.776**	-0.895**	-0.955**	-0.929**	-0.053	1.000					
8	0.0615	0.501**	-0.416**	-0.078	-0.001	0.995**	0.033	1.000				
9	0.188	-0.369	0.527**	0.273	0.271	-0.860**	-0.219	-0.896**	1.000			
10	0.068	0.496**	0.422**	0.085	0.005	-0.994**	-0.039	-0.999**	0.895**	1.000		
11	-0.468**	-0.360*	-0.438**	-0.580**	-0.741**	-0.164	0.569**	-0.081	-0.310	0.082	1.000	
12	-0.583**	-0.363*	-0.479**	-0.556**	-0.736**	-0.176	0.610**	-0.103	-0.219	0.103	0.807**	1.000

1= Grain Yield (kg/ha), 2=Leaf area index, 3=Number of leaf, 4=Plant height, 5=Plant dry weight, 6=Crop growth rate, 7=Days to 50%
Flowering, 8=1000 seeds weight, 9=Harvest index, 10=Weed control efficiency, 11=Weed dry weight, 12=Weed index, *=Significant at 5% level, **=highly significant (at 1%)

4.2 DISCUSSION

4.2.1 General

Weed infestation in sesame crop was generally higher in BUK than in Gurungawa, probably because of the high amount of rainfall and the temperature received in BUK. The overall performance of sesame as exemplified by yield attribute like plant height, number of leaves, crop growth rate, leaf area index, grain yield, days to 50%, 1000 seeds weight, biological yield and harvest index in BUK than Gurungawa, probably because of even distribution of rainfall, as well as the temperature received.

4.2.2 Effect of weed control treatments on growth of sesame

The result obtained shows that, weed control treatment significantly affected plant height, number of leave, crop growth rate and leaf area index

The plant height obtained in the herbicide treatments was significantly high in both sampling periods and locations except in the weedy check which gave the shortest height and this was expected because of weed competition in plants for growth resources usually retards growth. Due to the competition for solar radiation between the weed and the crop use in photosynthesis that will produce assimilate for the plant growth. Similar observations were made by Ndarubu (1997) and Katung (1997). The number of leave obtained in the herbicide treatments was significantly higher in both sampling period and locations except in the weedy check which gave the least number of leave and this was expected because of weed competition in plants for growth resources usually retards growth. Due to the competition for solar radiation between the weed and the crop use in photosynthesis that will produce assimilate for the plant growth. The result is in agreements with the finding of Johnson *et al.* (2002). The crop growth rate obtained in the herbicide treatments was significantly higher in both sampling period and locations except in the weedy check which gave the least crop growth rate and this was expected because of weed competition in plants for growth resources usually retards growth. Due to the competition for solar radiation between the weed and the crop use in photosynthesis that will produce assimilate for the plant growth. The leaf area index obtained in the herbicide treatments was significantly high in both sampling period and locations except in the weedy check which gave the least leaf area index and this was expected because of weed competition in plants for growth resources usually retards growth. Due to the competition for solar radiation between the weed and the crop use in photosynthesis that will produce assimilate for the plant growth. The result is in agreements with the finding of Busari *et al.* (1993).

Two hoe weeding and application of Metolachlor at 2.5 kg a.i./ha resulted in plant hight, higher number of leaves, leaf area index and crop growth rate which could be probably be attributed to the ability of hoe weeding to prevent outgrow of weeds after emergence and the ability of Metolachlor to suppress weed emergence at early stage. This greatly enhanced rapid growth through the efficient utilization of available soil nutrients by the crop. The result is in agreements with the finding of Busari *et al.* (1993).

Application of Pendimenthalin at 2.5 kg a.i./ha also significantly increased plant height, number of leaves leaf area index and crop growth rate but less to hoe weeding and Metolachlor at 2.5 kg a.i./ha this could resulted in increased the dosage of the herbicide whereas, application of pendimethalin at 2.0 kg a.i./ha produced lowest in all aforementioned growth parameters, this is due to low dosage application of herbicide. The result is in agreements with the finding of Johnson *et al.* (2002).

