WEED MANAGEMENT TOWARDS IMPROVEMENT OF GROWTH AND YIELD OF SESAME VARIETIES

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CERTIFICATE

*This is to certify that thesis entitled, "***WEED MANAGEMENT TOWARDS IMPROVEMENT OF GROWTH AND YIELD OF SESAME VARIETIES***" submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.) in AGRONOMY****, embodies the result of a piece of bona-fide research work carried out by* ***MST. NUSRAT AKTAR****, Registration no.* ***09-3358*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: 26/05/2016
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DEDICATED

TO

MY BELOVED PARENTS AND ALL

THE RESPECTED TEACHERS

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2014 to study the response weed control methods on the growth and yield of different sesame varieties. The experiment comprised of two factors viz. (1) variety and (2) weed management as three varieties (V_1 = BARI til- 3, V_2 = BARI til - 4, V_3 = Lal til) and five weeding levels (W_1 = no weeding, W_2 = one hand weeding at 20 days after sowing (DAS), W_3 = two hand wedding at 20 DAS and 40 DAS W_4 = Pre emergence herbicide Sunup 480 SL (Glyphoset) @ 3.7 l ha^{-1} spraying at land preparation and W_5 = Post emergence herbicide, Release 9 EC (Phenoxprop-p-ethayel) @ 650 ml ha^{-1} spraying at 15-20 days after germination (DAG) respectively that were laid out in split plot design. Results revealed that BARI til- 4 stood superior to others in respect of branches $plant^{-1}$, dry matter content $plant^{-1}$, leaves $plant^{-1}$, capsules $plant^{-1}$, seeds $capsule^{-1}$, 1000 seeds weight, seed yield, stover yield and harvest index. Among the weed management practices, the highest plant height, dry matter content $plant^{-1}$ and leaves $plant^{-1}$ were obtained by the application of pre emergence herbicide at land preparation time (W_4) while maximum result of yield contributing characters and yield parameter were obtained from two hand weeding treatment (W_3). In combination, the highest plant height (145.73cm) was observed in BARI til-3 with pre emergence herbicide treatment. Highest capsules $plant^{-1}$ (85.00), seeds $capsule^{-1}$ (97.00), seed yield (1.73 t ha^{-1}) and harvest index (18.97%) were obtained from BARI til-4 with two hand weeding. The highest 1000 seeds weight (3.90 g) was obtained from BARI til-4 with the application of Sunup 480 SL at @ 3.7 l ha^{-1} land preparation time. The highest biological yield (9.89 t ha^{-1}) and stover yield (8.43 t ha^{-1}) were obtained from BARI til-3 with two hand weeding treatment. Economic analysis revealed that BARI til 4 with two hand weeding for weed control recorded maximum gross margin (TK 98,980 ha^{-1}) with 2.60 benefit cost ratio.

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LIST OF ABBRIVIATIONS

BARI	= Bangladesh Agricultural Research Institute
cm	= Centimeter
^0C	= Degree Centigrade
DAS	= Days after sowing
DAG	= Days after germination
et al.	= and others (*at elli*)
Kg	= Kilogram
Kg ha^{-1}	= Kilogram $hectrare^{-1}$
g	= gram (s)
LSD	= Least Significant Difference
Mop	= Muriate of Potash
m	= Meter
pH	= Hydrogen ion conc.
TSP	= Triple Super Phosphate
t ha^{-1}	= ton $hectare^{-1}$
%	= Percent

CHAPTER I

INTRODUCTION

Ecological degradation, population pressure and poverty coupled with malnutrition are the priorities for the present day of agricultural researchers. So the plant scientists are facing the challenge that how to meet the food requirement of this unchecked population (Thirtle *et al*., 2003). Hence, nutrition oriented sustainable agricultural production system is of utmost priority in the present context. In this acute context, oil seeds are inseparable ingredients of vegetarian diet and one of the cheapest weapons for combating the malnutrition problem by supplying dietary oil of protein to the people of our country. Oilseeds add important nutritional value to the diet due to high quality protein and or vegetable oil, together with oil soluble vitamins like vitamin A. Oilseeds, are the largest source of vegetable oils even though most oil-bearing tree fruits provide the highest oil yields (olive, coconut and palm trees) (Gunstone, 2002). Oilseeds are also used in animal feed because of their high protein content. Their seeds contain energy for the sprouting embryo mainly as oil, compared with cereals, which contain the energy in the form of starch (McKevith, 2005).

Sesame *(Sesamum indicum* L.) is one of the most ancient oilseed crops of the world. This commonly grown oil seed crop belongs to the family Pedaliaceae. It is an annual crop with height ranging from 50 to 100 cm tall. It is one of the important oil crops and ranked 9th among the top thirteen oil seed crops, which make up to 90% of the world edible oil production (Kafiriti and Deckers, 2001).

The importance of sesame lies in the variety of useful materials that can be extracted from it. Sesame is widely used in the food, pharmaceutical and other industries in many countries due to its high oil, antioxidant and protein contents because of its easy extraction, great stability, and drought resistance (Bedigian and Harlan 1986). Its seed contains about 50% edible and medicinal oil of high quality which can be conserved for a long time. They are used in baking, candy making, and other food industries. Sesame oil and foods fried in sesame oil have a long shelf life because the oil contains an antioxidant called sesamol. Sesame oil contains sesamoline and sesamine, which are used as synergists for insecticides (Ryu *et al.*, 1992). Due to presence of these compounds, its oil is resistant to rancidity hence sesame is known as the ‘queen of oilseeds’ (Namiki, 1995). Sesame oil is also used in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides. The seed contains about 50 - 51% oil, 17 - 19% protein and 16 - 18% carbohydrate and its seed meal contains 42% protein (Khan and Sheikh, 1985). This oil is edible, odorless and semi-drying containing oleic acid (47%), linoleic acid (39%), stearic and palmitic acids (Yermanos *et al.*, 1972). Til oil-cake is good feed for poultry, fish, cattle, goat, sheep etc.

It is one of the important sources of edible oil seed crops in Bangladesh. It is the second largest source of edible oil in Bangladesh next to *Brassica* both in respect of acreage and production which occupying 9.4% of the total oilseed area (BBS, 2012). It is cultivated almost everywhere in the country in the early summer (March-May) under Rain fed condition. In Bangladesh 40,000 hectares of land was cultivated for sesame production and 42,000 tons is produced (FAOSTAT, 2014). The average yield 1.05 t ha^{-1} of this crop in Bangladesh is found lower compared to that in other countries. Lack of modern varieties coupled with poor agronomic management is responsible for lower yield (Khaleque & Begum, 1991). The yield of sesame may be increased by using improved high yielding variety. On the other hand modern varieties yielded low when they experienced with weed competition.

Weed is one of the most important factors responsible for lower yield of crop (Islam *et al.*, 1989). Weed crop competition commences with germination of the crop and continues till its maturity. Several Growth stages of sesame such as emergence, flowering and capsule setting are greatly hampered from weed competition. Weed infestation of these stages causes poor growth and ultimately yield reduces.

All crops have a vulnerable stage during their life cycle when they are particularly sensitive to weed competition. In general, it ranges up to first 25-50% of the life time of crops. The presence of weeds at critical period for weed control (CPWC) leads to serious yield losses (Weaver and Tan, 1983; Weaver *et al.,* 1992; Knezevic *et al.*, 2002). Weed-induced yield reduction up to 135% and need for a critical weed free period of 50 days after planting (Balyan, 1993). In particular the slow growth of sesame in the early stage leaves seedlings towards maximum weed competition thus severely affects the seedling establishment (Bennett *et al.,* 2003) and end up with lower yield at harvest. Lack of proper weeding reduced the yield of sesame up to 65% (Hussein *et al.*, 1983; Beltrao *et al.*, 1991 and Grichar *et al*., 2001a). The yield of sesame can be increased by 21 to 53% with adoption of improved technologies such as improved variety, recommended dose of fertilizer, weed management and plant protection. Planting sesame seeds is difficult because the seeds are small and need to be placed precisely in the soil. Mechanization of sesame cultivation therefore requires good weed control for 50 to 60 days after planting (Langham *et al*., 2007).

Weeds above critical population thresholds can significantly reduce crop yield and quality. However, the aim of weed management should be to maintain weed population at a manageable level. Timely control of weeds either manually or using herbicide is essential for higher harvest yield in sesame. Proper combination of pre- and post-emergence herbicides could be used to control the weeds in the sesame and obtain seed yield comparable with weed-free conditions (Vafaei *et al*., 2013).

