INFLUENCE OF WEED MANAGEMENT STRATEGIES ON GROWTH, YIELD AND QUALITY OF SESAME (*Sesamum indicum* L.) IN KANO SUDAN SAVANNA ZONE, NIGERIA.

BY

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A DISSERTATION SUBMITED TO THE DEPARTMENT OF AGRONOMY, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF SCIENCE (M.Sc.) IN AGRONOMY (CROPS AND CROPING SYSTEMS IN DRYLANDS).

JULY, 2021

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. Abdulrahman Lado and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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……..
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CERTIFICATION

This is to certify that the research work for this dissertation and subsequent write-up by Yaou Idi Kabirou (SPS/17/MAG/00029) were carried out under our supervision.

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(Head of Department)

APPROVAL

This dissertation entitled "Influence of Weed Management Strategies on Growth, Yield and Quality of Sesame (*Sesamum indicum* L.) in Kano Sudan Savanna Zone of Nigeria" by Yaou Idi Kabirou (SPS/17/MAG/00029) has been examined and approved for the award of Master of Science Degree in Agronomy (Crops and Cropping Systems in the Drylands).

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DEDICATION

This research work is dedicated to my dear mother, Hamsatou Oumarou, my defunct father, Yaou Idi, my beloved wife, Mrs Nafissa Ibrahim, my daughter, Oummou Salma Kabirou and my entire family.

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ABSTRACT

A field trial was conducted in 2019 rainy season at Research and training farm of Centre for Dryland Agriculture, Bayero University Kano and National Horticultural Research Institute of Bagauda, Kano in order to determine the effect of weed management strategies on growth, yield and quality of sesame. The experiment consisted of one sesame variety (X-Sudan) and eleven levels of weed management strategies (Manual hoe weeding at 3 and 6 weeks after sowing, Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1}, Pre-emergence application of Pendimethalin at 1.5kg a.i ha^{-1}, Pre-emergence application of Tithonia at 5 % (W/V), Pre-emergence application of Tithonia at 10 % (W/V), Pre-emergence application of Tithonia at 5 % (W/V) followed by postemergence application of Tithonia 5 % (W/V), Pre-emergence application of Tithonia at 5 % (W/V) followed by postemergence application of Tithonia at 10 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by post-emergence application of Tithonia at 5 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by post emergence application of Tithonia at 10 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS and Weedy check). The treatments were laid out in randomized complete block design (RCBD) with three replicates. The results indicated that, manual hoe weeding at 3 and 6 WAS recorded the lowest weed density, weed index, weed dry weight and the highest weed control efficiency at both BUK and Bagauda. It could be concluded that hoe weeding at 3 and 6 WAS resulted in the production of highest grain yield but not economical. Pre-emergence application of pendimethalin at 1 kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS proved to be more economical and could therefore be recommended in the study areas.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Sesame is a survivor crop that has been planted by subsistence farmers for 7,500 years in areas that will not support the growth of other crops or under difficult conditions (Langham, 2008). It is one of the oldest crops known to humans (Grichar, Dotray and Langham, 2011). Sesame belongs to *Pedaliaceae* family and is one of the most important and ancient oilseed crops, better known as "Queen of oil seed crops" by virtue of its edible quality oil (Raikwar, 2016). The genus *Sesamum* comprises of 35 wild species besides the only cultivated species, *Sesamum indicum* (Ali, 2006). It is an herbaceous annual plant with erected growth and a height of 0.5 to 2 m (Weiss, 1971). *Sesamum indicum* is grown in tropical zones as well as in temperate zones between latitudes 40°N and 40°S. The plant grows up to 50 to 100 cm in height, with opposite leaves 4 to 14 cm long with an entire margin; they are broad lanceolate, to 5 cm broad, at the base of the plant, narrowing to just 1 cm broad on the flowering stem (Onsaard, 2012). The flowers are white to purple, tubular, 3 to 5 cm long, with a four lobed mouth (Salunkhe *et al.*, 1992). The fruit of sesame is a capsule containing 50-100 seeds. The sesame seeds are pear-shaped, overate, and small flatted with dimensions of 2.80 mm in length, 1.69 mm in width and 0.82 mm in thickness (Onsaard, 2012).

Sesame has been cultivated in the Middle East and India for 4000 years ago. About 60% of the world's sesame production was from China, India, Myanmar, Ethiopia and Nigeria during 2011 (Kumar and Hiremath,2018). According to Food and Agricultural Organization of the United Nations, 6,549,725 tons of sesame was produced worldwide in 2019 on an area of 12,821,752 ha with a yield of 510,8 kg. ha^{-}

[1]. In the same year, Africa produced 3,998,148 tons harvested on an area of 8,737,270 ha yielding 457,6 kg. ha^{-1}. ha^{-1}. Nigeria is the largest producer of sesame seeds in Africa, and the third largest in the world, with about 480,000,00 tons produced in 2019. Nigeria currently produces about 300,000 tons of sesame seed; about 26 states presently grow sesame with largest producing states being Jigawa, Nasarawa, Benue and Taraba (Adewale, 2019).

Sesame seed is an important oil seed crop widely used in the food, pharmaceutical and other industries in many countries due to its high oil and antioxidant contents (Vafaei, Razmjoo and Karimmojeni, 2013). Apart from being an important oil seed source, sesame seed is a potential source of protein. It is rich in water soluble antioxidants such as sesamin, sesamol, sesamolin, and sesaminol glucosides (Langham, 2008) which inhibit the development of rancidity in the oil (Bennett, 1998). Langham (2008) also specified that sesame seed contains 34.4 to 59.8% of oil, 32.7 to 58.2% of oleic acid, 27.3 to 59.0% of linoleic acid and 19 to 30% of protein, especially methionine. The sesame seed is considered as raw materials in the production of bakery products and confectionery; while the oil is use in the industries for the production of soap, perfume, carbon paper, pharmaceuticals and edible vegetable oils (Yol *et al.*, 2010). It provides food for human beings. Sesame cake is also use in the production of livestock feed as well as organic fertilizer (Ogbonna and Umar, 2011).

1.2 PROBLEM STATEMENT

In Nigeria, sesame yields are generally low due to drought, poor soil fertility, inappropriate varieties and poor cultural practices among which is weed control strategies. Weeds are serious pest of most crops due to competition for light, nutrients, moisture and space, and this causes serious reduction in crop yield (Lahmod and

Alsadaawi, 2012). According to Yahaya (2011) sesame cannot tolerate weed competition especially at early stage of growth. The presence of weeds is a major obstacle in sesame production (Sperry *et al.*, 2016) and can negatively influence sesame yield. Zuhair *et al*. (2011) noted that weed infestation during the early growth period of sesame causes yield reductions of about 35 to 70 %. Babiker *et al.* (2014) reported that unrestricted weed growth reduced sesame grain yield by 30 %. Weeds also may harbor insects and act as a host for certain plant pathogens. Some weed seeds are morphologically similar with sesame seed and can adulterate sesame grains thereby decreasing its quality and oil content. Weed competition in sesame may reduce the size of sesame seed and hence oil content.

1.3. JUSTIFICATION OF THE STUDY

In Nigeria, sesame cultivation has experienced a remarkable expansion in recent years. This increase in plantings and production, notwithstanding low yield, technical and socio-economic constraints reflect the population's enthusiasm for this crop. It has been always considered a secondary crop and has been rarely subjected to appropriate weed control. Weed management is an important component of plant protection that can improve the production potential of crops. It is a system approach whereby whole land use planning is done in advance to minimize the weeds invasion in aggressive forms and give crop plants a very strong competitive advantage over the latter (Rana and Rana, 2016). Eliminating or reducing the detrimental effects of weeds on agronomic crops is the ultimate goal of weed management. Efficient and effective weed management will help increase sesame production and improving the quality of the produce. This will certainly help in improving the level of food security, economic growth and development among of the rural population. Sesame is now becoming an export crop. In International market, it requires 99.99 % purity (Vafaei, *et al.*, 2013).

To achieve this high percent purity, proper and efficient weed management is not only important but necessary.

1.4. OBJECTIVES OF THE STUDY

The study seeks to achieve the following objectives

i To evaluate the effect of different weed control strategies on growth and yield of sesame.

ii To determine the effect of different weed control strategies on quality of sesame.

iii To evaluate the profitability of different weed management strategies in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CONCEPT OF WEEDS

Weeds can be defined as plants that are unwanted in a given situation and may be harmful, dangerous or economically detrimental. They are generally those plants that negatively affect the various interest of human principally crop production (Ajayi, 2018). According to Das (2011), Awodoyin and Akande (2014), a weed is any plant, native or non-native, that interferes with crop by competing with crops for limited resources in agroecosystems and has the habit of encroaching where it is not wanted. Simultaneous emergence and rapid growth of weeds leads to weed competition for moisture, light, space and nutrients. Weeds have the ability to develop rapidly, to self-pollinate, disperse widely and tolerate large range of environmental conditions (Akobundu, 1987; Frick and Johnson, 2012). They may grow faster than crops and successfully compete for space, water, sunlight and available nutrients (Akobundu and Agwakwa, 1998; Milberg and Hallgren, 2004; Hamma and Ibrahim, 2013).

Weeds may be classified into many groups. They are classified based on their morphology, habitat, life cycle, growth habit; life style and climate. Based on morphology, weeds are classified into broad leaved, narrow leaved and sedges. Based on where they are found, weeds are categorized into terrestrial weeds and aquatic weeds (Akobundu, 1987). They are grouped into ephemerals, annuals, biennials and perennial weeds based on life cycle; they are also classified into autotrophic weeds and parasitic weeds based on their mode of living (Akobundu, 1987).