Hand weeding (3 and 6WAS) supported significantly higher plant dry weight, and this could resulted the moisture content of the soil and soil condition which later triggered regeneration of weed after weeding at 6WAS the result is in agreements with the finding of (Imoloame, 2017).

4.2.3 Effect of weed control treatment on the yield and yield components of sesame

From the results obtained it was seen that yield and yield components of sesame were significantly affected by the weed control treatments.

Hoe weeding at (3 and 6WAS) produced more grain yield, biological yield, 1000 seeds weight and harvest index than all remaining treatments, consequently, application of pendimethalin at both rate (2 and 2.5 kg a.i/ha) had low seed weight and grain yield compared to hand weeding and metolachlor at both rate (2 and 2.5 kg a.i/ha). This could occur by ability of pendimethalin injured susceptible plants by binding molecules, which ultimately leads to an inhibition of cell mitosis. The result is in agreements with the finding of (Appleby and Valverde, 1989)

4.2.4 Effect of organic and inorganic fertilizers on the growth and yield of sesame

From the results obtained, it was seen that growth and yield of sesame were significantly increased by the application of NPK (50:60:35) and cow dung at 6 tons/ha. This could be attributed to the low nutrient status of the soil and the ability of both fertilizer and manure to supplied nutrients contained in them gradually to support crop growth which later translated to high yield and growth attributes. The result is in agreements with the finding of (Aliyu, 2003 and Anon, 2007a).

Both yield and growth of sesame were recorded highest at NPK (50:60:35) and cow dung at 6 tons/ha while lowest yield and growth were obtained by the application of cow dung at 0 and 3 tons/ha because cow dung at 6 tons/ha had more quantity of nutrients compared to cow dung at 0 and 3 tons/ha.

4.2.5 Response of sesame to cow dung rates

Results from the study showed that there was a positive response of both growth and yield parameters of sesame plants to the application of cow dung at both locations. Growth parameters such as plant height, number of leaves, leaf area index and crop growth rate were all enhanced by the highest (6 tons/ha) cow dung rate. Application of cow dung manure at 6 tons/ha also hastened the days to 50% flowered. The significant increase in growth and yield of the plants could be credited to mineralized nutrients (NPK) that improved the crop performances.

4.2.6 Correlation

There was highly significant and positive correlated between growth parameters and grain yield, while weed dry weight and weed index were highly negative correlated at both locations.

4.2.7 Interaction between the cow dung and weed control method

Two hoe weeding 3 and 6WAS with application of cow dung at 6t/ha significantly increased plant height, number of leaf, leaf area index and crop growth rate followed by the application of metolachlor at 2.5 kg a.i/ha with application of cow dung at 6t/ha. The least growth parameters was observed at the plots of weedy check with application of cow dung at 0t/ha than application. In addition, application of cow dung and at 3t/ha with two hoe weeding were statistically similar with the application of cow dung and pendimethalin at 2.5 kg a.i/ha.

Two hoe weeding 3 and 6WAS with application of cow dung at 6t/ha significantly increased seed weight, grain yield, biological yield and harvest index followed by the application of metolachlor at 2.5 kg a.i/ha with application of cow dung at 6t/ha. The least yield and yield components were observed at the plots of weedy check with application of cow dung at 0t/ha than application

CHAPTER FIVE

5.0 SUMMARY, CONCLUSSION AND RECOMMENDATIONS

5.1 Summary

Field experiment was conducted in 2017 growing season at the Research Farm of Faculty of Agricultural science, Bayero University, Kano (Lat 11^o 58$'$N and Long 8^o 33$'$E and 475m above sea level) and Gurungawa in Kombotso local Government area (lat 11^o 56$'$N and long 8^o 31$'$E and 475m above sea level) all in Sudan savanna zone of Nigeria.

The aim of the study was to evaluate the performance of sesame (*Sesame indicum* L.) as influenced by weed control treatments and fertilizers in Kano state of Nigeria. The experiment consisted of three levels of cow dung (0, 3 and 6 tons/ha), two levels of Metolachlor (2.0 and 2.5 kg a.i./ha), two levels of Pendimethalin (2.0 and 2.5 kg a.i./ha), two hoe weeding (3 and 6WAS) while NPK (50:60:35) and free weedy check were included as control.