The traditional method of weed control is expensive now days when use of herbicide is convenient in case of costing. To ensure timely weeding & effective weed control use of herbicide proved its efficacy. Eventually crop yields are improving with this method. Still hand weeding is preferable where labor availability is not a problem.

Therefore improved varieties along with proper weed management could be the most important approach for better sesame production. The present study was therefore, undertaken with the following objectives.

1. To study the effect of different varieties on the growth, yield attributes and yields of sesame.
2. To find out the suitable method of weeding for maximum yield of sesame.
3. To study the combined effect of variety and weeding method on the growth and yield of sesame.

CHAPTER II

REVIEW OF LITERATURE

The growth and development of sesame are influenced due to varietal performance of different sesame cultivars and management practices. Among the management practices, weeding can be regarded as an important one. Experimental results are available from home and abroad to reveal that weeding and sesame cultivars with high yield potential may influence growth and yield to a great extent. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1 Effect of variety

2.1.1 Effect on growth characters

2.1.1.1 Plant height

Nahar *et al.* (2008) conducted an experiment under rainfall condition at the Bangabundhu Sheikh Mujibur Rahman Agricultural University, Gazipur during Kharif-l (March to June, 2002) season to study the effect of nitrogen fertilizers on growth character, nitrogen content and yield of sesame varieties viz. T -6, BARI Til-2 and BARI Til-3. The nitrogen levels were 0, 50, 100 and 150kg ha^{-1}. The tallest plant (121.70 cm) was recorded under N 150 kg ha^{-1} for BARI Til-3.

Subrahmaniyan *et al.* (1999) recorded different types of plant height in different sesame varieties.

Shelke *et al.* (2014) conducted a field experiment at college of agriculture, Latur (M.S.) India during *kharif* 2011-12 on loamy soil. The experiment consisting of factorial combination of three levels of phosphorus (20, 25 and 30 kg ha^{-1}) and three levels of sulphur (20, 30 and 40 kg ha^{-1}) Sesame variety Phule Til No. 1 was used as a cultivar crop. Results showed that progressive increase in levels of phosphorus significantly increased the plant height of sesame.

2.1.1.2 Dry matter weight plant^{-1}

Umar *et. al.* (2011) was conducted a field trial to evaluate the performance of two sesame varieties (Sesamum indicum L) in response to levels of nitrogen fertilizer and intra row spacing at the research farm of Institute for Agricultural Research, Samaru in the Northern Guinea Savanna of Nigeria, during the wet seasons of 2009 and 2010. The treatments consisted of two sesame varieties (NCRIBen001M and NCRIBen002M), four nitrogen levels (20, 40, 60 and 80 kg N/ha) and three intra row spacing (5, 10 and 15cm). He found that the two varieties significantly differed in terms total dry matter accumulation where NCRIBen001M significantly outperformed NCRIBen002M.

2.1.1.3 Branches plant^{-1}

Hassan *et al.* (2006) conducted an experiment for the evaluation of some sesame varieties in different planting dates. They reported that the greater number of branches plant^{-1} was produced by variety Say'un1 in the first season and by Balady red in the second one; while Say'un2 produced the lowest number of branches plant^{-1} with significant differences.

Baswaid *et al.* (2001) conducted an experiment on the comparative study of some varieties of sesame (*Sesamum indicum*) on growth and yield under Tuban Valley condition in India. They reported that highest numbers of branches plant^{-1} were recorded from variety Tahama compared with Mareb and Kanana varieties.

2.1.1.4 Leaves plant^{-1}

Mahmud (2006) found the lowest number of leaves in BINA til-1 sesame variety as compared to some sesame genotypes like SM-5, SM-9, SM-12, and SM-13.

2.1.2 Effect on yield contributing characters

2.1.2.1 Capsules plant^{-1}

El Naim *et al.* (2012) conducted a field experiment during 2005/2006 season to investigate the performance of three cultivars of sesame (*Sesamum indicum* L) namely; Elobeid1, Promo (recently improved cultivars) and Hirhri (an old traditional cultivar). Promo cultivar recorded with higher capsules per plant.

Chowdhury (2005) conducted an experiment with several sesame varieties and found that BINA til-1 produced lowest number of capsules per plant whereas local variety (T-6) produced higher number.

Baswaid *et al.* (2001) reported that highest numbers of total capsules plant^{-1} were recorded from Tahama compared with Mareb and Kanana.

2.1.2.2 Seeds capsule^{-1}

El Naim *et al.* (2012) reported that Promo cultivar had higher number of seeds per capsule.

In case of seeds per capsule, BINA til-1 produced higher number of seeds per capsule and local variety (T-6) produced lower number reported by Chowdhury (2005).

2.2.2.3 1000 Seeds weight

Chowdhury (2005) reported that BINA til-1 produced higher 1000-seed weight compared to local variety (T-6).

Subrahmaniyan *et al.* (1999) found difference in 1000-seed weight with different sesame varieties.

2.2.2.4 Effect on Seed yield

El Naim *et al.* (2012) conducted a field experiment during 2005/2006 season to investigate the performance of three cultivars of sesame (*Sesamum indicum* L) namely; Elobeid1, Promo (recently improved cultivars) and Hirhri (an old traditional cultivar). They found no significant differences in seed yield between cultivars.

Al amin (2008) conducted an experiment to study the pheno-physiological development of some sesame varieties. The experiment comprised of four varieties of sesame viz. i) T-6, ii) BINA til-1, iii) BARI til-2 and iv) BARI til-3. The T-6 and BARI til-2 produced the highest biological yield.

Hassan *et al.* (2006) reported that Say'un 1 variety surpassed Balady Red variety and Say'un2 variety in seed yield ha^{-1} and oil percentage with significant differences.

Ravikant *et al.* (2006) conducted an experiment on the formulation of selection criteria for high oil yield in sesame (*Sesamum indicum* L.). They reported that three traits (among 11) viz. 1000-seed weight, seed oil content (%) and seed yield were most effective for selection of elite genotypes for high oil yield.

Chowdhury (2005) stated that BINA til-1 produced higher economic seed yield compared to local variety (T-6).

Solanki *et al.* (2001) conducted an experiment on the phenotypic stability for seed yield in sesame (*Sesamum indicum*). They reported that the genotype RT 274 had the highest seed yield and showed better performance under favorable environmental conditions, while RT 46 was found suitable under unfavorable environmental conditions.

Sriram *et al.* (2000) conducted an experiment on the performance of improved varieties of sesame under rain fed conditions. They reported that the adoption of improved cultivar, chemical seed treatment, 40 kg N ha^{-1} (urea) and plant protection measures resulted in 50–88 % increase in yield over the traditional farmers' practices.

2.2 Effect of weed management

2.2.1 Effect of weed management on growth characters

2.2.1.1. Plant height

Islam *et al.* (2014) evaluated the effects of seed rate and weeding regime on the weed infestation and crop performance of sesame. Two factors viz. seed rate (6, 7, 8, 9 or 10 kg ha^{-1}) and weeding regimes (no weeding, single-weeding, weeding twice and complete weeding) were included in the experiment. . The two weeding and weed free treatment resulted significantly superior performance over no weeding in respect of plant height.

Amare (2011) concluded that an increase in weed free period was associated with lower weed emergence and greater resources uptake by sesame plants that caused plants to be tall.

Ahmed *et al.* (2009) carried out several field experiments between 2007 and 2008 rainy seasons to investigate the effects of planting date (mid may, early and late June) and weeding regimes (weedy check, weeding once, weeding twice and weed free) on the growth and yield of sesame (*Sesamum indicum* L.). Results obtained indicated that weeding regime significantly affected plant height. Effect of weeding once and weed free were statistically the same and differed significantly from weedy check and weeding twice. Weedy check produced significantly shortest plants than the rest of the weeding regimes mainly due to competition from weeds

2.2.1.2 Dry matter weight plant^{-1}

Yadav (2004) reported that lowest weed dry matter and highest weed control efficiency were achieved under pre-emergence application of pendimethalin 0.5 kg ha^{-1} + 1 HW at 40 DAS.

Bennett *et al.* (2003) found in their research that in developing countries, weed infestation is a major concern for sesame production; this is particularly the case where modern agricultural practices such as mechanical weeding and the application of herbicides are limited. Weed species generally have better nutrition efficiency and typically dominates and weakens crop plants, which negatively affects plant morphology and eventually crop yield. In particular, there is an initial slow growth phase during the first four weeks of the sesame life cycle. This delicate period makes sesame seedlings particularly vulnerable to weed competition and severely affects the seedling establishment. According to the researcher, sufficient weed control increased sesame dry matter accumulation.