2.2. EFFECT OF WEED COMPETITION ON GROWTH AND YIELD OF SESAME

Sesame crop is very sensitive to weeds. An effective weed control strategy is an indispensable approach in the improvement of sesame production. Weeds are serious pests of most crops and cause serious reduction in crop yield. Mruthul *et al.* (2015) noted that weed competition in sesame is critical during the period between 15 to 30 days after sowing (DAS). When they emerge, sesame cotyledons are very small compared to other crops and do not grow as fast. According to Rao (2000), weeds can efficiently remove plant nutrients from the soil than sesame to grow faster and inhibit sesame growth due to adverse effect on photosynthesis and assimilates accumulation. Consequently, the sesame growth and yield components can be reduced by the presence of weeds, i.e., plant height, crop growth rate, number of branches, number of capsules and seeds per capsule, seed weight per plant and per capsule, 1000 seeds weight, grain yield, etc. (Ibrahim *et al*., 1988, Beltrao *et al.,* 1991, Grichar *et al*., 2001a.). Plant height decreased with prolonged weedy duration and increased with increased weed free period (Ahmed *et al.,* 2014). They also observed that number of capsules per plant and 1000-seeds weight decreased with increasing weed competition. Tepe *et al.* (2011), noted that yield losses in sesame are generally caused by delayed weeding or insufficient weed control and the lack of proper weed control is one of the main constraints resulting in low yields of sesame (Mruthul *et al.*, 2015). A maximum number of capsules could be obtained by weed free periods and yield reductions from 35 to 70 % may be caused by insufficient weed control during the early growth period of sesame (Zuhair *et al*., 2011). Farooq *et al*. (2008) reported that weeds may cause yield losses of 35-75% and 70-100% in lowland and upland agroecosystems, respectively.

2.3. EFFECT OF WEED COMPETITION ON SESAME QUALITY

Weed competition may reduce the quality of sesame seeds, e.g., seeds purity, size, oil content, etc. Weeds may reduce crop quality through contamination (Benson, 1982; Jabran *et al*., 2008; Farooq *et al*., 2011). Vafaei *et al.* (2013) reported that sesame seeds and many weed seeds are similar in size. Therefore, cleaning of the seeds may be difficult and this may adulterate the physical purity of the sesame seeds. Any weed seed that is in a sesame sample in a large percentage is difficult to separate out, no matter the size. Ahmed *et al.* (2014) reported that increasing weedy period especially late in the season (70 days after emergence or more) decreased seed oil content.

2.4. METHODS OF WEED CONTROL IN SESAME

2.4.1 Cultural Weed Control

This refers to any practice applied to create favorable field condition for crops. These practices help in controlling weeds if used properly. Cultural weed control alone cannot control weeds, but reduces weed population. These practices include crop rotation, planting methods, tillage, fertilizer application, field preparation, choice of varieties, etc. Peruzzi *et al*. (2007) and Schonbeck (2013) observed that crop rotation, maintaining good soil fertility, using well-adapted competitive forage species, on rangeland, are examples of cultural weed control.

2.4.2 Manual Hand Weeding

In Nigeria, manual hoe-weeding is still the most common weed control practice in sesame for small farmers with limited resources or abundance of human labour. Many farmers may use animal traction as a weed management method. Through hand weeding, the space between rows and sesame plants is hoed. Early hand weeding causes seedlings to grow faster because of improved soil aeration and the reduced competition for nutrients. However, the manual/mechanical weeding during

the early-stage of growth of sesame seedling is difficult. Sesame grows slowly in the first three to four weeks. The roots follow moisture and with rain or irrigation in this period, they may grow laterally and stay near the surface. Cultivating too close to the plant can cut roots and plants will wilt quickly and possibly die (Grichar *et al.*, 2011). Feaking (1973) reported that hand-weeding is very laborious and the careless manipulation of the hoe may easily damage the crop especially if weeding is made at the pegging stage. Tractors drawn cultivators are also in use for controlling weeds, however this method is limited by the sizes of farmers' land, the cost involved and many other factors.

2.4.3 Chemical Weed Control

The second common way for controlling weeds is the use of chemicals. This method refers to the application of synthetic and or toxic products named herbicides to suppress weeds in order to prevent weed competition. Chikoye *et al*. (2005) reported that the use of herbicides is an important method in the modern concept of weed control. Herbicides are classified as pre-emergence and post emergence herbicides. A pre-emergence herbicide is applied to the soil before emergence of the specified weed or crop, whereas a post emergence herbicide is applied after emergence of the specified weed or crop (Rahman *et al.*, 2017). Herbicides are very efficient in the control of weeds. Herbicidal weed management saves time and is more favorable due to scarcity of human labour availability during peak season. However, Jallow (2019) noted that in developing countries the use of herbicides is limited by scientific knowledge, the limitation of available herbicides, the inadequacy of current information on local requirements, skills and the application methods and timing. It has been shown that sesame yield was increased by the application of metolachlor and trifluralin (Hussein *et al.*, 1983) or was not affected by S-metolachlor (Grichar *et al*.,

2001b). Other studies showed that metolachlor adequately controlled weeds but caused unacceptable crop injury or reduced the sesame plant stands and caused sesame stunting when compared with the untreated check in one of two years (Langham *et al*. 2007, Grichar *et al*. 2009). According to Grichar *et al. (*2011), post emergence herbicides that control broadleaf weeds in sesame have caused some sesame injury or yield reduction. They also added that herbicides can effectively control weeds but can also affect sesame growth and yield (Grichar *et al.,* 2018). In the same idea Langham *et al.* (2007) opined that metolachlor controlled weeds well but reduced sesame plants stand or caused unacceptable crop injury while Diuron have controlled weeds without significant reduction in the yield.

2.4.4 Biological Weed Control

The use of biological control methods in field crops is being considered, but is not still much in use. This method refers to the application of a bioherbicide. Bioherbicides may be compounds derived from microbes such as fungi, bacteria, viruses, or protozoa; or phytotoxic plant residues, extracts or single compounds derived from other plant species. They can be applied as in aerial sprays or in a powder applied to the soil. Most agricultural pests have one or more naturally occurring enemies that reduced its population. Plant pathogens can be used to control weeds in a similar way to chemical herbicides. Drost and Doll, (1980) noted that allelopathy may be used as a tool in weed management by applying the residues of allelopathic weeds or crop plants as mulches or water extracts in the field. Cheema, Khaliq and Farooq (2008) added that allelopathic plant extracts show potential results in many studies. In the industry, bio-herbicides and other bio-pesticides are often referred to as "naturals". Bioherbicides utilize such naturally occurring enemies, rather than depending on man-made chemicals. This can be important because agents of

biological control ordinarily have fewer effects on the environment than do synthetic chemicals. Moreover, they tend not to lead to the public health problems that chemicals are associated with. The use of allelopathic water extracts is cheap (Rahamdad and Muhammad, 2012) with less or no-environment pollution. *Tithonia diversifolia*, belonging to the family *Asteraceae* is an example of allelopathic plants. It has both inhibitory and stimulatory allelopathic effects due to its allelochemical constituents. Ajayi (2018) reported that the screening of the aqueous extracts of *Tithonia diversifolia* leaf indicated the presence of tannins (1.75 ± 0.31 mg/g), phenols (2.42 ± 0.59 mg/g), alkaloids (1.50 ± 0.45 mg/g), flavonoids (0.60 ± 0.09 mg/g) and saponins (1.82 ± 0.50 mg/g). The aqueous extracts of root and shoot of *Tithonia diversifolia* inhibited the germination and the growth of *Amaranthus cruentus* (Otusanya *et al*., 2007). Also, it has been reported that leachate of *Tithonia diversifolia* suppressed the total germination of *Abelmoschus esculentus* (Ademiluyi, 2012) and that its shoot aqueous extract inhibited the germination of *Tridax procumbens* (Ademiluyi, 2013) in cultivated crops.

CHATER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

The experiment was conducted during 2019 cropping season at two different locations. The first location was Research and training farm of Centre for Dryland Agriculture, Bayero University Kano (11°58'52.5" N and 008°24'48.6" E). The second location was at National Horticultural Research Institute, Bagauda, Kano, Nigeria (11°33'25.93" N and 008°23'11.97" E) all in the Sudan savanna zone of Nigeria.

3.2 METEOROLOGICAL DATA

Records of rainfall, temperature (maximum and minimum) and relative humidity were collected for the two locations during the period of the study from the meteorological stations of Research and training farm of Centre for Dryland Agriculture, BUK and National Horticultural Research Institute of Bagauda, Kano, Nigeria.

3.3 SOIL ANALYSIS

Soil samples were randomly collected from the two experimental sites at a depth of 30 cm using an auger. The samples collected were bulked, sieved, air dried

and were taken to the Laboratory of Centre for Dryland Agriculture, BUK for analysis. The soil textural class; percentage of sand, silt and clay, Total nitrogen, available phosphorus, organic carbon were determined by using the procedure of Benard *et al*., (2004)., CEC, E.A, soil pH by using a pre calibrated pH meter method (Mucha *et al*., 2004). Exchangeable bases: K, Na, Mg, Ca were determined by using extraction method as described by Anderson and Ingram (1993).