The experiment was laid out in a split plot design with cow dung and NPK applied to the main plot and weed control methods to the sub-plot, and were replicated three times in the two different locations. The findings of the study revealed that hoe weeding at 3 and 6WAS out yielded Metolachlor at the rates of (2.0 and 2.5 kg a.i/ha) as well as Pendimethalin at the rates of (2.0 and 2.5 kg a.i/ha) and exhibited superior growth and yield components of Sesame plant such as grain yield, biological yield, 1000 seeds weight, number of leaves, plants height, leaf area index, crop growth and days to 50% flowered, though result indicated that Metolachlor at the rate of 2.5 kg a.i/ha followed Pendimethalin at the rate of 2.5 kg a.i/ha gave significantly higher in growth and yield of sesame plant compared with others such as Metolachlor and Pendimethalin at the rate of 2.0 kg a.i/ha and free weedy check which had relatively lower of growth and yield of Sesame plant though had the highest weed dry weight than the other weed control treatments. Free weedy check, Metolachlor and Pendimethalin at the rates of 2.0 kg a.i/ha had more weed dry weight and weed index but lower in weed control efficiency compared to the two hoe weeding, Metolachlor and Pendimethalin at 2.5 kg a.i/ha which produced lower weed dry weight and weed index but higher weed control efficiency.

NPK (50:60:35) exhibited superior growth and yield components of Sesame plant such as number of leaves, plants height, leaf area index, crop growth rate, grain yield, biological yield, 1000 seeds weight, days to 50% flowered and harvest index. Cow dung at 6 tons/ha gave significantly higher growth and yield of sesame compared with the others rates. Apparently, cow dung at the rate of 3 tons/ha had more weed dry weight, weed control efficiency and weed index than cow dung at the rates of 0 and 6 tons/ha but the values are relatively similar.

5.2 Conclusion

Conclusively, two hoe weeding at 3 and 6WAS, Metolachlor at (2.5 kg a.i/ha) and Pendimethalin at (2.5 kg a.i/ha) can be considered for the two study areas. Similarly application of cow dung at (6 tons/ha) and NPK (50:60:35) can be also considered but depending on the choice of farmer and available resources.

5.3 Recommendation

Two hoe weeding 3 and 6WAS, Metolachlor at (2.5 kg a.i/ha) and Pendimethalin at (2.5 kg a.i/ha) can be recommended for the two study areas, similarly application of cow dung at (6 tons/ha) and NPK (50:60:35) can be also recommended but depending on the choice of farmer. More research is needed to ascertain if there is any effect on using chemicals and cow dung for supplementing use of hoe and inorganic fertilizer in order to improved farmers live hood.

More research is needed to ascertain if there is any effect on using chemicals and cow dung for supplementing use of hoe and inorganic fertilizer in order to improved farmers live hood.

APPENDIX

Appendix 1: Meteorological data covering the Experimental Period at BUK Kano, 2017

	Rainfall (mm)	Solar Radiation (mj/j)	Temperature (^{0}C)		Relative Humidity (%)	
Month			Min	Max	Min	Max
June	187.60	7.59	25.32	39.35	21.03	86.22
July	219.60	6.65	20.20	30.07	44.19	80.71
August	361.73	7.72	24.03	31.45	41.27	86.54
September	103.29	7.67	21.19	32.71	54.08	95.00
October	31.20	8.81	32.67	25.21	45.14	91.10
November	0.0	9.54	21.45	35.81	23.10	70.11
TOTAL	903.42					

Source: Meteorological station of Bayero University Kano

Appendix 2: Meteorological data covering the Experimental Period at IITA Kano, 2017

	Rainfall(mm)	Solar Radiation (mj/j)	Temperature (^{0}C)		Relative Humidity (%)	
Month			Min	Max	Min	Max
June	75.00	6.21	21.12	43.76	33.29	57.77
July	160.00	6.16	20.97	37.05	51.60	50.57
August	292.79	4.85	20.01	34.43	57.48	73.80
September	103.29	6.44	20.88	34.99	64.22	77.58
October	31.20	6.63	23.84	30.92	65.30	73.70
November	0.0	8.64	19.92	37.32	38.58	66.22
TOTAL	662.28					