2.2.1.3 Branches plant^{-1}

El Naim *et al.* (2010) found that increasing weeding times increased plant height due to efficient weed control. The highest number of branches per plant was obtained in weeding twice and in weed free plot. This result may be attributed to vigorous plant with less competition for light, nutrients, and free space in weed free environment.

2.2.2 Effect on yield contributing characters

2.2.2.1 Capsules plant^{-1}

Zubair *et al.* (2011) reached a conclusion that maximum number of capsules in sesame, in all season weed free treatment, may be due to the efficiency of photosynthesis which was supported by the ample uptake of water, nutrients and radiation in the absence of weeds. This increased photo-assimilates allocation into reproductive parts led to an increase in no. of capsules per plant.

Saudy and Abd El-Momen (2009) conducted an experiment to evaluate the cultural and manual weed management in sesame. W_1 was the best practice for enhancing capsules plant^{-1}.

2.2.2.2 Seeds capsule^{-1}

Islam *et al.* (2014) evaluated that Number of seeds capsule^{-1} was statistically significant with the weeding regimes. The two weeding and weed free treatment resulted significantly superior performance over no weeding in respect of number of seeds capsule^{-1}. Number of seed capsule^{-1} giving the highest value in the weed free group followed by two weeding and one weeding group and the no-weeding group was last.

2.2.2.3 1000 Seeds weight

Islam *et al.* (2014) mentioned that 1000-seed weight was statistically significant with the weeding regime (The two weeding and weed free treatment). The highest 1000-seed weight was recorded in the weed free conditions followed by single weeded and subsequently by non-weeded plots.

Bhadauria *et al.* (2012) found that two hand-weeding at 15 and 30 DAS resulted in significantly highest value in 1000 seeds weight.

2.2.2.4 Effect on Seed yield

Ahmed *et al.* (2014) conducted several field experiments during two summer seasons (2011 and 2012) at El-Nubaria Research Station, Agricultural Research Center, to estimate the optimum time for weed control and determine the effect of weed competition period length (14, 28, 42, 56, 70, 84 and all season after emergence) and weed free duration on growth and yield factor of sesame. The results showed that 79 % and 81 % decrease in seed yield of all season weedy, compared to all season weed free, in the first and second season, respectively. Also, data revealed that critical period for weed control (CPWC) in 2011 season ranged from 15–70 days after emergence (DAE) for acceptable yield loss (AYL) of 5 % and from 18–54 DAE for AYL of 10 %. However, in 2012 season, CPWC ranged from 18–41 DAS for AYL 5 % and from 20–30 DAS for AYL 10 %.

Duary and Hazra (2013) reported a critical period for weed control (CPWC) of 19–40 DAS in the first season and 20–42 DAS in the second season in case of sesame.

Tyagi *et al.* (2013) found a critical period for weed control (CPWC) of 15–45 DAS for sesame.

Vafaei *et al.* (2013) conducted and experiment to explore the effects of the pre-emergence herbicides alachlor (1680, 2400 g ha^{-1}) and trifluralin (720, 1200 g ha^{-1}), the post-emergence herbicides bentazone (360, 480 g ha^{-1}) and haloxyfop (250, 375 g ha^{-1}) and their combinations, along with the effect of seed hydro-priming on weed control, growth and yield of sesame (*Sesamum indicum* L.). Weed density was reduced from 94.8% (alachlor rate 1680 g ha^{-1}) to 100% (trifuralin 720 g ha^{-1}) at the stage before application of post-emergence herbicides, while weed density was reduced from 31.6 % (bentazone 480 g ha^{-1}) to 89.1% (bentazon + trifuralin at 360 and 720 g ha^{-1}) at the beginning of the pollination stage. Weed density, however, was reduced from 24.5 % (haloxyfob 250 g ha^{-1}) to 86.8% (bentazone + alachlor at 360 and 720 g ha^{-1}) at physiological maturity stage. The weed-free variant produced the highest dry matter weight followed by the application of 720 g ha^{-1} trifluralin, 2400 g ha^{-1} alachlor, 250+720 g ha^{-1} holoxyfob + trifluralin, 1680 g ha^{-1} alachlor and 250+1680 holoxyfob +

alachlor. The application of 720 g ha^{-1} trifluralin produced the highest grain yield followed by weed-free, holoxyfob + trifluralin (250 and 720 g ha^{-1}), holoxyfob + alachlor (250 and 1680 g ha^{-1}), alachlor at 2400 g ha^{-1} and alachlor at 1680 g ha^{-1}. Bentazone as a post-emergence herbicide combined with pre-emergence herbicides alachlor or trifluralin had the highest efficiency in reducing weed density and controlled grass and broadleaf weeds across the growing season. The application of the post-emergence herbicide individually had lower efficiency on weed control. The application of pre-emergence herbicides was thus accentuated. The results showed that proper combination of pre- and post-emergence herbicides along with seed priming could be used to control the weeds in the sesame and obtain seed yield comparable with weed-free conditions.

Bhadauria *et al.* (2012) conducted a field experiment to find out the most effective control measure for weeds in sesame (*Sesamum indicum* L.) under rainfed condition. Result showed that two hand weeding (weed free) recorded lowest weed population and dry weight which was significantly superior over rest of the treatments. All the weed control treatments produced significantly more seed yield (kg ha^{-1}) than weedy check. Two hand-weeding at 15 and 30 DAS resulted in significantly highest value in capsules $plant^{-1}$, test weight as well as seed yield over rest of the treatments.

Grichar *et al.* (2012) conducted an experiment during the 2007 and 2008 growing seasons under weed-free conditions in South Texas and the High Plains region of Texas to evaluate pre-emergence herbicides for sesame tolerance. No reduction in sesame stand was noted with any herbicide at south Texas location; however, at the High Plains location, linuron at the 2X rate reduced stand counts 28 days after treatment (DAT) in 2007 and diuron reduced sesame stand 147 DAT in 2008 when compared with the untreated check. At the 1/2X rate all herbicides exhibited minimal stunting while at the 1X rate stunting was variable and varied between locations. At the 2X rate, all herbicides caused sesame stunting compared to the untreated check. No herbicide, with the exception of linuron at the 2X rate in 2008 at the High Plains location, reduced sesame yield when compared with the untreated check. Although some herbicide treatments resulted in sesame stunting, this did not result in any yield reductions and this can be attributed to the ability of the sesame plant to compensate for injury and/or reduced stands.

Imoloame *et al.*(2011) conducted several field trials in 2006 and 2007 cropping seasons at the University of Maiduguri Teaching and Research Farm located in Maiduguri, Nigeria, to evaluate the effect of different pre-emergence herbicides on weed infestation and productivity of sesame (*Sesamum indicum* L.) The experiment consisted of 22 treatments, which included 4 different pre-emergence herbicides applied at 5 rates each namely butachlor, metolachlor, diuron and pendimethalin at 0.5, 1.0, 1.5, 2.0 and 2.5 kg a.i. ha^{-1}, weeding at 3 and 6 weeks after sowing (WAS) and a weedy check. Among the herbicides tested, butachlor at 2.0 kg a.i. ha^{-1} and diuron at 1.0 kg a.i. ha^{-1} produced significantly the highest grain yield in 2006, while metolachlor at 1.5 kg a.i. ha^{-1} produced significantly the highest grain yield in 2007 and the combined means. For effective weed control and higher yield, metolachlor at 1.5 kg a.i. ha^{-1} and butachlor at 2.0 kg a.i. ha^{-1} are recommended as an alternative to two hoe-weedings at 3 and 6 WAS for the production of sesame in the Sudan Savanna zone of Nigeria.

Langham (2008) showed sesame susceptibility to post-emergence herbicides but a toleration of haloxyfop. The application of haloxyfop has been recommended where there is an outbreak of grass weed in the sesame field.

Langham *et al.* (2007) reported that diuron reduced the yield or controlled weeds without significant reduction in the yield. In Nicaragua, metolachlor (1.5 and 2.2 kg ha^{-1}) provided good grass control, did not damage the sesame and doubled the yield of the untreated check. In Australia, it was reported that metolachlor adequately controlled weeds but caused unacceptable crop injury. In reviewing research using post emergence herbicides, it is sometimes difficult to understand exactly at what stage of growth the herbicide was applied.

Ndarubu *et al.* (2003) reported highest sesame yield and effective weed control with application of herbicide mixture of metolachlor + metobromuron at 1.0 + 1.0 kg a.i. ha^{-1} in the Guinea Savanna of Nigeria.