3.4 TREATMENTS AND EXPERIMENTAL DESIGN

3.4.1 Treatments

The experiment consisted of eleven treatments of weed management strategies viz., Manual hoe weeding at 3 and 6 weeks after sowing, Pendimethalin at 1kg a.i ha^{-1}, Pendimethalin at 1.5kg a.i ha^{-1}, Tithonia at 5 % (W/V), Tithonia at 10 % (W/V), Tithonia extract at 5 % (W/V) followed by postemergence application of Tithonia extract at 5 % (W/V), Tithonia extract at 5 % (W/V) followed by postemergence application of Tithonia extract at 10 % (W/V), Pendimethalin at 1kg a.i ha^{-1} followed by post-emergence application of Tithonia extract at 5 % (W/V), Pendimethalin at 1kg a.i ha^{-1} followed by post emergence application of Tithonia extract at 10 % (W/V), Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing and Weedy check.

The pre-emergence application was done immediately after sowing while the post emergence application of the aqueous extract was done at six weeks after sowing.

3.4.2 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates using X-Sudan variety of sesame obtained from Jigawa

Research Institute. The gross plot size was 4.5 m x 3 m (13.5 m^2) consisting of six ridges each of 3 m long and spaced of 0.75m apart. The net plot was 4.5 m^2 consisting of the two innermost ridges. A discard of 1 m was left between plots and 2 m between replications. The field layout is presented on page 58 (Appendix iii).

3.5 PREPARATION OF AQUEOUS EXTRACT OF TITHONIA AND PENDIMETHALIN DETAILS

The shoots of *Tithonia diversifolia* were collected from bush and air dried for seven days. The dried shoots were chopped into pieces with fodder cutter and were air dried at room temperature to a constant weight, milled with A2 grinder into fine powder and sieved. The powder was soaked into the ratio of 1000 g to 10litre of distilled water to obtain 10% (w/v) concentration. The mixture was filtered through four layers of Muslin cloth to obtain the water extract. One litre of this was diluted to make 5% (w/v) concentrations by adding 1 litre of distilled water.

Pendimethalin is a pre-emergence herbicide used for the control of annual grasses and some broadleaf weeds. It acts by suppressing cell elongation and cell division (Ashton and Craft,1981).

3.6 CULTURAL PRACTICES

3.6.1 Land Preparation

The land was cleared, ploughed, harrowed and made into ridges spaced of 75cm. It was demarcated into plots of 4.5 m x 3m making 13.5 m^2 of gross size.

3.6.2 Sowing

The sowing was done per pinch when the rainy season was fully established with 75 cm inter rows and 20 cm intra rows spacing making 90 stands per plot.

3.6.3 Weeding

Weeding was done as detected by the treatments.

3.6.4 Fertilizer Application

The fertilizer was applied at the rate of 60 kg ha^{-1} of nitrogen, 20 kg ha^{-1} of phosphorus (P_2O_5) and 20 kg ha^{-1} of potassium (K_2O) using NPK 15:15:15 and urea. The NPK was applied at 3 WAS and the urea at 6 WAS.

3.6.5 Pest and Disease Control

Preventive control was done weekly from the beginning of flowering using Permethrin 30% at the rate of 1 kg a.i. ha^{-1}.

3.6.6 Harvesting

The sesame was harvested at maturity when the capsules turned yellow and the basal leaves started dropping. The seeds were weighed using electric balance to obtain the grain yield per net plot. The grain yield per net plot was extrapolated to grain yield per hectare.

3.6.7 Threshing

Threshing was done when the entire harvested crops were fully dried.

3.7 DATA COLLECTION

3.7.1 Weed Studies

% Weed flora composition

The weed count was taken from two randomly placed 1 m^2 quadrants in each plot. The weeds were counted and sorted into broad leaves, narrow leaves and sedges and the mean value was extrapolated as percentage for each experimental unit.

Weed density

The weed count was taken from the two randomly placed 1 m^2 quadrants in each plot and the mean value was recorded and extrapolated into hectare.

Weed dry weight

The weeds from two randomly placed 1 m^2 quadrant were collected and dried in an oven at 65^0C to a constant weight. The dried weeds were weighed using electric balance (ADAM model, precision= 0.1 g) and recorded the mean value as weed dry weight of that particular plot.

Weed control efficiency (WCE) (%)

Weed control efficiency is a measure of the efficiency of weed control methods in restricting the weed growth. It was determined at physiological maturity of the crop by using the following relation as described by Mani *et al*. (1976).

$$\text{WCE}= \frac{\text{Weed Dry Weight in unweeded control (g)} - \text{Weed Dry Weight in treatment (g)}}{\text{Weed Dry Weight in unweeded control}} X\ 100$$

Weed index (WI %)

The weed index was determined as follows

$$\text{WI}= \frac{\text{yield from weed free (hand weeded) plot} - \text{yield from treated plot}}{\text{yield from weed free (hand weeded) plot}} X100$$

3.7.2 Growth Characters

Stand count at harvesting

The standing plants in each net plot were counted and recorded at harvesting.

Crop Growth Rate (CGR)

As The crop growth rate was determined from five randomly selected plants at 3 and 6 WAS as suggested by Happer (1999). The plants were uprooted, free from soil and dried in an oven at 65^0C to a constant weight and dry matter was determined. The growth rate was computed using the equation below and recorded:

$$\text{CGR} = \frac{W_2 - W_1}{T_2 - T_1}\ \text{g/week}$$

Where, W_1 is the dry weight of the plant at 3WAS

W_2 is the dry weight of the plant at 6WAS

T1 is time1 (3 weeks) and T2 is time2 (6 weeks)

Days to 50% flowering

The number of days from sowing to when 50% of plants in a plot had flowered was determined for each plot. The flowering stage was considered to be achieved when 50% of plants had flowered in each plot.

Days to 50% maturity

The number of days from sowing to when 50% of plot matured was recorded for each treatment. The maturity was considered to be achieved when the basal leaves dropped and the capsules turned to yellow.

Plant height (cm)

The height of five randomly selected and tagged plants were taken at physiological maturity using a meter rule by measuring from the tip of the crop to the base and the

mean value was recorded.

Number of branches per plant

The number of branches per plant were counted at physiological maturity from five randomly selected and tagged plants per plot and the mean recorded.

3.7.3 Yield Characters

Number of capsules per plant

The number of capsules per plant were counted at physiological maturity from the five randomly selected plants in each plot and the mean value recorded.

Number of seeds per capsule

The number of seeds per capsule were recorded from ten capsules selected randomly and the mean value recorded for each plot.

Seed weight per plant

The seed weight per plant was determined by dividing the seed weight per plot by the number of plants per plot.

Seed weight per capsule

The seed weight per capsules was determined by dividing the seed weight per plot by the number of capsules per plot.

Grain yield (kg. ha^{-1})

The grain yield per net plot was weighed using electronic balance and was extrapolated to grain yield per hectare using the following formula:

$$Grain\ Yield\ (kg.ha^{-1}) = \frac{Grain\ yield\ per\ net\ plot(kg)}{Net\ plot\ area\ (m^2)}\ X\ 10{,}000m^2$$

1000 grains weight

One thousand sesame graine were counted from each plot using seed counter and then weighed using electronic balance (ADAM model, precision= 0.1 g).

3.7.4 Quality Characters

Oil content (%)

A total of 20g of seeds were collected from each plot and subjected to laboratory analysis to determine the percentage of oil content in the grain using the Soxhlet extraction procedure as described by Malik *et al.*, (2003).

Seeds physical purity (%)

20g of seeds were collected from each plot and subjected to laboratory analysis to determine the seeds physical purity (%) as described by FAO and Africa

Seeds (2018). Each sample was separated into pure sesame seeds, other crop seeds, weed seeds and inert matter. The sesame pure seeds and the other components were weighed. The percentage of pure sesame seeds was determined as follows.

$$\text{Seeds Physical Purity (\%)} = \frac{\text{weight of the pure sesame seeds}}{\text{T}otal\ weight\ of\ all\ components} \ X\ 100$$

3.7.5 Soil Properties

A part from the soil samples collected before the experiment; other samples were collected as per treatment at harvesting in order to evaluate the effect of weed control methods on chemical properties of the soil**.**

3.8 DATA ANALYSIS

The data collected from the experiment were subjected to analysis of variance (ANOVA) using GenStat software, 17th Edition. The means were compared using Students Newman-Keuls Test (SNK) at 5 % level of probability. The Pearson correlation analysis was done to determine the relationship between the growth and yield variables. Economic analysis was also done.

Economic analysis:

The cost of all inputs and labour were determined and the economic returns was calculated using the following parameters.

Total cost: The cost of all production (land preparation, rent of land, sowing, cost of treatments application, cost of herbicides and pesticides, cost of seeds and harvest, etc)

Gross revenue: Grain yield X unit price of three hundred and seventy Naira per kilogram (₦ 370 Kg^{-1}) (the prevailing market price of sesame in Kano at the time of harvest).

Net return = Gross Revenue – Total Cost

Benefit cost ratio = Gross Revenue / Total Cost

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CHATER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Soil Analysis

The results of soil analysis before sowing at BUK and Bagauda during 2019 rainy season is presented Table 1. The results indicated that the soil at BUK was sandy clay with particle size distribution of 64.70 % sand, 22.04 % silt and 13.26% clay while at Bagauda the soil was sandy clay loam with particle size distribution of 49.54 % sandy, 33,50 % silt and 16.96% clay. The organic carbon, nitrogen and available phosphorus were low at both locations. The exchangeable bases were also low except CEC and Ca at both locations. Table 2 and Table 3 show the chemical properties of the soil at harvest as per treatment at BUK and Bagauda respectively. The values of total nitrogen, organic carbon. and CEC obtained at BUK before sowing (Table 1) were lower than that obtained at harvest (Table 2) for most of the treatments. However, the pH and K recorded before sowing were higher than that recorded at harvest by all treatments. At Bagauda, available P and CEC were higher at harvest than at sowing. However, the total nitrogen at sowing and at harvest were

similar for most of the treatments and the pH at sowing was lower at harvest than at sowing.