Source: IITA Kano Meteorological station

REFERENCES

Abdullahi, A.E., Modisa, O., Molosiwa, O. and Mosarwe, L., (2000), *Cynodon dactylon* control in sunflower (*Helianthus annuus* L*)* with the post-emergence graminicides in a semi-arid environment. *Crop protection* 20(5): 411-414

Abubakar, S. S., Onyibe, J. E., & Tologbonshein, E. B. (1998). The role of extension Research and information dissemination in enhancing beniseed production Production, marketing of resource poor farmers. *Proceedings of the First Workshop on Beniseed held at the National Cereal Research Institute*, Badegi, Nigeria, March 3rd – 5th,1998. Pp86-9.

Adesina G.O, Akinyerniju O.A, Ayeni A.O (1998). Control of weeds in soybeans with imidozalinone herbicides. *Nig. Jour. Of weed sci*.,11:7-15

Agoola A.A., (1994). A recipe of continuous Arable crop production in the forest zones of western Nigeria. In Snchez., P.A and H.V., alternative to slash and burn Agriculture, symposium 15th international soil science congress, Acapulco, Mexico p107-120

Ahmad, N., M. Rahim and U. Khan, (2007). Evaluatio of differentvarieties, seed rates and row spacing of groundnut, planted under agro-ecological conditions of Malak and division. *J. Agron.,* 6: 385-387

Alege, G.O, Akinyele, B.O and Agianaku, E (2009). Department of Crop, Soil and Pest Management, Federal University of Technology, Akure. *Volume, 14, Nos 1 and 2, pp 60-63*

Akobundu I.O., (1979). Weed control in Nigeria. *PANS.* 25(3): 287-298

Akobundu I.O., (1980). Weed science Research at h International I nstitute of Tropical Agriculture and Research Needs in Africa. *Weed science.* 28(4): 439-445

Akobundu I.O (1987). *Weed science in the tropics, principles and practices*. John Wiley and Sons pp 522.

Aliyu, I,. and Lagoke, S.T.O, (2000). Profitable chemical weeds control in ginger (*Zingibier officionale Roscoe)* production in Northern Nigeria

Anonymous. (1997). A Guide Book for Field Crops in Thailand. *Field Crops research Institute, Dept. of Agriculture*. Bangkok, Thailand, p.166.

Anonymous (2004). Sesame production in Texas USDA http//nisu.edu/croppropiles/docs/ussesa me.html.

Anonymous, (2004b). H20: The power of water. BASF Corp. *Research Triangle Park, NC. 4p.*

Anonymous (2006). Fertilizer use in Zimbabwe. FAO/UN. Rome. 55pp.

Anonymous (2007); PROTA.*Sesame indicum* L in PROTA 14:*Vegetable oils/ Oleagineux.Record display*

Anonymous , (2007a). Guia Tecnica para producer ajonjoli de temporal en Michoacan, Instituto Nacional de Investigaciones Forestales, agricolas, y pecunarias,

http://www.sagarpa.gob.mx/dlg/michoacan/inifap/ajonjoli_tdap.pdf, accessedSSS 29 Mar 2007.

Anonymous, (2007c). Guia tecnica para el cultivo del"ajonjoli", http://www.agronegocios.gob.sv/comoproducir/guias/ajonjoli.pdf+ajonjoli+el+salvado+herbicida&hl=en&ct=clnk&cd=1&gl=us, accessed 13 Apr 2007.

Anonymous, (2008).World sesame situation, American Sesame Growers Association.Html:file//C:\world status of sesame. Mht (15/01/08).

Appleby, A. and Valverde, B. (1989). Behavior of dinitroaniline herbicides in plants. Weed *Technol. 3, 198-206.*

Ashri, A., Roebbelen, G. and Downey R.K. (1989*). Oil crops of the world*. McGraw-Hill, New York, pp: 375-387

Ashton, F. and Crafts, A. (1981). Dinitroanilines, In: *Mode of Action of Herbicides*. JohnWiley & Sons, Inc., New York. pp. 201-223.