Langham and Weimers (2002) found that high population of weeds may delay combining; leaves of the weeds may envelop plants and trap moisture, or thicker stem weeds such as pigweed (*Amaranthus* spp.) will take longer to dry down. In direct combining, weeds can be a big problem because they add moisture to the combine bin. There are many cases where the sesame seeds are dry and weed seeds are not. Thick stems can add moisture, but the major problem is with weed seeds.

Grichar *et al.* (2001 a) reported that metolachlor at 3.36 kg a.i. ha^{-1} increased yield up to 80% over the untreated check. Metolachlor provided the best control of weeds and least sesame injury among all the herbicides evaluated. They also found that phytotoxicity of pendimethalin at 1.2 kg a.i. ha^{-1} which reduced sesame plant stands by 8 % to 98% compared to untreated check.

Grichar *et al.* (2001 b) showed with their research findings that sesame yield was not affected by S-metolachlor. They also observed that sesame yield was reduced by 62% when compared with weed-free control under bentazone application. Under weedy conditions, metolachlor at 0.6 to 3.4 kg ha^{-1} did not reduce sesame height or yield when compared with the untreated check.

Punia *et al.* (2001) proved that low doses of trifluralin acted selectively on sesame and appropriately controlled the weeds but in high doses it had an undesirable effect on sesame.

Narkhede *et al.* (2000) observed that cultural practices i.e.two hand weeding and hoeing in sesame significantly gave higher seed yield than rest of the integrated weed management practices. Among integrated weed management practices, quizalofop-ethyle with 1 HW produced higher number of capsules $plant^{-1}$, seeds $capsule^{-1}$, test weight and seed yield (kg ha^{-1}) which were statistically at par with trifluralin with 1 HW followed by pendimethalin + 1 HW treatments. Among herbicide alone, quizalofop-ethyle recorded significantly higher number of capsules $plant^{-1}$ over treatments trifluralin and pendimethalin. However, this treatment was on par with trifluralin in case of test weight and seed yield (kg ha^{-1}). While in case of seeds $capsule^{-1}$, the affect was found to be non-significant.

Chauhan and Gurjar (1998) reported that weed control treatment may be attributed to kill and check the growth of weeds due to application of herbicides resulting in reduction in dry matter and increased weed control efficiency.

Sootrakar *et al.* (1995) reported that HW 3 times (25, 40 and 55 DAS) resulted in the lowest weed counts and the highest weed control efficiency (98.8%). They concluded that application of herbicide and cultural practices resulting in thatmetolachlor and trifluralin increased sesame yield by 45% when compared with the unweeded check. The premix of metolachlor and metobromuron provided good broadleaf weed control while both metolachlor alone and the premix provided good annual grass control.

Dowson (1970) reported that most of the reduction in crop vigor and yield in sesame was as a result of weed competition with crops for essential nutrients, water below the soil and for light and space above the soil surface.

Lyubenov and Kostadinov (1970) found that pre-emergence application of mixtures of 3 kg ha^{-1} of linuron and 3 kg ha^{-1} of alachlor gave effective control of weeds and increased seed yields and seed oil content in sesame in Bulgaria.

Santelman *et al.* (1963) found slight phytotoxicity and a reduction in sesame yield with linuron at 2.24 kg ha^{-1}. Diuron, linuron, the premix of diuron plus linuron, and S-metolachlor at 1/2X rate exhibited excellent sesame tolerance; however, when the rate was increased to 1X rate, linuron, and S-metolachlor resulted in the least sesame stunting.

After a long review of literatures it may be concluded that variety and weed management had significant influence on sesame and other crops to produce increased plant growth and yield characters. Sesame varieties and weeding management as one or two time hand weeding, use of herbicide or combined effect of both produced maximum growth and yield value of sesame.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to study the effect of different levels of weed management on the improvement of growth and yield of sesame varieties (cv. BARI til-3, BARI til-4 and Local Lal til). Materials used and methodologies followed in the present study have been described in this chapter.

3. Description of the experimental site

3.1 Location

The field experiment was conducted at the agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2014.

3.2 Site and Soil

Geographically the experimental field was located at 23^0 77' N latitude and 90^0 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro ecological Zone-Modhupur Tract (AEZ-28). The land topography was medium high and soil texture was silty clay with pH 5.9. The morphological, Physical and chemical characteristics of the experimental soil have been presented in Appendix 1.

3.3 Climate and Weather

The climate of the locality is sub tropical which is characterized by High Temperature and heavy rainfall during Kharif sesason (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The mean maximum air temperature and minimum air temperature range were (35.6-39.4^{0}C) and (17.4-20.2^{0}C) rspectively.The mean relative humidity range from (89.2-32.4%), total rainfall varies from (3.8-282.7 mm) were recorded from the SAU meterological Yard, Dhaka. However the prevailing weather conditions during the study period (March-July) have been presented in Appendix 2.

3.4 Plant materials

BARI til- 3, BARI til-4 and one local cultivar (Lal til) were used as planting materials. BARI til-3 and BARI til- 4 were developed by BARI. Plant height of BARI til-3 and BARI til-4 cultivars ranges from 100-110 and 90-120 cm respectively. Life cycle of BARI til-3 cultivar is about 90 to 100 days and BARI til-4 cultivar is about 90 to 95 days after emergence. Average yield of both cultivars are about 1.20-1.40 and 1.4-1.5 ton ha^{-1} respectively. The seeds of both cultivars were collected from BARI, Joydebpur Gazipur. The other local cultivar was collected from Ullapara, Sirajgonj.

3.5 Treatments under investigation

There were two factors in the experiment namely variety and weeding as mentioned below:

A. Factor-1 (Variety: 3)

I). V_1 = BARI til-3
ii). V_2 = BARI til-4
iii). V_3 = Local (Lal til)

B. Factor-2 (Weed management: 5)

I). W_1 = No weeding (control),
ii). W_2 = One hand weeding at 20 days after sowing (DAS),
iii). W_3 = Two hand weeding at 20 DAS and 40 DAS,
iv). W_4 = Pre emergence herbicide, **Sunup 480 SL** spraying before land preparation,
v). W_5 = Post emergence herbicide, **Release 9 EC** spraying at 15 days after germination (DAG).

Treatment combination: Fifteen treatment combinations are as follows

V_1W_1	V_2W_1	V_3W_1
V_1W_2	V_2W_2	V_3W_2
V_1W_3	V_2W_3	V_3W_3
V_1W_4	V_2W_4	V_3W_4
V_1W_5	V_2W_5	V_3W_5

3.6 Description of herbicides

Table 1. Short description of the herbicides used in the experiment

Trade Name	Common Name	Mode of action	Selectivity	Dose	Time of application
Sunup 480 SL	Glyphoset	Systemic	Non selective	3.71 l ha^{-1}	Pre-emergence
Realease 9EC	Phenoxyprop-p-ethayel	Systemic	Bermuda grass,Jungle Rice,Nutgrass, Scrab grass	650 ml ha^{-1}	Post-emergence

3.7 Experimental Design and layout

The experiment was laid out in a split plot design having 3 replications. There were 15 treatments combinations and 45 units' plots. The unit plot size was 3.6 m^2 (2m×1.8m). The blocks and unit plots were separated by 1.5m and 1.0m spacing respectively. Treatment factor variety was placed on main plot and weeding factor was placed on sub plot.

3.8 Land Preparation

The experimental land was opened with a power tiller on 21st march. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 25th March and was ready for sowing seeds.

3.9 Fertilizer application

The fertilizers were applied as basal dose as N, P and K @57.50, 72.30 and 30 kg ha^{-1} through the application of Urea, TSP and MoP respectively. All the fertilizers and half dose of urea were applied at final land preparation in all plots and rest half dose of urea was applied at 25 DAS.

3.10 Sowing of seeds

Seeds were sown at the rate of 7.5 kg ha^{-1} in the furrow on 31st March, 2014 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained as per treatment arrangements with continuous sowing of seed in the line.

3.11 Germination of seeds

Seed germination occurred from 3rd day of sowing. On the 6th day percentage of germination was more than 85% and in the 7th day nearly all baby plants (seedling) came out of the soil.

3.12 Intercultural Operation

3.12.1 Thinning

Thinning was done to maintain 5 cm plant to plant distance after 10 days of germination.

3.12.2 Weed control

Weed control was done as per experimental treatments.

3.12.3 Irrigation and drainage

Pre-sowing irrigation was given to ensure maximum germination percentage. During experimental period, there was heavy rainfall for several times. So it was essential to remove the excess water from the field.