Table 1: Physical and Chemical Properties of Soil at BUK and Bagauda Locations During 2019 Rainy Season

Soil Properties	BUK	Bagauda
Physical (g. kg $^{-1}$)		
Sand	647	658.1
Silt	220.4	192.8
Clay	132.6	149.1
Texture Class	Sandy Clay	Sandy Clay Loam
Chemical		
pH	6.88	6.14
O. C. (g. kg $^{-1}$)	4.2	3.6
Nitrogen (g. kg $^{-1}$)	0.4	0.4
Available P (mg.kg $^{-1}$)	4.97	4.86
Cu (mg.kg $^{-1}$)	1.22	2.22
Mn (mg.kg $^{-1}$)	17.14	14.26
Zn (mg.kg $^{-1}$)	10.64	3.28
Fe (mg.kg $^{-1}$)	285.56	336.32
Exchangeable Bases (cmol.kg^{-1})		
Ca ++	1.25	1.25
Mg++	0.41	0.36
K++	0.19	0.18

Na++	0.10	0.13
CEC	1.98	2.05

Source: Laboratory of Centre for Dryland Agriculture, Bayero University Kano (BUK)

O.C = Organic Carbon, CEC = Cation Exchange Capacity

Table 2. Chemical Properties of Soil per Treatment at BUK During 2019 Rainy Season.

Weed Management Strategies	pH	N (g. kg^{-1})	P (g. kg^{-1})	K (Cmol.kg^{-1})	O.C (g. kg^{-1})	CEC (Cmol.kg^{-1})
Manual Hoe Weeding at 3 & 6 WAS	6.04	0.6	72.1	0.12	6.5	2.72
Pendimethalin at 1 kg a.i ha^{-1}	6.14	0.8	56.7	0.08	4.9	2.78
Pendimethalin at 1.5 kg a.i ha^{-1}	6.07	0.6	57.7	0.10	3.8	3.25
Tithonia at 5 % (W/V)	6.09	0.6	59.3	0.11	5	3.64
Tithonia at 10 % (W/V)	5.96	0.6	73.5	0.13	4.1	3.65
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	5.99	0.6	76	0.14	4.1	4.33
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	6.07	0.6	60.3	0.10	4.1	3.84
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	5.93	0.5	79.5	0.13	7.5	2.50
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	5.97	0.5	81.9	0.14	7.7	2.61
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	6.16	0.6	49.7	0.15	3.9	2.19
Weedy Check	6.14	0.5	49.7	0.15	4	2.09

Source: Laboratory of Centre for Dryland Agriculture, Bayero University Kano (BUK)

O.C = Organic Carbon, CEC = Cation Exchange Capacity

Table 3. Chemical Properties of Soil per Treatment at Bagauda During 2019 Rainy Season.

Weed Management Strategies	pH	N (g. kg^{-1}))	P (g. kg^{-1})	K (Cmol.kg^{-1})	O.C(g. kg^{-1})	CEC (Cmol.kg^{-1})
Manual Hoe Weeding at 3 & 6 WAS	6.14	0.5	48.6	0.18	3.6	2.01
Pendimethalin at 1 kg a.i ha^{-1}	6.14	0.4	48.6	0.18	3.6	2.05
Pendimethalin at 1.5 kg a.i ha^{-1}	6.07	0.4	68.4	0.17	8.5	2.25
Tithonia at 5 % (W/V)	5.82	0.4	49.7	0.15	3.4	2.27
Tithonia at 10 % (W/V)	5.80	0.4	49.7	0.15	3.4	2.26
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	5.95	0.4	48.6	0.19	3.5	1.95
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	6.14	0.4	48.6	0.18	3.7	2.17
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	5.88	0.4	49.7	0.15	3.4	2.14
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	6.03	0.3	65	0.20	6.3	2.06
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	5.87	0.3	48.6	0.20	3.2	1.98
Weedy Check	6.07	0.4	58.7	0.15	8.2	2.31

Source: Laboratory of Centre for Dryland Agriculture, Bayero University Kano (BUK)

O.C = Organic Carbon, CEC = Cation Exchange Capacity

4.1.2 Weed Flora Composition

The effect of weed management strategies on the number of broad leaves, narrow leaves (grasses) and sedges at harvest in sesame field at BUK and Bagauda was presented in Table 4. Weed management strategies significantly ($P < 0.05$) affected the weed flora composition in sesame field at the both locations. Weedy check recorded the largest number of broad leaves, narrow leaves and sedges in both locations. The lowest number of broad leaves was recoded with Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS at both locations. Manual hoe weeding at 3 and 6 WAS had lower number of narrow leaves species at both locations. Less number of sedges were observed on Manual hoe weeding at BUK and on pre and post emergence application of Tithonia at Bagauda.

4.1.3 Weed Density

The influence of weed management strategies on weed density in sesame field at BUK and Bagauda is shown in Table 5. The results indicated that weed management strategies had significant ($P < 0.05$) effect on weed density at both locations. Weedy check significantly recoded the highest weed density while manual

hoe weeding at 3 and 6 WAS recorded the lowest weed density at both locations. However, Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS also recorded the lowest weed density in both locations. This was statistically different from pre-emergence application of Tithonia followed by post emergence application of Tithonia at all concentrations at both locations.

4.1.4 Weed Dry Weight

The influence of weed management strategies on weed dry weight in sesame field at BUK and Bagauda is shown in Table 5. The results indicated that weed management strategies had significant ($P < 0.05$) effect on weed dry weight at both locations. Manual hoe weeding at 3 and 6 WAS recorded the lowest weed dry weight while weedy check significantly recoded the highest weed dry weight at both experimental sites. However, Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS also recorded the lowest weed dry weight in both locations.

4.1.5 Weed Control Efficiency

Weed control efficiency as influenced by weed management strategies is shown in Table 6. The results showed that weed management strategies had significant ($P < 0.05$) effect on weed control efficiency in both locations. Manual hoe weeding at 3 and 6 WAS recorded highest weed control efficiency. Weedy check recorded the lowest weed control efficiency. Pre and post emergence application of Tithonia extract had higher weed control efficiency than pre-emergence application of pendimethalin at all rates in both locations in 2019 rainy season.

4.1.6 Weed Index

Weed index as influenced by weed management strategies is shown in Table 6. The results showed that weed management strategies had significant ($P < 0.05$) effect on weed index in both locations. Manual hoe weeding at 3 and 6 WAS recorded

the lowest weed index. Weedy check recorded the highest weed index Pre and post emergence application of Tithonia extract had lower weed index than pre-emergence application of pendimethalin at all rates in both locations in 2019 rainy season.

Table 4. Effect of Weed Management Strategies on the Number of Broad Leaves, Narrow Leaves and Sedges at Harvest in BUK and Bagauda During 2019 Rainy Season.

	Location					
	BUK			Bagauda		
Weed Management Strategies	Broad Leaves	Narrow Leaves	Sedges	Broad Leaves	Narrow Leaves	Sedges
MHW at 3 and 6 WAS	23.33cde	31.33f	00b	23.33c	74.00c	1.667ab
Pendimethalin at 1 kg a.i ha^{-1}	33.33b	80.67b	1.00b	34.00bc	151.00b	00b
Pendimethalin at 1.5 kg a.i ha^{-1}	34.33b	66.00c	3.00b	58b	96.00bc	4.667ab
Tithonia at 5 % (W/V)	37.33b	87.00b	0.333b	48.67bc	97.3bc	1.667ab
Tithonia at 10 % (W/V)	32.33b	83.00b	5.00ab	47.33bc	116.3bc	0.667b
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	32.33b	66.33c	00b	27.67bc	86.3bc	0.333b
Tithonia at 5% (W/V) fb Tithonia at (W/V)	34.00b	57.00d	2.00b	24.33c	122.3bc	00b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	24.33cd	57.00cd	0.333b	30.33bc	110.3bc	00b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	28.33bc	52.00d	0.667b	34.67bc	127bc	00b
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	17.33d	43.33e	0.333b	24.00c	92.70bc	00b

Weedy Check	79.00a	116.00a	7.00a	119.33a	219.70a	7.333a
Level of probability	< 0.001	< 0.001	0.002	<.001	< 0.001	0.052
SEM	1.997	2.517	1.103	6.89	13.98	1.572

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 5. Influence of Weed Management Strategies on Weed Density (m^{-2}) and Weed Dry Weight (kg. ha^{-1}) at Harvest at BUK and Bagauda During 2019 Rainy Season.