Bahman, E and James, F.P. (1999): Composted and non composted manure application to conventional and no tillage systems in corn yield and nitrogen uptake. *Agronom journal* 91: 819pp

Black, C.A. (1965). *Metbods of soil analysis II chemical and microbiological properties.* American Society of Agronomy, Madison Wisconsin: 1572.

Bennett, M. (1998). Sesame seed. The new rural industries, a handbook for farmers and investors. www.ridc.gov.au/pub/handbook/sesame.html, accessed 3 Apr 2007.

Byrd, Jr., J. & York, A. (1987). Annual grass control in cotton (*Gossypium hirsutum*) with fluazifop, sethoxydim, and selected dinitroaniline herbicides. *Weed Sci. 35, 388-394.*

Buchanan, G.; Murray, D. & Hauser, E. (1982). Weeds and their control in peanuts. *In Peanut Science and Technology*. Pattee, H. & Young, C. (Eds.), pp. 206-249, Amer. Peanut Res. Educ. Soc., Inc., Yoakum, TX.

Busari, L.D. and Bature, P. (1993). Evaluation of selected herbicides for weed control in sesame (*Sesamum indicum* L*)*. in the Southern Guinea Savanna zone of Nigeria.Nigeria. *Journal of Weed Science* 6: 7-12

Cardina, J. & Swann, C. (1988). Metolachlor effects on peanut growth and development. Peanut Sci. 15, 57-60.

Chamblee, R. Thompson, Jr.,W. & Bunn, T. (1982). Management of broadleaf signalgrass (*Brachiaria platyphylla*) in peanuts (*Arachis hypogaea*). Weed Sci. 30, 40-44.

Chenault, E. Bean, B. & Salisbury, C. (1992). Influence of incorporation methods on pigweed (*Amaranthus palmeri* S. Wats) and barnyardgrass [*Echinochloa crus-galli* (L.) Beauv] control with trifluralin and pendimethalin in sorghum (*Sorghum bicolor* L. Moench). Proc. South. *Weed Sci. Soc. 45, 57.*

Chikoye, D. and F. Ekeleme. (2001). Weed Flora and Soil Seed banks in Fields Dominated by *Imperata cylindrical* in the Moist Savannah of West Africa. *Weed Research*, 41: 475-490

Chikoye, D., S. Schultz., and F. Ekeleme. (2004). Evaluation of Integrated Weed Management Practices for Maize in the Northern Guinea Savanna of Nigeria. *Crop protection.* 23: 895-900

Culpepper, A. (1996). Sicklepod (*Senna obtusifolia*) management in sulfonylurea-tolerant soybean (*Glycine max*) and weed management systems in no-tillage bromoxyniltolerant cotton (*Gossypium hirsutum*). M. S. Thesis. North Carolina State Univ. Raleigh, NC, 138pp.

Dadari *et al., (*2005). The effect of post-emergence weed control on irrigated wheat in the Sudan savannah of Nigeria. *Crop protection.* 24: 842-847

Dotray, P. Keeling, J., Grichar, W., Prostko, E., & Lemon, R. (2004). Peanut response to ethalfluralin, pendimethalin, and trifluralin preplant incorporated. *Peanut Sci. 30, 34-37.*

Duhoon, S.S.;Jyotishi, A.; Deshmukh, M.R and Singh, N.B. (2004). Optimazation of sesame *(sesamum indicum L.) Production through bio/natural inputs.* http://www.cropsceince.au/res.

Ennis, Jr., W. (1964). Selected toxicity in herbicides. *Weed Res. 4, 93-104*.

FAO (Food and Agricultur Organization of the United Nation. (2002). sesame Production.Information.http://WWW.ecoport.org/EP.exeSEntFull?ID=1937

FAO (2008). Regional sesame production, trade and consumption. *United Nation/ Food and Agricultur Organization. Pp.*

FAO, (2009) Food and Agricultural Organisation of the United Nation.Faostat database available on line http;/faostat fao.org/site/567/default.aspx (05. 12.2011).