3.13 Harvesting and sampling

The crop was harvested at 93 DAS. The crop was harvested plot wise when 80% of the capsules became matured. Samples were collected at random from different places of each plot leaving undisturbed plant in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun 4 to 6 consecutive days for achieving safe moisture of seed.

3.14 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from plants by beating the bundles with bamboo sticks.

3.15 Drying, Cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level (12.5%). The dried seeds and straw were cleaned and weighed.

3.16 Recording of Data

The data were recorded on the following parameters

I. Weed parameters

a) Weed density (no.)
b) Weed biomass (g m^{-2})

ii. Crop Growth parameters

All the data were collected at 15 days interval but at 75 DAS data could not be collected due to heavy rainfall for few days at that time.

a) Plant height (cm) at 15 days interval from 15 DAS up to harvest

b) Leaves plant^{-1} (no.) at 15 days interval from 15 DAS up to 60 DAS

c) Branch plant^{-1} (no.) at 15 days interval from 45 DAS up to harvest

d) Above ground dry matter weight plant^{-1} at 15 days interval from 15 DAS up to Harvest (g)

e) Crop growth rate (CGR) plant^{-1} at 15 days interval from 15 DAS up to harvest (g m^{-2} day^{-1})

f) Relative growth rate (RGR) plant^{-1} at 15 days interval from 15 DAS up to harvest (g g^{-1} day^{-1})

iii. Yield contributing parameter

a) Capsules plant^{-1} (no.)

b) Seeds capsule^{-1} (no.)

c) 1000 seeds weight (g)

iv. Yield parameter

a) Seed yield (t ha^{-1})

b) Stover yield (t ha^{-1})

c) Biological yield (t ha^{-1})

d) Harvest index (%)

3.17 Procedure of recording data

3.17.1 Weed parameters

i. Weed density

The data on weed infestation as well as density were collected from each treated plot at 20 days interval. A plant quadrate of 1.0 m^2 was placed at three different spots of 3.6 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

ii. Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 70^0C. After drying, weight of each species was taken and expressed to g m^{-2}.

3.17.2 Crop growth parameter

i. Plant height (cm)

Five plants were collected randomly from each plot. The height of the plants was measured from the ground level to the tip of the plant at 15, 30, 45, 60 days after sowing (DAS) and at harvest time (93 DAS).

ii. Leaves plant^{-1} (no.)

Five plants were collected randomly from each plot. Number of leaves per plant was counted from each plant sample and then averaged at 15, 30, 45, 60 days after sowing and harvest time (93 DAS).

iii. Branch plant^{-1} (no.)

Five plants were collected randomly from each plot. Number of fruit bearing branch per plant was counted from each plant sample and then averaged at 45, 60 days after sowing (DAS) and at harvest time (93 DAS).

iv. Above ground dry matter weight plant^{-1} (g)

Five plants were collected randomly from each plot at 15, 30, 45, 60 days after sowing and at harvest time (93 DAS). The sample plants were oven dried for 72 hours at 70^0C and then dry weight plant^{-1} was determined.

v. Capsules plant^{-1} (no.)

Number of capsules plant^{-1} was counted from 5 plants and then average capsule number was calculated.

vi. Seeds capsule^{-1} (no.)

Number of seeds capsule^{-1} was counted from randomly selected 20 capsules of plants and the average seed number was calculated.

Vii. Weight of 1000 - seeds (g)

1000-seeds were counted which were taken from the seeds sample of each plots separately, then weighed in an electrical balance and data were recorder.

viii. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} (2m^2) and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

ix. Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell of harvested area was sun dried and the weight was recorded and then converted to t ha^{-1}.

x. Biological yield (t ha^{-1})

The summation of seed yield and above ground Stover yield was the biological yield. Biological yield = Seed yield + Stover Yield.

xi. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

$$HI\ (\%) = \frac{Economic\ yield\ (seed\ weight\ )}{Biological\ yield\ (Total\ dry\ weight\ )} \times 100$$

Here, Biological yield = Seed yield + Stover yield

xiii. Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula developed by Radford (1967):

$$\frac{1}{GA} \times \frac{W2-W1}{T2-T1} \quad \text{g plant}^{-1}\ \text{day}^{-1}$$

Where,

GA= Ground area (m^2)

W_1= Total dry weight at previous sampling date

W_2= Total dry weight at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

xiv. Relative growth rate (RGR)

Relative growth rate (RGR) is the growth rate relative to the size of the population. Relative growth rate (RGR) was calculated using the formula developed by Radford

$$\frac{\ln W2-\ln w1}{T2-T1} \text{ g g}^{1}\ \text{day}^{-1}$$

Where,

W_1=Total dry weight at previous sampling date

W_2=Total dry weight at current sampling date

T_1= Date of previous sampling

T_2 =Date of current sampling

ln = Natural logarithm

3.18 Economic analysis

From beginning to ending of the experiment, individual cost data on all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production.

I. Input cost

Input costs were divided into two parts. These were as follows:

A. Non-material cost (labor)

The human labor was obtained from adult male laborers. Eight working hours of a laborer was considered as a man day. The mechanical labor came from the tractor.

B. Material cost

The seed of sesame (BARI til-3 and BARI til-4) was purchased from BARI Headquarter @ Tk.50 and 55 per kg respectively, local Lal til was purchased from Ullapara, Sirajgonj @Tk.30 per Kg. Chemical fertilizers eg. Urea, TSP, and MoP were bought from the authorized dealer at local market. Irrigation was done from the existing facilities of irrigation system of the Sher-e-Bangla Agricultural University field. Herbicides were bought from the respective dealers at local market.

ii. Overhead cost

The interest on input cost was calculated for 6 months @ Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank. The value of land varies from place to place and also from year to year. In this study, the value of land was taken Tk. 200000 per hectare. The interest on the value of land was calculated @ 12.5% per year for 6 months.

iii. Miscellaneous overhead cost (common cost)

It was arbitrarily taken to be 5% of the total running capital.

iv. Gross Return

Gross return from sesame (Tk. ha^{-1}) = Value of grain (Tk. ha^{-1}) + Value of Straw (Tk. ha^{-1})

v. Net return

Net return was calculated by using the following formula:

Net return (Tk. ha^{-1}) = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1}).

vi. Benefit cost ratio (BCR)

Benefit cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:

BCR = Gross return (Tk. ha^{-1}) \ Cost of production (Tk. ha^{-1})

3.19 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program STATISTIX 10 and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the weed parameters, crop characters and economic evaluation of the production of BARI til-3,BARI til- 4 and Lal til (local) as influenced by variety and weed control treatments have been presented and discussed in this chapter.

4. 1 Weed parameter

4.1.1 Weed density

It is a general observation that conditions favorable for growing sesame is also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Table 1 shows that 10 weed species were found during the experiment. It was observed that the species, Chapra (*Eleusine indica*) accounted the highest in number and thereafter were Mutha (*Cyperus rotundus*), Malancha (*Alternanthera philoxeroides*), Anguli ghash (*Digitaria sanguinalis*) and so on. The lowest weed in number was Bon pat (*Corchorus acutangulus).*

Table 1. Name of weeds found in the experimental field

SL. No.	Local name	Common name	Scientific name	Family
1.	Chapra	Goose grass	*Eleusine indica*	Poaceae
2.	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae
3.	Anguli ghas	Scrab grass	*Digitaria sanguinalis*	Poaceae
4.	Mutha	Nutsedge	*Cyperus rotundus*	Cyperaceae
5.	Shak notae	Pig weed	*Amaranthus viridis*	Amaranthaceae
6.	Shama	Bernyard grass	*Eichinochloa crussgali*	Poaceae
7.	Bonpat	Wild jute	*Corchorus acutangulus*	Tiliaceae
8.	Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae
9.	Helencha	Harkuch	*Enhydra fructuans*	Compositae
10.	Nunia shak	Common purslane	*Portulaca oleracea*	Portulacaceae

Number of weed species and total number of weeds in 1 m^2 were affected significantly by the different treatment combinations (Table 2). It was observed that the lowest number of weed species and total weeds m^{-2} was observed in V_2W_3 (5.67 and 118.67 respectively). On the other hand, the highest number of weed species and total number of weeds m^{-2} (15.67and 296, respectively) was obtained from V_3W_1.