	Weed Density at harvest		Weed Dry Weight (kg. ha^{-1})	
Weed Management Strategies	BUK	Bagauda	BUK Bagauda	
Manual Hoe Weeding at 3 & 6 WAS	54.70f	99.00d	282.80i	309.20h
Pendimethalin at 1 kg a.i ha^{-1}	115.00b	173.70b	449.80b	495.30b
Pendimethalin at 1.5 kg a.i ha^{-1}	103.30c	158.70bc	426.80c	482.30bc
Tithonia at 5 % (W/V)	124.70b	147.7bcd	480.80b	482.00bc
Tithonia at 10 % (W/V)	120.30b	164.30bc	422.60c	470.70cd
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	98.70cd	114.30cd	409.20d	460.70de
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	93.00d	146.70bcd	397.90e	450.20e
Pendimethalin at 1 kg a.i ha-1 fb Tithonia at 5 % (W/V)	81.70e	140.70bcd	379.40f	430.30f
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	81.00e	141.70bcd	355.90g	417.40f
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	61.00f	113.30cd	310.80h	344.50g
Weedy Check	195.30a	346.30a	648.80a	690.80a

Level of probability	< 0.001	< 0.001	<0.001	< 0.001
SEM	2.842	10.89	3.52	5.15

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 6. Influence of Weed Management Strategies on Weed Control Efficiency and Weed Index at BUK and Bagauda During 2019 Rainy Season.

	Weed Control Efficiency (%)		Weed Index (%)	
Weed Management Strategies	BUK	Bagauda	BUK Bagauda	
Manual Hoe Weeding at 3 & 6 WAS	56.38a	55.24a	00i	00g
Pendimethalin at 1 kg a.i ha^{-1}	30.66i	28.24h	42.11b	35.27bc
Pendimethalin at 1.5 kg a.i ha^{-1}	34.21g	30.15ghi	39.02c	35.29b
Tithonia at 5 % (W/V)	32.04h	30.17gh	38.34c	35.56b
Tithonia at 10 % (W/V)	34.83g	31.81fg	37.14c	34.62bc
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	36.91f	33.26ef	33.94d	35.01bc
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	38.66e	34.79e	30.96e	30.06b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	41.49d	37.68d	15.61f	21.95d
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	45.14c	39.57c	12.36g	15.45e
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	52.09b	50.11b	3.93h	4.54f

Weedy Check	–	–	50.33a	48.68a
Level of probability	< 0.001	< 0.001	< 0.001	<0.001
SEM	0.427	0.619	0.690	1.264

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

4.1.7 Crop Growth Rate

The effect of weed management strategies on crop growth rate is presented in Table 7. Weed management Strategies significantly ($P < 0.05$) influenced crop growth rate in both locations. Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS significantly gave the highest crop growth rate while weedy check recorded the lowest one in both locations. However, manual hoe weeding at 3 and 6 WAS recorded higher crop growth rate than pre-emergence and post emergence application of Tithonia at all rates in both locations. Similarly, pendimethalin application at all rates had lower crop growth rate than pre-emergence application of Tithonia followed by post emergence application of the tithonia extracts at all levels in both locations.

4.1.8 Stand Count at Harvest

The effect of weed management strategies on stand count at harvest is presented in Table 7. Weed management Strategies significantly ($P < 0.05$) influenced stand count at harvest in both locations. Pendimethalin at 1kg a.i ha^{-1} followed by

supplementary hoe weeding at 6 WAS significantly gave the highest stand count at harvest while weedy check recorded the lowest one in both locations. However, manual hoe weeding at 3 and 6 WAS recorded higher stand count at harvest than pre-emergence and post emergence application of Tithonia at all rates in both locations. Similarly, pendimethalin application at all rates had lower stand count than pre-emergence application of Tithonia followed by post emergence application of the tithonia extracts at all levels in both locations.

Table 7. Effect of Weed Management Strategies on Crop Growth Rate and Stand Count at Harvest at BUK and Bagauda During 2019 Rainy Season.

	Crop Growth Rate (g)		Stand Count at Harvest (N^0. ha^{-1})	
Weed Management Strategies	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	0.3050b	0.2597b	55556b	51852b
Pendimethalin at 1 kg a.i ha^{-1}	0.1480g	0.1553ef	36297f	39012de
Pendimethalin at 1.5 kg a.i ha^{-1}	0.1577g	0.1443f	39630e	41235de
Tithonia at 5 % (W/V)	0.1567g	0.1563f	46667d	41481de
Tithonia at 10 % (W/V)	0.1950f	0.1560ef	45926d	41482de
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	0.2227e	0.1387f	44815d	40494de
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	0.2197 e	0.1723e	44815d	45185cd
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	0.2760c	0.1963d	51111c	47901bc
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	0.2477d	0.2107c	51852c	47407bc
Pendimethalin at 1kg a.i ha^{-1} fb	0.3257a	0.2877a	57778a	56543a

SHW at 6 WAS				
Weedy Check	0.0860h	0.0863g	36297f	38519[e]
Level of probability	<0.001	< 0.001	<0.001	0.001
SEM	0.00341	0.00481	743	1416.8

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

4.1.9 Days to 50% Flowering

The influence of weed management strategies on Days to 50% flowering at BUK and Bagauda is presented in Table 8. The results showed that there was significant ($P < 0.05$) effect of weed management strategies on days to 50% flowering in both locations. Treatment of Pendimethalin at 1 kg a.i ha^{-1} followed by tithonia at 10% (WV) gave the shortest days to 50% flowering at BUK, while hoe weeding at 3 and 6 WAS recorded the shortest days to 50% flowering at Bagauda. The weedy check took longest days to 50% flowering in both locations.

4.1.10 Days to 50% Maturity

The influence of weed management strategies on Days to 50% maturity at BUK and Bagauda is presented in Table 8. The results showed that there was significant ($P < 0.05$) effect of weed management strategies on days to 50% maturity in both locations. Treatment of hoe weeding at 3 and 6 WAS gave the least days to 50% maturity at BUK, but at Bagauda it was Pendimethalin at 1 kg a.i ha^{-1} followed

by SHW at 6 WAS, while the weedy check took longest days to 50% maturity in both locations. Pre emergence followed by post emergence application of tithonia had shorter days to maturity than pendimethalin application at all rates in both locations.

4.1.11 Plant Height

The influence of weed management strategies on plant height in BUK and Bagauda during 2019 rainy season is presented in Table 9. In both locations, weed management strategies significantly ($P < 0.05$) affected plant height. Manual hoe weeding significantly recorded the tallest plants while weedy check resulted to the shortest plants in both locations.

4.1.12 Number of Branches per Plant

The influence of weed management strategies on number of branches per plant in BUK and Bagauda during 2019 rainy season is presented in Table 9. In both locations, weed management strategies significantly ($P < 0.05$) affected number of branches per plant. Manual hoe weeding significantly recorded the higher number of branches in both locations while the lowest number were obtained at treatment of Tithonia at 5 % and 10 % at BUK which were however similar to unweeded check.

Table 8. Effect of Weed Management Strategies on Days to 50% Flowering and 50% Maturity at BUK and Bagauda During 2019 Rainy Season.

	Days to 50% Flowering		Days to 50% Maturity	
Weed Management Strategies	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	47.67f	46.00c	92.00c	95.30c
Pendimethalin at 1 kg a.i ha^{-1}	63.67b	49.33ab	109.00a	103.00b
Pendimethalin at 1.5 kg a.i ha^{-1}	63.00b	48.33bc	109.00a	102.70b
Tithonia at 5 % (W/V)	60.00c	48.33bc	107.00a	102.70b
Tithonia at 10 % (W/V)	61.00c	47.33bc	107.70a	102.00b
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	56.67d	47.33bc	109.00a	104.00b
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	50.67e	47.67bc	99.00b	103.00b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	51.00e	47.00bc	98.00b	103.70b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	44.67g	46.67bc	97.00b	103.30b
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	46.00fg	46.33c	93.00c	95.00c

Weedy Check	66.67a	51.00a	109.00a	108.70a
Level of probability	< 0.001	< 0.001	< 0.001	< 0.001
SEM	0.595	0.611	0.759	0.555

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 9. Effect of Weed Management Strategies on Plant Height and Number of Branches per Plant at BUK and Bagauda During 2019 Rainy Season.

	Plant Height (cm)		Number of Branches per Plant	
Weed Management Strategies	BUK	Bagauda	BUK Bagauda	
Manual Hoe Weeding at 3 & 6 WAS	135.10a	138.00a	8.667a	4.333a
Pendimethalin at 1 kg a.i ha^{-1}	107.10e	102.90de	4.000d	2.667b
Pendimethalin at 1.5 kg a.i ha^{-1}	104.20f	107.80cd	4.000d	3.00ab
Tithonia at 5 % (W/V)	99.90g	96.20eg	3.667d	2.333b
Tithonia at 10 % (W/V)	109.40de	94.90eg	3.667d	2.667ab
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	113.90c	109.50cd	5.667c	3.333ab
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	110.80d	109.10cd	5.000cd	2.000b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	116.20c	112.00cd	4.667cd	2.000b
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	116.70c	115.70c	5.667bc	2.000b
Pendimethalin at 1kg a.i ha^{-1} fb	128.10b	125.80b	6.667b	2.333b

SHW at 6 WAS				
Weedy Check	98.00g	96.30f	4.000d	2.000b
Level of probability	< 0.001	< 0.001	< 0.001	0.017
SEM	0.838	2.219	0.313	0.418

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

4.1.13 Number of Capsules per Plant

Number of capsules per plant as influenced by weed management strategies was presented in Table 10. Weed management strategies had significant ($P < 0.05$) effect on number of capsules per plant in both locations during 2019 rainy season. Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS recorded higher number of capsules per plant than the other treatments in both locations. Weedy check had the lowest number of capsules per plant Pendimethalin alone at all rates had lower number of capsules per plant than tithonia extract alone or with other combinations in both locations.