Grichar, W. (1991) Sethoxydim and broadleaf herbicide interaction effects on annual grasscontrol in peanuts (*Arachis hypogaea*). *Weed Technol*. 5, 321-324.

Grichar, W. & Colburn, A. (1993). Effect of dinitroaniline herbicides upon yield and grade of five runner cultivars. Peanut Sci. 20, 126-128.

Grichar, W.; Colburn, A. & Baughman, P. (1996). Yellow nutsedge (*Cyperus esculentus*) control in peanut (*Arachis hypogaea*) as influenced by method of metolachlor application. *Weed Technol.* 10, 278-281.

Grichar WJ, Sestak DC, Brewer KD, Besler BA, Stichler CR, Smith DT(2001). Sesame (*Sesamum indicum L.*) tolerance and weed control with soil applied herbicides. *Crop Prot*., 20: 389-394.

Grichar, W. Sestak, D., Brewer, K., Besler, B., Stichler, C., & Smith, D. (2001a). Sesame (*Sesamum indicum* L.) tolerance and weed control with soil-applied herbicides. *Crop Protect*. 20, 389-394.

Grichar, W. Besler, B., Dotray, P., Johnson, W. III, & Prostko, E. (2004a). Interaction of flumioxazin with dimethenamid or metolachlor in peanut (*Arachis hypogaea*). *Peanut Sci*. 31, 12-16.

Grichar, W. Lemon, R., Dotray, P. & Besler, B. (2004b). Control of problem weeds and net returns with herbicide programs in peanut (*Arachis hypogaea*). *In: Weed Biology and Management*, Inderjit (Ed). pp.485-515, Kluwer Academic Publ. Dordrecht, The Netherlands.

Grichar, W. Besler, B. & Brewer, K. (2005a). Weed control and grain sorghum (*Sorghum bicolor*) response to postemergence applications of atrazine, pendimethalin, and trifluralin. *Weed Technol*. 19, 999-1003.

Grichar, W. Besler, B., Lemon, R. & Brewer, K. (2005b). Weed management and net returns using soil-applied and postemergence herbicide programs in peanut (*Arachis hypogaea* L.*). Peanut Sci*. 32, 25-31.

Grichar, W. (2006). Using soil-applied herbicides in glyphosate-resistant soybeans along the Texas Gulf Coast. *Weed Technol*. 20, 633-639.

Grichar, W.; Dotray, P. & Langham, D. (2009). Sesame (*Sesamum indicum* L.) response to preemergence herbicides. *Crop Protect*. 28, 928-933.

Haruna, M. I and S. Abimiku, M. (2012). Yield of Sesame (Sesamum indicum L.) as Influenced by Organic Fertilizers in the Southern Guinea Savanna of Nigeria. Sustainable Agriculture Research. 1. 10.5539/sar.v1n1p66.

Hussein, M. El-Hatlab, A., Abd-El Raouf, M., Shaban, S. & El-Deek, M. (1983). Effect of soil herbicides on weeds, yield and quality of sesame, *Sesamum indicum* L. Z. Acker. Pflanzenbou 152, 173-185.

Ibrahim, A. El Wekil, H. Yehia, Z. & Shaban, S. (1988). Effect of some weed control treatments on sesame (*Sesamum indicum* L.) and associated weeds. *Journal of Agronomy and Crop Science* 160, 319-324.

Ishaya, D.B., Tunku, P and N.C, Kuchinda. (2008). Evaluation of some weed control treatments for long season weed control in maize under zero and minimum tillage at Samaru in Nigeria. *Crop protection.* Pg 1047-1051

Ishaya, D.B., Tunku, P and M.S Yahaya. (2008). Effect of pre-emergence herbicide mixtures on cowpea (*Vigna unguiculata L.)* at Samaru in northern Nigeria. *Crop protection.* Volume 27, Issue 7, July 2008. Pg 1105-1109

Johnson, W.,I Prostko, E. and Mullinix, B., Jr., (2002). Texas panicum (*Panicum texanum*) control in strip-tillage peanut (*Arachis hypogaea). Peanut Sci*. 29, 141-145.