Table 2. Weed density as per treatment combinations

Treatments	**No. of weed species**	**No. of weeds m^{-2} at different days after sowing**			**Total weeds m^{-2} during crop growing period**
		20 DAS	**40 DAS**	**At harvest 93DAS**	
V_1W_1	14		- -	280	280
V_1W_2	10.33	120.67	- -	53.67	174.34
V_1W_3	8.67	118	20.67	19.33	154
V_1W_4	11.33	- -	- -	175.67	175.67
V_1W_5	9.67	- -	- -	161.33	161.33
V_2W_1	13.67	- -	- -	254.67	254.67
V_2W_2	9	109.67	- -	40.67	150.34
V_2W_3	5.67	76.67	21.33	20.67	118.67
V_2W_4	8.33	- -	- -	182	182
V_2W_5	7.6	- -	- -	173	173
V_3W_1	15.67	- -	- -	296	296
V_3W_2	7.5	122	- -	70.67	192.67
V_3W_3	6	96	34.67	24.67	155.34
V_3W_4	12.33	- -	- -	183	183
V_3W_5	9.67	- -	- -	160.33	160.33

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.1.2 Weed biomass

Weed population had considerable effect on crop production. We can say from table 3 that the highest dry weight of weed (374g m^{-2}) was observed in V_3W_1. The lowest dry weed biomass (108.58 g m^{-2}) was observed in V_2W_3 where two hand weeding was done.

Table 3. Effect of variety and weed management on dry weed biomass

Treatments	**Dry weight of weeds at different DAS (g m^{-2})**			**Total dry weight of weed (g m^{-2}) during crop growing period**
	20 DAS	**40 DAS**	**At harvest (g m^{-2})**	
V_1W_1	- -	- -	215.32	215.32
V_1W_2	90.13		21.3	111.43
V_1W_3	70.05	20.33	21.97	112.35
V_1W_4	- -	- -	115.87	115.87
V_1W_5	- -	- -	133.07	133.07
V_2W_1	- -	- -	281.8	281.8
V_2W_2	87.06		43.47	130.53
V_2W_3	77.35	20.00	11.23	108.58
V_2W_4	- -	- -	118.67	118.67
V_2W_5	- -	- -	122.77	122.77
V_3W_1	- -	- -	374	374
V_3W_2	118.07		63.8	181.87
V_3W_3	111.29	19.33	16.23	146.85
V_3W_4	- -	- -	162.23	162.23
V_3W_5	- -	- -	186.13	186.13

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.2 Growth parameters

4.2.1 Plant height (cm)

4.2.1.1 Effect of variety

Environmental factors and genetic characteristics of plants play an important role in determining the plant height. Data on plant height at different days of sesame was influenced by variety have been presented in Fig. 1. At 15 and 30 DAS no significant variation of plant height was found due to variety (Appendix III and Table 1), the plants height (12.40, 35.75 cm for V_1, 39.91, 13.18 cm for V_2 and 11.79, 34.30 cm for V_3) were found similar. Numerically higher plant height was found in V_2 and lower plant height was found in V_1. At 45 DAS highest plant was found in V_2 (90.13 cm) and lowest plant height (86.74 cm) was found in $V_{3.}$ Afterwards V_1 produced significantly higher plant heights (119.15 cm and 110.95cm at 60 and 90 DAS) and lowest plant height (108.2 cm and 103.65 cm) was obtained from $V_{3.}$

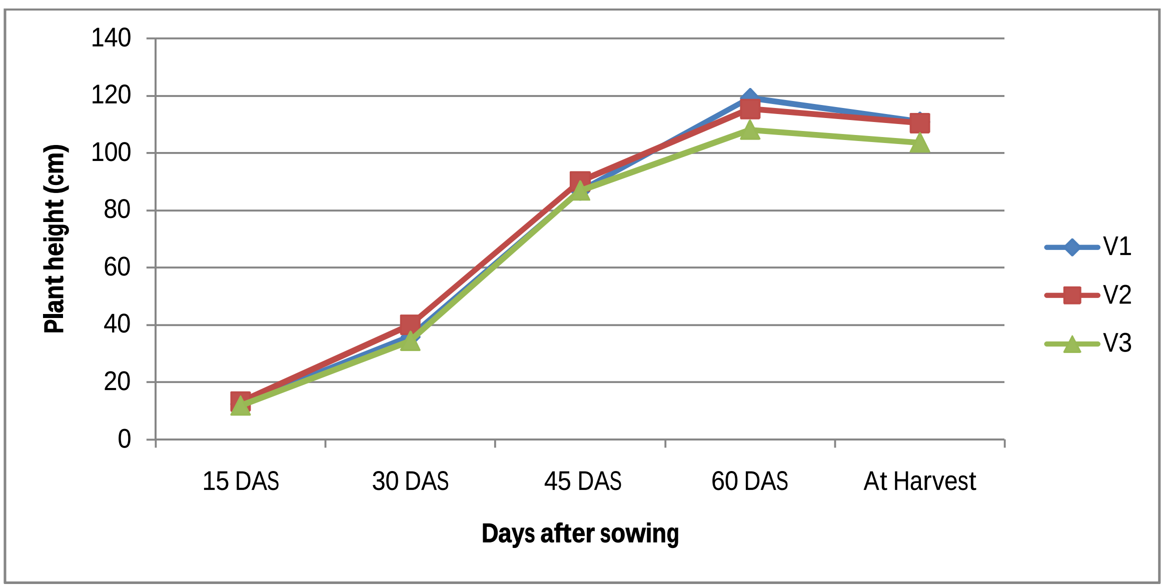

Figure 1. Effect of variety on plant height of sesame at different days ($LSD_{0.05}$ = NS, NS, 2.31, 7.06 and 3.83 at 15, 30, 45, 60 DAS and harvest, respectively)

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (local)

4.2.1.2 Effect of weed management

The plant height was significantly influenced by weed management at all growth stages of sesame (Fig. 2). At 15 DAS the highest plant height (15.28 cm) was recorded in W_4 followed by W_5 (13.05 cm), W_3 (12.88 cm) and then W_2 (12.60) where the lowest was achieved with W_1 (8.46 cm). AT 30 DAS, the highest plant height (42.28 cm) was recorded in W_4 which was statistically similar with W_3 (41.58 cm) and W_5 (36.15cm) while the lowest was achieved with W_1 (29.00cm). At 45 DAS, the highest plant height (98.31 cm) was recorded in W_4 the second highest value of plant height (89.83 cm) was obtained from W_3 which was statistically similar with W_2 (88.17 cm) Ahmed *et al.* (2009) indicated that weeding regime significantly affected plant height while the lowest was achieved with W_1 (79.016cm).

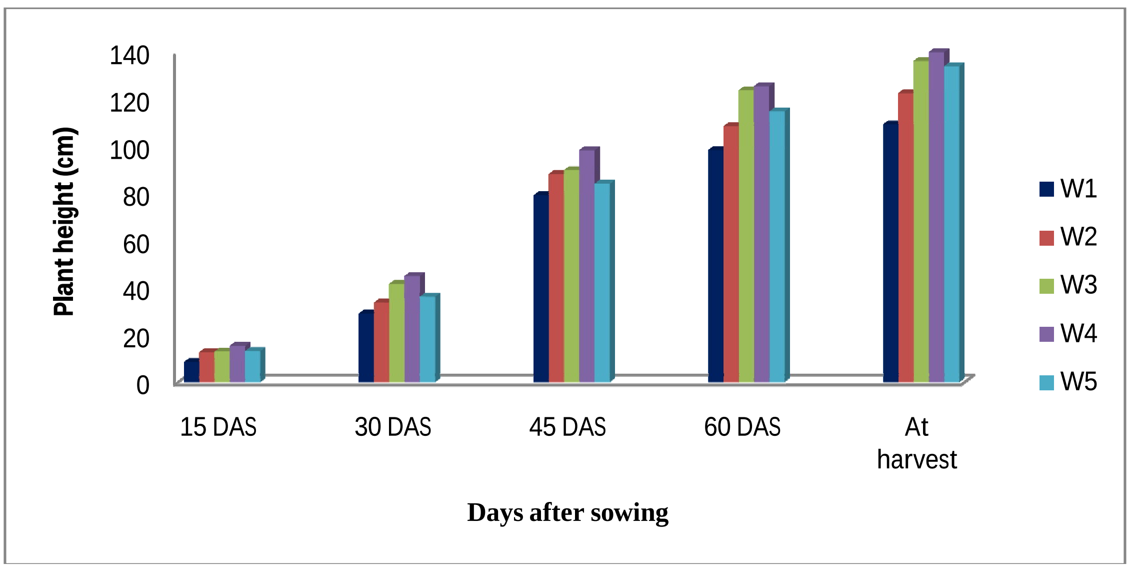

Figure 2. Effect of weed control methods on plant height of sesame at different days after sowing ($LSD_{0.05}$ = 2.18, 7.99, 2.22, 3.45 and 4.65 at 15, 30, 45, 60 DAS and harvest, respectively)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

At 60DAS, the highest plant height (125.43 cm) was recorded in W_4 which was statistically similar with W_3 (123.71 cm) where the lowest was achieved with W_1 (98.38 cm).At harvest the highest plant height (139.89 cm) was recorded in W_4 which was statistically similar with W_3 (136.14 cm) where the lowest was achieved with W_1 (109.22 cm).