4.1.14 Number of Seeds per Capsule

Number of seeds per capsule as influenced by weed management strategies was presented in Table 10. Weed management strategies had significant ($P < 0.05$) effect on number of seeds per capsule in both locations during 2019 rainy season. More number of seeds per capsule was recorded with Pendimethalin at 1kg a.i ha^{-1}

followed by supplementary hoe weeding at 6 WAS in BUK and with Manual Hoe Weeding at 3 and 6 WAS in Bagauda. Weedy check had the lowest number of seeds per capsule in both locations.

4.1.15 Seed Weight per Plant

The effect of weed management on seed weight per plant in BUK and Bagauda during 2019 rainy season is shown in Table 11. Weed management strategies had significant influence on seed weight per plant in both locations. Manual hoe weeding significantly ($P < 0.05$) recorded higher seed weight per plant. Weedy check significantly recorded the lowest seed weight per plant in both locations. Pre emergence application of pendimethalin at 1 – 1.5 kg a.i ha^{-1} alone had low seed weight per plant than pre-emergence application of tithonia followed by other ways of weed control in both locations.

4.1.16 Seed Weight per Capsule

The effect of weed management on seed weight per capsule in BUK and Bagauda during 2019 rainy season is shown in Table 11. Weed management strategies had significant influence on seed weight per capsule in both locations. Manual hoe weeding significantly ($P < 0.05$) recorded higher seed weight per capsule which was similar with Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS in both locations. Weedy check significantly recorded the lowest seed weight per capsule in both locations.

Table 10. Effect of Weed Management Strategies on Number of Capsules per Plant and Number of Seeds per Capsule at BUK and Bagauda During 2019 Rainy Season.

Weed Management Strategies	Number of Capsules per Plant		Number of Seeds per Capsule	
	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	121.67b	110.00a	70.00b	54.33a
Pendimethalin at 1 kg a.i ha^{-1}	62.67e	63.00e	56.00fg	30.60bc
Pendimethalin at 1.5 kg a.i ha^{-1}	69.67e	64.00de	63.67bde	25.33c
Tithonia at 5 % (W/V)	87.67d	65.00de	62.00def	32.67abc
Tithonia at 10 % (W/V)	100.67c	72.00cd	57.67efg	32.00abc
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	106.00c	74.67c	70.00bc	34.33abc
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	107.67c	66.67de	65.67bcd	36.33abc
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	101.00c	96.00b	66.67bcd	50.00ab
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	106.00c	99.00b	60.67def	50ab
Pendimethalin at 1kg a.i ha^{-1} fb	132.00a	116.00a	80.67 a	53.33ab

SHW at 6 WAS				
Weedy Check	60.00e	55.00f	53.00g	20.33c
Level of probability	< 0.001	< 0.001	< 0.001	0.001
SEM	3.057	2.052	1.521	4.82

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 11. Effect of Weed Management Strategies on Seed Weight per Plant and Seed Weight per Capsule at BUK and Bagauda During 2019 Rainy Season.

	Seed Weight per Plant (g)		Seed Weight per Capsule (g)	
Weed Management Strategies	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	27.46a	23.70a	0.6767a	0.6733a
Pendimethalin at 1 kg a.i ha^{-1}	16.50d	15.00d	0.3500de	0.3500d
Pendimethalin at 1.5 kg a.i ha^{-1}	16.29d	13.05e	0.3767cde	0.3733d
Tithonia at 5 % (W/V)	15.71d	14 de	0.3700cde	0.3700d
Tithonia at 10 % (W/V)	14.96d	14.42d	0.3967cd	0.3833d
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	20.29c	17.27c	0.6000b	0.5800b
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	19.50c	16.50c	0.4100cd	0.4200c
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	20.55c	17.05c	0.4267c	0.4200c
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	22.87b	19.39b	0.3800cde	0.4400c

Pendimethalin at 1kg a.i ha^{-1} fb				
SHW at 6 WAS	26.90a	23.33a	0.6700a	0.6700a
Weedy Check	11.62e	11.22f	0.3200e	0.3200[e]
Level of probability	< 0.001	< 0.001	0.001	<0.001
SEM	0.576	0.329	0.015	0.009

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

4.1.17 1000 Grains Weight

The influence of weed management strategies on 1000 grains weight at BUK and Bagauda is presented in Table 12. The results had shown significant effect of weed management strategies on 1000 grains yield in BUK but there was no significant influence on 1000 grains weight in Bagauda. Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS had recorded the heavier 1000 seed weight at BUK. Pre emergence application of tithonia extract followed by post emergence application of tithonia had heavier 1000 seed weight than pre-emergence application of pendimethalin alone at all rates in both locations. Weedy check plot recorded the lowest 1000 seed weight in both locations.

4.1.18 Grain Yield

The influence of weed management strategies on grain yield at BUK and Bagauda is presented in Table 12. The results had shown significant effect of weed management strategies on grain yield in both locations. Manual hoe weeding at 3 and

6 WAS recorded the highest grain yield in both locations. Weedy check plot recorded the lowest grain yield in both locations.

4.1.19 Oil Content

The effect of weed management strategies on seed oil content at both locations is presented in Table 13. The results indicated significant influence of weed management strategies on oil Content at BUK, while at Bagauda, the results showed there was non-significant difference between treatments. Pre emergence application of Pendimethalin followed by supplementary hoe weeding at 6 WAS had the highest percentage of seed oil Content than other weed management strategies in both locations. Pre-emergence application of pendimethalin alone at all rates had lower percentage of Oil Content than Tithonia combined with other weed management strategies in all locations. Weedy check had the lowest percentage of Oil Content in all locations.

4.1.20 Physical Seed Purity

The effect of weed management strategies on physical seed purity at both locations is presented in Table 13. The results indicated significant influence of weed management strategies on physical seed purity in all locations. Pre emergence application of Pendimethalin followed by supplementary hoe weeding at 6 WAS had the highest percentage of Physical Seed Purity than other weed management strategies in both locations. Pre-emergence application of pendimethalin alone at all rates had lower percentage of physical seed purity than Tithonia combined with other weed management strategies in all locations. Weedy check had the lowest percentage of Physical Seed Purity in all locations.

Table 12. Effect of Weed Management Strategies on 1000 Grains Weight and Grain Yield at BUK and Bagauda During 2019 Rainy Season.

Weed Management Strategies	1000 Seed Weight (g)		Grain Yield (kg. ha^{-1})	
	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	3.467a	3.100	1223.9a	1212.9a
Pendimethalin at 1 kg a.i ha^{-1}	2.800bc	2.933	738.9g	736.3g
Pendimethalin at 1.5 kg a.i ha^{-1}	2.700bc	3.267	789f	788f
Tithonia at 5 % (W/V)	2.767bc	3.367	800.2g	798.3f
Tithonia at 10 % (W/V)	2.667bc	2.967	819.5f	815f
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	2.967b	3.167	871.4e	864e
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	2.900bc	3.500	920d	919.3d
Pendimethalin at 1 kg a.i ha-1 fb Tithonia at 5 % (W/V)	2.800bc	3.067	1069.5c	1065.9c
Pendimethalin at 1 kg a.i ha-1 fb Tithonia at 10 % (W/V)	2.967b	3.433	1121.2b	1113.6b
Pendimethalin at 1kg a.i ha^{-1} fb SHW at 6 WAS	3.600a	3.267	1159.7b	1151.1b
Weedy Check	2.500c	2.833	388.9h	375.3h

Level of probability	<0.001	0.149	< 0.001	< 0.001
SEM	0.094	0.164	16.44	15.97

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 13. Effect of Weed Management Strategies on Oil Content and Physical Seed Purity (%) at BUK and Bagauda During 2019 Rainy Season.

	Oil Content (%)		Physical Seed Purity (%)	
Weed Management Strategies	BUK	Bagauda	BUK	Bagauda
Manual Hoe Weeding at 3 & 6 WAS	51.60a	52.28	98.73a	98.33a
Pendimethalin at 1 kg a.i ha^{-1}	48.33a	47.80	95.87ab	96.33a
Pendimethalin at 1.5 kg a.i ha^{-1}	47.75a	48.94	96.50ab	95.53ab
Tithonia at 5 % (W/V)	48.38a	48.53	96.95ab	94.29ab
Tithonia at 10 % (W/V)	47.35 a	49.45	97.00ab	95.44ab
Tithonia at 5 % (W/V) fb Tithonia at 5 % (W/V)	52.95a	51.15	97.89ab	97.67a
Tithonia at 5% (W/V) fb Tithonia at 10 % (W/V)	49.21a	50.78	98.15a	98.27a
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	50.00a	51.74	98.33a	96.70a
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	49.10a	49.17	98.81a	96.46a

Pendimethalin at 1kg a.i ha^{-1} fb				
SHW at 6 WAS	53.82a	52.82	98.96a	98.67a
Weedy Check	40.41b	47.35	94.85b	91.76b
Level of probability	< 0.001	0.681	0.006	0.005
SEM	1.454	2.151	0.691	1.036

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Students-Newman-Keuls (SNK) Test. SEM= standard error of mean, MHW= Manual Hoe Weeding, SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

4.1.21 Net Revenue (₦ ha^{-1}) and Benefit Cost Ratio

The effect of weed management strategies on net revenue and benefit cost ratio at BUK and Bagauda is shown in Table 14 and 15, respectively. At BUK, Pendimethalin at 1 kg a. i ha^{-1} fb SHW at 6 WAS gave a net revenue of ₦ 96,460.00 and a benefit cost ratio of 1.2899. This was followed by Pendimethalin at 1.5 kg a.i ha^{-1} which gave a net revenue of ₦ 41,875.00 and a benefit cost ratio of 1.1674 while weedy check operated a loss of net revenue of −₦ 70,551 and a loss of benefit cost ratio of 0.6710 (Table 14). At Bagauda, pendimethalin at 1 kg a.i ha^{-1} fb SHW at 6 WAS gave a net revenue of ₦ 96,914.00 and a benefit cost ratio of 1.2948. This was also followed by Pendimethalin at 1.5 kg a.i ha^{-1} which provided a net revenue of ₦ 46,234.00 and a benefit cost ratio of 1.1884. Unweeded check operated a loss of net revenue of −₦ 70,704 and a loss of benefit cost ratio of 0.6626 (Table 15).