Katung, P.D (1997). Effects of sowing date and plant population on yield and yield components of sesame (*sesamum indicum* L) Unpublished M.sc. Thesis, submitted to the postgraduate school, Ahmadu Bello University, Zaria. 74pp

Kent, R., E.E and Becker. M. (2001). The influence of cropping system on weed community of rice in Cote d'ivoire, West Africa. *Agriculture Ecosystem and Environment.* 8: 299-307

Kim, J.; Kang, C., Oh, S. and Lee, H. (1986). Studies on the weed control and phytotoxicity of herbicides under polyethylene film mulching in the sesame upland. Research of the Rural Development Admin.*, Plant Environment Mycology and Farm Products Ultilization*. Korea Republic 28, 72-78.

Kuepper, G. and L. Gegner (2004). Fundamental of Sustainable Agriculture*: Organic crop production overview*. *http://www.attrg.ncat.org/attra-pub/organiccrop.html. Retrieved on 03/09/08.*

Langham D.; Riney, J., Smith, G., Wiemers, T., Pepper, D. & Speed, T. (2010). Sesame Producers Guide*. Sesaco Corp*. 33 p.

Mahadi,M.A.,Dadari,S.A.,Tanimu,B.,Kuchinda,N.C.,andShinggu,C.P.(2012) Influence of weed control treatments and cow dung manure on growth and development of quality protein maize. *Biological and Environmental Science Journal for the Tropics* 9 (1)168-174

Malik, N. & Muhammed-Ramzan. (1992). Effect of herbicides and cultural operations on weed control and grain yield of sesame. *Journal of Agricultural Research Lahore 30, 147-152.*

Martin, C. (1995). Development of an effective weed control system for sesame in the Northern Territory. *Proceedings of Sesame Workshop*, Darwin and Katherine, NewTerritory, pp. 121-127.

Miller, A. Bellinder, R., Bradley, B., Rauch, B., Goffinet, M., & Welser, M. (2003). Cabbage (*Brassica oleracea*) response to pendimethalin applied postemergence. *Weed Technol*. 17, 256-260.

Mondal,S.S. Verna, D. and Kuila, S. .(1992). Effect of organic and inorganic sources of nutrient in growth and seed yield of sesame. (*sesamum indicum L.*). *Indian Agron*, 37 (4): 258-262.

Mueller, T. Shaw, D. & Witt, W. (1999). Relative dissipation of acetochlor, alachlor, metolachlor, and SAN 582 from three surface soils. *Weed Technol*. 13, 341-346.

Ndarubu, A.A (1997). Effects of inter-row spacing and chemical weed control treatments on sesame (*sesamum indicum* L) Unpublished M.sc. Thesis submitted to the post graduate school, Ahmadu Bello University, Zaria.

NCRI, (2002). Oilseed Reshearch Program Report.NCRI Review Meeting 22-28 june 2002.

NCRI,(2005). *Technology for Beniseed (sesame) production*. 3th Edition. oilseed Research Programme, NCRI, Badeggi (vol. 3 .march 2005).

NCRI,(2008).Oilseed Research Division Report. 2008 Reserach Review and Planning National Cereals Research Institute Badeggi Workshop 26-30 May 2008.

Obuo, J.E., E. Adipala, and D.S.O. Osiru. (1997). Weed suppression in a cowpea/sorghum intercrop. 16th *East African Bienial Weed Science Conference Proceedings.* 113-118

Olorunmaiye P.M (2010). Weed control potential of five legumes Cover crops in maize/cassava intercrop in a southern Guinea savanna ecosystem of Nigerian. *Australian journal of Crop Science* 4(5): 324-329.

Onwueme,I.C. and Sinha, T.D. (1991).*Field crop production in Tropical Africa* .The Netherlands. 480pp

Oplinger, (1990). *Alternative field Crop Manual* (sesame).Dept. of Agronomy and Soil Sceinces, College of Agriculture and life sceinces and Cooperative Extension Services, University of Wisconsin-Madison W1 53706.

Osborne, B. Shaw, D. & Ratliff, R. (1995). Response of selected soybean (*Glycine max*) cultivars to dimethenamid and metolachlor in hydroponic conditions. *Weed Technol.* 9, 178-181.