4.2.1.3 Combined effect of variety and weed management

Combination between variety and weeding exerted significant effect on plant height (Table 4). The highest plant height (17.54cm) and (104.10cm) at 15 DAS and 45 DAS were observed in V_2 with pre emergence herbicide for weed management (V_2W_4) in case of 15 DAS which was statistically similar with V_1W_4, V_2W_5 and V_3W_3 while at 15 DAS and 45 DAS the shortest plant height was obtained with V_3W_1 (7.03 cm and 75.00 cm) which was statistically similar with V_1W_1. At 30 DAS the tallest plant (48.05cm) was observed with V_2W_3 which was statistically similar with V_1W_3 V_1W_4 (46.56cm), V_1W_5 V_2W_2 , V_2W_4, V_2W_5, V_3W_2,V_3W_3, V_3W_4 and V_3W_5 and the shortest plant height (25.72 cm) was obtained with V_1W_1. At 60 DAS, the highest plant height was obtained with V_1W_3 (140.67 cm) and shortest plant height (89.67 cm) was obtained with V_1W_1 which was statistically similar with V_3W_1 and V_2W_2 .At harvest the tallest plant (145.73cm) was observed with V_1W_4 which was statistically similar with V_1W_3, V_1W_5, V_2W_4 and V_2W_5 and the shortest plant height was obtained with V_2W_1 (106.48cm) which was statistically similar with V_1W_1. The results obtained from all other treatment combinations were significantly different from each other. It was observed that weeds controlled with different weed managements showed better growth or height due to less competition thus crop enjoyed better water nutrient uptake .The similar discussion made by Amare (2011), where he worked on sesame with weed control managements.

4.2.2 Branches plant^{-1}(no.)

4.2.2.1 Effect of variety

The branches plant^{-1} was significantly influenced by variety at all growth stages of sesame except at harvest stage (Fig. 3). At 45 DAS, the maximum (2.22) branches were recorded from V_3 while the minimum (1.40) branches in V_1 which was statistically similar with V_2. At 60 DAS the maximum (7.73) branches was recorded from V_1 while the minimum (6.46) braches in V_3. No significant variation of branches plant^{-1} was found due to variety of sesame at harvest stage.

Table 4. Combined effect of variety and weed management on plant height of sesame

Treatments	Plant height (cm.)				
	15 DAS	30 DAS	45 DAS	60 DAS	At Harvest
V_1W_1	8.80 ef	25.72 d	77.60 ij	89.67 i	108.0 h
V_1W_2	12.79 b-d	31.55 cd	80.03 hi	117.33 e	120.77 e-g
V_1W_3	13.09 b-d	41.46 a-d	90.67 cd	140.67 a	138.75 a-c
V_1W_4	15.22 ab	46.56 ab	97.67 b	126.67 b-d	145.73 a
V_1W_5	12.08 b-e	33.46 a-d	88.31 de	121.40 c-e	138.57 a-c
V_2W_1	9.56 d-f	32.12 b-d	84.90 e-g	113.13 ef	106.48 h
V_2W_2	13.32 b-d	36.10 a-d	86.60 de	95.27 hi	127.43 de
V_2W_3	11.22 c-e	48.05 a	93.00 c	131.27 b	136.80 bc
V_2W_4	17.54 a	43.59 a-c	104.10 a	129.48 b	143.00 ab
V_2W_5	14.24 a-c	39.69 a-d	82.03 f-g	107.33 fg	141.03 ab
V_3W_1	7.03 f	29.17 cd	75.00 j	92.33 I	113.17 gh
V_3W_2	11.69 b-e	33.27 a-d	97.88 b	112.82 ef	119.27 fg
V_3W_3	14.33 a-c	35.22 a-d	85.83 ef	99.20 gh	132.87 cd
V_3W_4	14.07 b-d	38.53 a-d	93.17 c	120.13 de	130.93 de
V_3W_5	12.83 b-d	35.30 a-d	81.83 gh	115.60 ef	122.03 ef
$LSD_{(0.05)}$	3.995	16.28	4.11	8.77	8.11
CV (%)	18.06	22.41	2.60	3.12	3.73

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

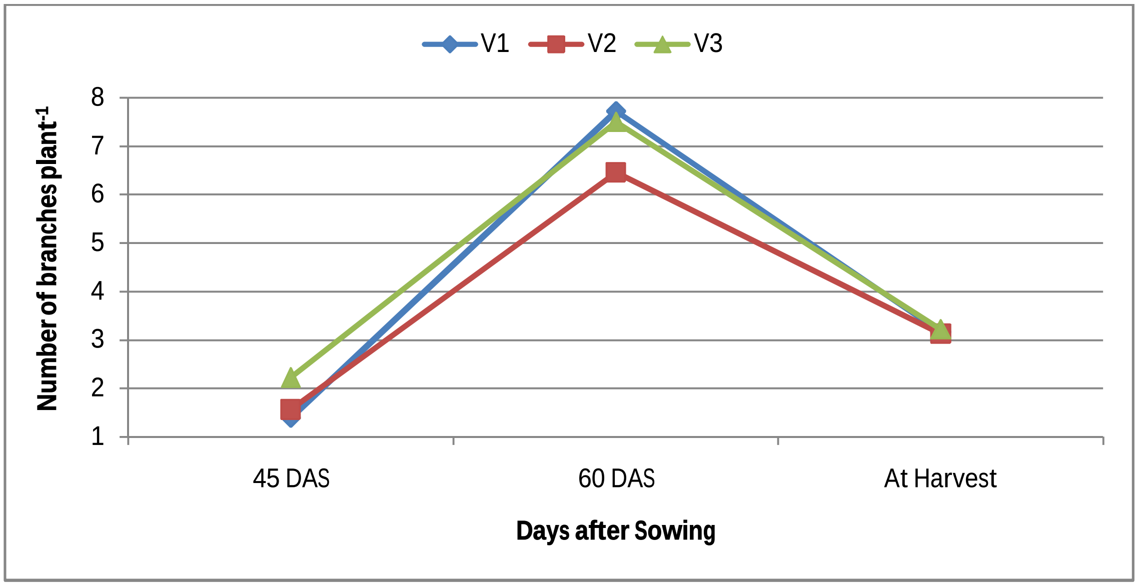

Figure 3. Effect of variety on the no. of branches plant^{-1} of sesame at different days after sowing ($LSD_{0.05}$ = 0.16, 0.23 and NS at 45, 60 DAS and harvest, respectively)

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (local)

4.2.2.2 Effect of weed management

Branches plant^{-1} was significantly influenced by different weed management at all growth stages of sesame (Fig. 4). At 45 DAS the maximum number of branches (1.93) plant^{-1} was recorded in W_1 which was statistically similar with W_3 (1.89) and W_4 (1.80) and the lowest number of branches (1.49) was achieved with W_2 which was statistically similar with W_4 (1.52). At 60 DAS and at harvest stage the maximum branches (8.90 and 3.67) were recorded from W_5 and W_4 respectively and minimum branches (5.79 and 2.63) were obtained from W_1. El Naim *et al.* (2010) found that the highest number of branches per plant was obtained in weeding twice and in weed free plot.