4.1.22 Correlation Matrix between Growth and Yield Characters

The correlations between yield and growth variates for BUK and Bagauda are presented in table 16 and 17, respectively. The correlations between yield and yield variables and all growth characters were significant and positive at BUK (Table 16). Similar trend was observed at Bagauda except that non-significant correlation was observed between grain yield and number of branches per plant and between crop growth rate and number of branches per plant (Table 17).

Table 14. Effect of Weed Management Strategies on Cost Benefit and Return Analysis at BUK during 2019 Rainy Season.

Weed Management Strategies	Total Yield (Kg ha^{-1})	Total Variable Cost (₦)	Average Price/Kg	Gross Revenue (₦)	Net Revenue or Loss (₦)	Benefit Cost Ratio
Manual Hoe Weeding at 3 & 6 WAS	1223.90	413,592	370	452,843	39,251	1.0949
Pendimethalin at 1 kg a.i ha^{-1}	738.90	244,555	370	273,393	28,838	1.1179
Pendimethalin at 1.5 kg a.i ha^{-1}	789	250,055	370	291,930	41,875	1.1674
Tithonia at 5 % (W/V)	800.20	584,814	370	296,074	−288,740	0.5062
Tithonia at 10 % (W/V)	819.50	1,032,591	370	303,215	−729,376	0.2936
Tithonia at 5 % (W/V) fb Tithonia at 5% (WV)	871.40	955,184	370	322,418	−632,766	0.3375
Tithonia at 5% (W/V) fb Tithonia at 10 % (WV)	920	1,202,958	370	340,400	−862,558	0.2829
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	1069.50	628,925	370	395,715	−233,210	0.6291
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	1121.20	1,176,702	370	414,844	−761,858	0.3525

Pendimethalin at 1 kg a.i ha^{-1} fb SHW at 6 WAS	1159.70	332,629	370	429,089	96,460	1.2899
Weedy Check	388.90	214,444	370	143,893	−70,551	0.6710

SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 15. Effect of Weed Management Strategies on Cost Benefit and Return Analysis at Bagauda during 2019 Rainy Season.

Weed Management Strategies	Total Yield (Kg ha^{-1})	Total Variable Cost (₦)	Average Price/Kg	Gross Revenue (₦)	Net Revenue or Loss (₦)	Benefit Cost Ratio
Manual Hoe Weeding at 3 & 6 WAS	1212.90	409,122	370	448,773	39,651	1.0969
Pendimethalin at 1 kg a.i ha^{-1}	736.30	239,526	370	272,431	32,905	1.1373
Pendimethalin at 1.5 kg a.i ha^{-1}	788	245,335	370	291,569	46,234	1.1884
Tithonia at 5 % (W/V)	798.30	580,614	370	295,371	−285,243	0.5087
Tithonia at 10 % (W/V)	815	1,112,588	370	301,55	−811,038	0.2710
Tithonia at 5 % (W/V) fb Tithonia at 5% (WV)	864	949,144	370	319,68	−629,464	0.3368
Tithonia at 5 % (W/V) fb Tithonia at 10% (WV)	919.30	1,123,758	370	340,141	−783,617	0.3026
Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 5 % (W/V)	1065.90	622,555	370	394,383	−228,172	0.6334

Pendimethalin at 1 kg a.i ha^{-1} fb Tithonia at 10 % (W/V)	1113.60	1,097,665	370	412,032	−685,633	0.3753
Pendimethalin at 1 kg a.i ha^{-1} fb SHW at 6 WAS	1151.10	328,933	370	425,907	96,974	1.2948
Weedy Check	375.30	209,565	370	138,861	−70,704	0.6626

SHW= Supplementary Hoe Weeding, WAS= Weeks After Sowing, fb= followed by.

Table 16. Correlation Matrix Between Growth and Yield Variables at BUK

	CGR	NB. $Plant^{-1}$	NC. $Plant^{-1}$	PH	SW. C^{-1}	GRAIN YIELD
CGR	1					
NB. $Plant^{-1}$	0.454**	1				
NC. $Plant^{-1}$	0.907**	0.703**	1			
PH	0.918**	0.869**	0.816**	1		
SW. C^{-1}	0.777**	0.803**	0.766**	0.838**	1	
GRAIN YIELD	0.942**	0.804**	0.827**	0.926**	0.710**	1

CGR = Crop Growth Rate, NB. $Plant^{-1}$ = Number of branches per Plant, NC. $Plant^{-1}$ = Number of Capsules per Plant, PH = Plant Height, SW. C^{-1} = Seed Weight per Capsule.

Table 17. Correlation Matrix Between Growth and Yield Variables at Bagauda

	CGR	NB. Plant^{-1}	NC. Plant^{-1}	PH	SW. C^{-1}	GRAIN YIELD
CGR	1					
NB. Plant^{-1}	0.184^{NS}	1				
NC. Plant^{-1}	0.913**	0.185	1			
PH	0.821**	0.404*	0.824**	1		
SW. C^{-1}	0.765**	0.436*	0.786**	0.830**	1	
GRAIN YIELD	0.958**	0.259^{NS}	0.943**	0.895**	0.798**	1

CGR = Crop Growth Rate, NB. Plant^{-1} = Number of branches per Plant, NC. Plant^{-1} = Number of Capsules per Plant, PH = Plant Height, SW. C^{-1} = Seed Weight per Capsule.

4.2 DISCUSSION

4.2.1 Influence of Weed Management Strategies on Weed Control

Most of the treatments provided good control of grasses except weedy check at both locations. This is because these treatments were effective against sedges. This is in line with the findings of Buchanan *et al*. (1982); Chamblee *et al*. (1982); and Wilcut *et al*. (1995) who noted that Pendimethalin provide excellent control of annual grasses. However, manual hoe weeding at 3 and 6 WAS and pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing resulted in lower number of broad leaf, narrow leaf, weed index and weed dry weight and higher weed control efficiency than other methods in both locations. This implied that these categories of weed can be managed by this method of weed control. It also indicates that there was less competition for nutrients, moisture and space between weeds and

sesame crop as a result of weed control. This also showed the superiority of integrated methods of weed control over other methods as reported by Bhadauria *et al.* (2012). This result is similar to the report of Akbar *et al*. (2011) who mentioned that compared with the weedy check, hand pulling treatment provided a maximum reduction of total weed density by 94.9%. Also, the findings of Adewale (2019) supported that manual weeding at 3 and 6 WAS provided the highest weed control. Minz *et al.* (2018) and Bhatti *et al.* (2000) also supported our finding when announced that hand weeding caused significant reduction in total weed density. The lower weed dry weight and weed index in this treatment may be attributed to the smaller number of weeds, their destruction by these weed management strategies indicating their superiority over other strategies on managing weeds. Also, in the related development, Adewale (2019) found that hoe weeding at 3 and 6 WAS closely followed with application of pendimethalin or Metolachlor at 2.5 kg a.i ha^{-1} resulted in significant lower weed dry weight. Pre and post emergence application of Tithonia extract had higher weed control efficiency and lower weed density, weed dry weight and weed index than pre- emergence application of pendimethalin at 1 or 1.5 kg a.i ha^{-1}. This was in line with the findings of Ajayi (2018) who reported that aqueous extracts of *T.diversifolia* leaf at 7.5 % and 10 % (w/v) concentrations were effective in reducing weed density in the cropping systems of cowpea.

Weedy check recorded significantly highest number of broad leaved, narrow leaved, weed density, weed dry weight and weed index in both locations. This is because the experimental site was rich in weed species population and no any weed control measure was applied. The weeds emerged freely and competed strongly with sesame crop as reported by Akobundu and Agwakwa, 1998; Milberg and Hallgren, 2004; Hamma and Ibrahim, 2013 who observed that weeds may grow faster than crops

and successfully compete for available nutrients, water, space and sunlight if no control measures were applied.

4.2.2 Influence of Weed Management Strategies on Growth and Yield of Sesame

The lowest stand count recorded in weedy check may have been due to some allelopathic weeds which might reduce the number of standing sesame plants. Highest values of various growth and yield variables such as plant height, number of branches per plant, seed weight per plant and seed weight per capsule were recorded with Manual hoe weeding at 3 and 6 WAS. This might be attributed to low competition between weeds and crop plants due to better control of weed which might have encouraged the crop to perform better. These results confirmed the findings of Riaz *et al*. (2006) who reported that increase in plant height was possibly due to better weed control at proper time, resulting in maximum utilization of moisture and nutrients by crop. It is also in the accordance of Ahmad *et al*. (1984) who reported that weeding at proper time successfully reduced competition between crop plants and weeds, and resulted in healthy crop stand. The shorter plants observed in weedy check plots may be attributed to faster weed emergence, compared to sesame plants which was reflected in greater uptake of growth resources leading to higher competitive ability of weeds and decreasing sesame vegetative growth in terms of decreased plant height. In similar opinion, Garko *et al*. (2016) reported that uncontrolled weeds suppressed the growth of the crops in weedy check plots as also reported by Amare (2011). Maximum number of capsules was recorded in Pendimethalin at 1kg a.i ha^{-1} followed by Supplementary Hoe Weeding at 6 WAS in this study. This could be attributed to efficiency of photosynthesis which was supported by the abundant uptake of water, nutrients and radiation in the absence of weeds. This increased photosynthetic assimilates allocation

into reproductive parts that led to an increase in the observed trait. Ahmed *et al.* (2014) and Zubair *et al.* (2011) reported similar incidence on sesame.