Prostko, E. Johnson, III, W. & Mullinix, Jr., B. (2001). Annual grass control with preplant incorporated and preemergence applications of ethalfluralin and pendimethalin in peanut (*Arachis hypogaea*). *Weed Technol*. 15, 36-41.

Rahman, S.A., J.F. Alamu and M.I Haruna (2001). "Comparative Economic Analysis of Maize production under organic and inorganic fertilizers: A case study of Daudawa village in Katsina State, Nigeria". *Nigerian Journal of Bio-Sciences.* Vol 1: 1 pp 64-65.

RMRDC (2004) Report on survey of agro-raw materials in Nigeria.Raw.materials research and development council. Abuja.

Ross, M. & Lembi, C. (1999). Herbicide incorporation techniques and equipment. In: Applied Weed Science. 2nd ed, Stewart, C., Stagman, J., Carnis, M., (Eds.), Pp. 371- 375, Upper Saddle River, NJ: Prentice-Hall.

Sapin, V. Mills, G, Schmidt, D., & O'Shanesy, P. (2000). Growing sesame in South Burnett. Department of Primary Industries, Queensland Government, www.dpi.qld.gov.au/fieldcrops/2888.html, accessed Nov 2003.

Schrodter, G. and Rawson, J. (1984). Herbicide evaluation studies in sesame. Aust. Weeds. 3, 47-49.

Shukla, V. 1984. Chemical weed control in sesame, Pesticides 18, 13-14.

Sibuga, K.P. (1997). Weed management in Eastern and Southern Africa: Challenges for the 21st century, *16th East African Weed Science Conference Proceedings.* 5-11

Soto-Soto, E. and Silva-Vasquez, J. (1987). Trials of pre-emergence in the cultivation of sesame (*Sesamum indicum* L.*), Informe de Las Labores de la Seccion de Agronomica Centro Experimental del Algodon*, pp. 131-145.

Watson, J.D (1952), The Physiology basis of variation in yield

Ukeje, E. (2004). Modernizing Small Hoilder Agriculture to ensure food security and gender empowerment: Issues and Policy International Group of twenty four. Research Papers available at *http://www.g24.org/research.html//u*.

Uzun, B. and Cagirgan, M,I (2006). Comparison of determination and interminate lines of sesame for Agronomic traits. *Field crops research*. 96;13-18., *Advances in Agronomy 4: 101-104.*

Watson, D,J (1952).The Physiology Basis of Variation in Yield. *Advances in Agronomy 4:101-104.*

Watson, J,D (1958)The Independence of net assimilation rate no leaf area index. *Annals of Botany 22: 37-54.*

Weber, J. (1990). Behavior of dinitroaniline herbicides in soils. *Weed Technol*. 4, 394-406.

Wehtje, G. Wilcut, J., Hicks, T. and McGuire, J. (1988). Relative tolerance of peanuts to alachlor and metolachlor. *Peanut Sci*. 15, 53-56.

Wesis,E.A. (1984). *Oilseed Crops.* Longman, London. Pp 283-340.

Weis, E,D (1984*), Oilseed Crops, Longman Group,London UK*

Wesis,E.A. (1984). *Oilseed Crops. Longman, London*. Pp 283-340.

Wilcut, J. York, A., Grichar, W. & Wehtje, G. (1995). The biology and management of weeds in peanut (*Arachis hypogaea*), *In Advances in Peanut Science*, Pattee, H. & Stalker, H.(Eds.).pp. 207-244. Amer. Peanut Res. Educ. Soc., Stillwater, OK.

Zeidan, M,S (2007), Effect of organic Manure and phosphorus Fertilizers on growth, Yield and quality of Lentil Plants in Sandy Soil, *Research Journal of Agriculture and Biological Sceinces.3 (6) 748-752.*

Zewdie, K. (1994). Effect of pre- and post-emergence herbicides on weed control and yield of sesame under irrigation., *Proceedings of the Ethiopian Weed Science Society*, Addis Abeba (Ethiopia), 15-16 Dec 1994.