The lighter seeds weight was obtained from weedy check in both locations. This might be due to increase in weed population that was associated with greater resources removal by weeds leading to reduction in photosynthetic assimilate production and translocation to the reproductive organs of crop plant, thereby decreasing seed weight. Spader and Vidal (2000) supported this finding where they reported that increased weed density decreased grain weight of maize. Higher grain yields were recorded by Manual hoe weeding at 3 and 6 WAS and Pendimethalin at 1kg a.i ha^{-1} followed by Supplementary Hoe Weeding at 6 WAS. This finding could be related to the maximum weed control efficiency and minimum weed index recorded in these treatments. Low competition between sesame crops and weeds leads to high number of capsules per plant, seed weight per capsule and seed weight per plant. This is related to the findings of Minz *et al.* (2018) who reported high yields of onion on manually weeded due to better weed control efficiency which might have created favorable environment which provides efficient utilization of environmental resources. Tithonia extracts alone or combined with any other weed control strategy resulted in higher yield than pendimethalin alone. This implies that tithonia is efficient in suppressing weeds due to its allelochemicals as supported by Ajayi (2018). Weedy check resulted in minimum yield in both locations. This finding is in agreement with the findings of Sperry *et al*. (2016) who reported that the presence of weeds is a major obstacle in sesame production and can negatively influence sesame yield; Zuhair *et al*. (2011) had earlier reported that insufficient weed control during the early growth period of sesame may lead to yield reductions of about 35 to 70 %. Similarly, Farooq *et al*.

(2008) also confirmed that weeds may cause sesame yield losses of 35-75% and 70-100% in lowland and upland agroecosystems respectively.

4.2.3 Profitability of Weed Management Strategies

Application of pendimethalin at 1 Kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing gave higher net revenue (₦ ha^{-1}) and benefit cost ratio than other weed management strategies. This implies that farmers recorded higher profit when they control weeds using chemical and cultural means in sesame production. This is similar to the findings of Imoloame *et al.* (2010) who confirmed that the use of herbicide is more profitable in the production of sesame. Similarly, Khan *et al.* (2005) reported that optimum and highest net returns obtained with the application of herbicides compared with the other methods of weed control treatment. Using Tithonia extracts as a way of weed control resulted to a great loss. This may be due to high cost of transport in getting the tithonia because the plant is not found in the study area. The study also proved that the use of manual hoe weeding is costly and not economical.

4.2.4 Influence of Weed Management Strategies on the quality of sesame

The highest percentage of physically pure seeds was recorded with pre-emergence application of Pendimethalin followed by supplementary hoe weeding at 6 WAS in both locations. This could be attributed to the lower weed density which might have reduced the contamination of sesame seeds by weed seeds or inert matter. Farooq *et al*. (2011) supported this when they observed that weeds reduce crop quality through contamination. In both locations, lowest percentage of grain Oil Content was obtained with weedy check. This could be attributed to severe competition between the crops and weeds which caused a reduction in photosynthesis process. Photosynthesis is responsible for the production of organic compounds in the plant such as carbohydrates,

proteins and fats. Therefore, prolonged weed competition will cause a reduction in oil content of seeds. This was in accordance with Ahmed *et al*. (2014) who noted that prolonged weed competition caused a reduction in oil content of seeds, and eventually reduce oil yield per hectare due to the decrease in seed yield and size of sesame.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The experiment was conducted during the 2019 rainy season in the Sudan savanna zone of Nigeria at two locations: The first location was at Research and training farm of Centre for Dryland Agriculture, Bayero University Kano (11°58’52.5” N and 008°24’48.6” E). The second location was at National

Horticultural Research Institute of Bagauda, Kano (11°33'25.93" N and 008°23'11.97" E). The objective was to access the response of sesame to different weed management strategies.

The experiment consisted of ten weed management strategies (Manual hoe weeding at 3 and 6 weeks after sowing, Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1}, Pre-emergence application of Pendimethalin at 1.5kg a.i ha^{-1}, Pre-emergence application of Tithonia at 5 % (W/V), Pre-emergence application of Tithonia at 10 % (W/V), Pre-emergence application of Tithonia at 5 % (W/V) followed by postemergence application of Tithonia 5 % (W/V), Pre-emergence application of Tithonia at 5 % (W/V) followed by postemergence application of Tithonia at 10 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by post-emergence application of Tithonia at 5 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by post emergence application of Tithonia at 10 % (W/V), Pre-emergence application of Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing) and Weedy check. The treatments were laid out in randomized complete block design (RCBD) with three replicates. All agronomical practices were carried out as per requirement of the treatments. Data were collected on weed, growth and yield characters and were subjected to analysis of variance (ANOVA) using GenStat software 17^{th} edition. Economic analysis was also done to determine the most profitable means of controlling weeds in the study area.

The results of the experimental sites indicated that at both locations, manual hoe weeding at 3 and 6 WAS recorded the highest weed control efficiency and the lowest weed index. Weedy check resulted in the highest weed density and weed dry weight and the lowest weed control efficiency, plant height, number of branches per

plant, number of capsules per plant, number of seeds per capsule, seed weight per capsule and seed weight per plant. The highest grain yield was recorded by manual hoe weeding at 3 and 6 WAS in both locations. This was followed by Pendimethalin at 1 kg a.i ha^{-1} followed by supplementary hoe weeding at 6 WAS, then Pendimethalin at 1 kg a.i ha^{-1} followed by Tithonia at 10 % (W/V) and Pendimethalin at 1 kg a.i ha^{-1} followed by Tithonia at 5 % (W/V). The highest net revenue and benefit cost ratio were recorded by pendimethalin at 1 kg a.i ha^{-1} followed by SHW at 6 WAS in both locations.

5.2 CONCLUSION

The result obtained from this study indicated that the application of manual hoe weeding at 3 and 6 WAS, pendimethalin at 1 kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing, pendimethalin at 1 kg a.i ha^{-1} followed by Tithonia at 10 % (W/V) and pendimethalin at 1 kg a.i ha^{-1} followed by Tithonia at 5 % (W/V) produced highest grain yield of sesame.

5.3 RECOMMENDATION

Based on the results of this work, the choice of pendimethalin at 1 kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing could be recommended for weed control in sesame field in the study areas. The use of more sesame varieties for multi-locations trials and further research on tithonia extracts in sesame could be also recommended.

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APPENDICES

Appendix i: Meteorological Data showing Annual Rainfall, Temperature and Relative Humidity during 2019 Rainy Season at BUK

	June	July	August	September	October
Rainfall (in mm)	37.19	154.56	238.78	2.71	44.08
Relative Humidity	47.69 %	62.13 %	79.40 %	71.52 %	6.50 %
Temperature (in °C)					
Maximum	36.31	30.39	29.12	31.84	31.87
Minimum	24.43	21.90	21.13	21.95	22.12

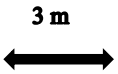
Source: GIS Laboratory of Centre for Dryland Agriculture (CDA), Bayero University, Kano (2019)

Appendix ii: Meteorological Data showing Annual Rainfall, Temperature and Relative Humidity during 2019 Rainy Season at Bagauda

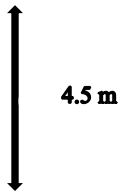
	June	July	August	September	October
Rainfall (in mm)	90	152.1	452.7	223.4	23
Relative Humidity	67%	84%	87%	70%	45%
Temperature (in °C)					
Maximum	37.90	33.10	34.40	31.20	33.90
Minimum	30.02	23.50	24.20	20.70	25.20

Source: Meteorological station of National Horticultural Research Institute, Bagauda (2019)

Appendix iii: The Field Layout



Block 1	11	9	8	1	3	6	5	2	10	7	4
Block 2	7	5	1	9	4	3	8	10	2	6	11
Block 3	3	11	4	2	9	6	5	7	10	1	8



1 = Manual hoe weeding at 3 and 6 weeks after sowing, 2 = Pendimethalin at 1kg a.i ha^{-1}, 3 = Pendimethalin at 1.5kg a.i ha^{-1}, 4 = Tithonia at 5 % (W/V), 5 = Tithonia at 10 % (W/V), 6 = Tithonia extract at 5 % (W/V) followed by postemergence application of Tithonia extract at 5 % (W/V), 7 = Tithonia extract at 5 % (W/V) followed by postemergence application of Tithonia extract at 10 % (W/V), 8 = Pendimethalin at 1kg a.i ha^{-1} followed by post-emergence application of Tithonia extract at 5 % (W/V), 9 = Pendimethalin at 1kg a.i ha^{-1} followed by post emergence application of Tithonia extract at 10 % (W/V), 10 = Pendimethalin at 1kg a.i ha^{-1} followed by supplementary hoe weeding at 6 weeks after sowing, 11 = Weedy check.