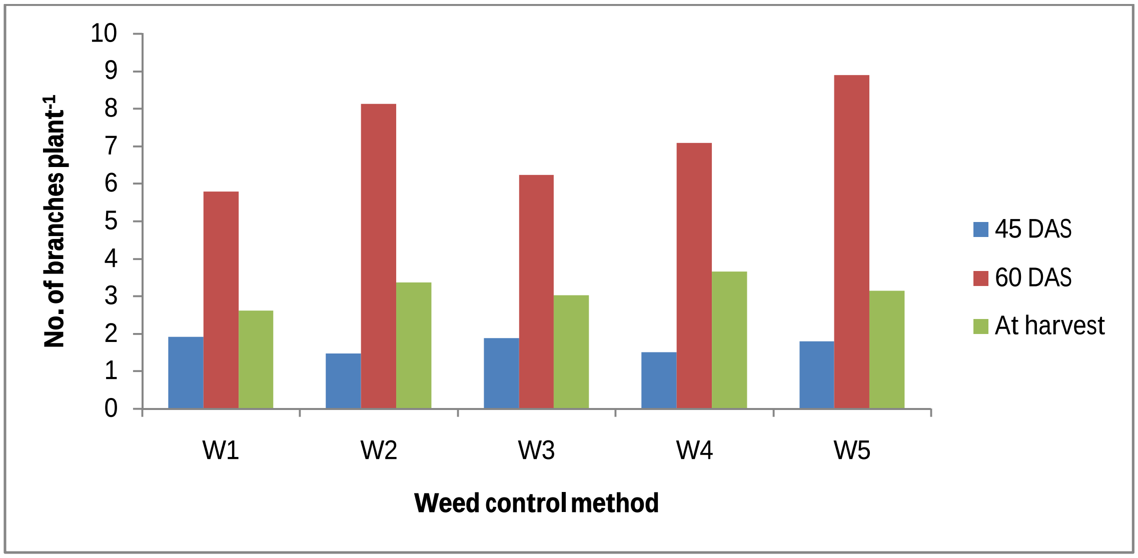

Figure 4. Effect of weed control methods on no. of branches plant^{-1} of sesame at different days after sowing ($LSD_{0.05}$ = 0.16, 0.34, and 0.19 at 45, 60 DAS and harvest, respectively)

W_1	=	No weeding
W_2	=	1 hand weeding at 20 DAS
W_3	=	2 hand weeding at 20 and 40 DAS
W_4	=	Pre emergence herbicide, Sunup spraying after land preparation
W_5	=	Post emergence herbicide, Release spraying at 15 DAG

4.2.2.3 Combined effect of variety and weed management

Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant and play an important role in enhancing seed yield. Data given in Table 5 stated that the number of branches plant^{-1} was influenced significantly by combination of variety and weed control methods. At 45 DAS, the highest no. of branches plant^{-1} (2.83) was observed in V_2W_5. At 60 DAS, maximum no. of branches plant^{-1} (10.70) was observed with V_1W_2. But at harvest, the highest no. of branches plant^{-1} (4.27) was found in V_2W_4.The minimum no. of branches plant^{-1} was obtained with V_1W_4 (0.80) at 45 DAS. At 60 DAS, the lowest no. of branches plant^{-1} was obtained with V_1W_1 (4.63). At harvest, V_3W_1 gave the minimum no. of branches plant^{-1} (2.77) which was statistically similar with V_1W_1 (3.06), V_1W_2 (3.03), V_1W_3 (297), V_1W_5 (3.00), V_2W_3 (2.83), V_2W_5 (3.07) and V_3W_4 (2.93). It might be due to application of pre emergence herbicide or post emergence herbicide and hand weeding which minimized weed competition for growth resources and allowed plants to take up enough moisture and nutrients for better growth, thus produced higher number branches plant^{-1}

Table 5. Combined effect of variety and weed management on branches Plant^{-1} of sesame

Treatments	**Interaction Effect of Variety and weeding**		
	45 DAS	**60 DAS**	**At Harvest**
V_1W_1	1.60 f	4.63 i	3.06 d-f
V_1W_2	1.13 h	10.70 a	3.03 d-f
V_1W_3	2.20 bc	7.60 d	2.97 ef
V_1W_4	0.80 i	5.73 gh	3.80 b
V_1W_5	1.27 gh	10.00 b	3.00 ef
V_2W_1	2.27 b	6.20 fg	2.07 g
V_2W_2	1.43 fg	7.03 de	3.40 cd
V_2W_3	1.13 h	5.57 h	2.83 f
V_2W_4	1.67 ef	6.23 fg	4.27 a
V_2W_5	1.30 gh	7.27 d	3.07 d-f
V_3W_1	1.93 c-e	6.53 ef	2.77 f
V_3W_2	1.90 de	6.67 ef	3.67 bc
V_3W_3	2.33 b	5.57 h	3.33 c-e
V_3W_4	2.09 b-d	9.30 c	2.93 f
V_3W_5	2.83 a	9.43 bc	3.40 cd
LSD $_{(0.05\%)}$	0.30	0.58	0.39
CV (%)	9.68	4.91	6.25

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying 15 DAG

4.2.3 Above ground dry matter (AGDM) weight plant^{-1}(g)

4.2.3.1 Effect of variety

Irrespective of varietal differences, the production of above ground dry matter weight was very slow up to 30DAS then it gradually increased with the time and finally maximum at harvest. Above ground dry matter weight plant^{-1} was significantly varied due to different treatment variations at all growth stages of sesame (Fig. 5). The maximum above ground dry matter weight plant^{-1} (0.66 g, 21.73 g, 21.73 g, 33.26 g) were obtained from V_2 at 15, 45, 60 DAS and At harvest . At 30 DAS, the maximum above ground dry matter weight plant^{-1} (1.36 g) was obtained from V_3. The minimum above ground dry matter weight plant^{-1} (0.41 g 7.04 g and 19.45 g) was obtained from $V_{3,}$ at 15, 45 and 60 DAS respectively. But at 30 DAS and at harvest stage the minimum above ground dry matter weight plant^{-1} (1.22 g and 30.56 g) was obtained from V_1.

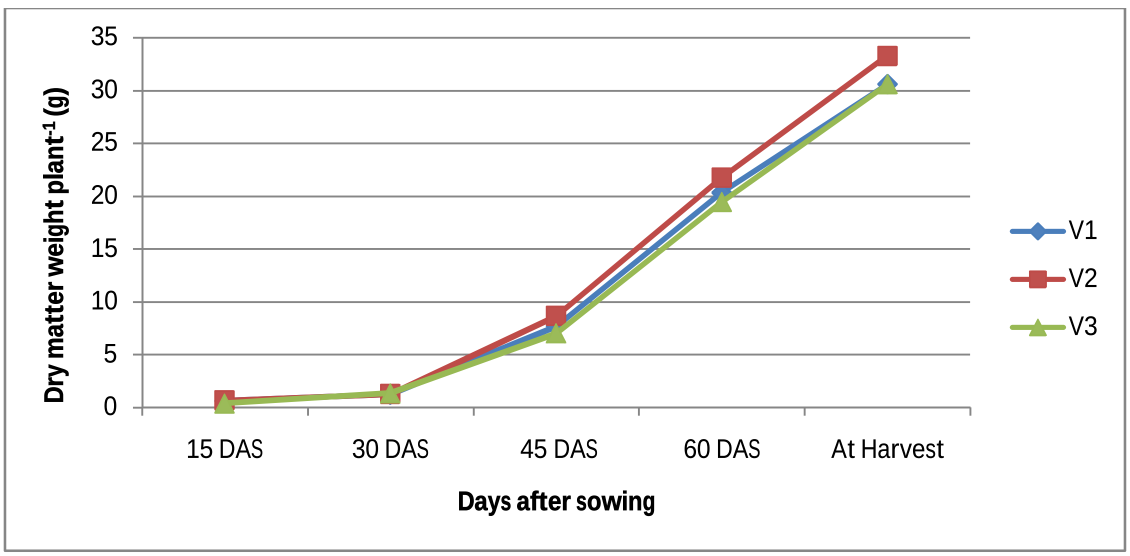

Figure 5. Effect of variety on above ground dry matter weight plant^{-1} of sesame at different days after sowing ($LSD_{0.05}$ = 0.09, 0.09, 0.86, 1.69, and 2.04 at15, 30, 45, and 60 DAS and at harvest, respectively)

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (local)

4.2.3.2 Effect of weed management

Above ground dry matter weight plant^{-1} was significantly influenced by number of weeding at all growth stages of sesame (Fig. 6). It was observed from the present study that the increasing time of weeding significantly increased dry weight plant^{-1} At 15, 30, 45, 60 DAS and harvest. At 15 DAS, the maximum above ground dry matter weight plant^{-1} (0.79 g) was obtained from $_{W4}$ and the maximum of dry matter weight plant^{-1} (1.46 g, 11.24 g and 24.09 g, respectively) were recorded in W_5 at 30, 45 and 60 DAS, respectively. At harvest the maximum above ground dry matter weight plant^{-1} (35.36 g) was obtained from W_3. The lowest dry matter weight plant^{-1} (0.27 g and 0.81 g and 26.29 g) were achieved with W_1 at 15 DAS, 30 DAS and at harvest respectively. At 45 and 60 DAS the lowest dry matter weight plant^{-1} (4.65 g and 17.24 g) were found in W_4. Yadav (2004) reported that lowest weed dry matter and highest weed control efficiency were achieved under pre-emergence application of pendimethalin 0.5 kg ha^{-1} + 1 HW at 40 DAS.

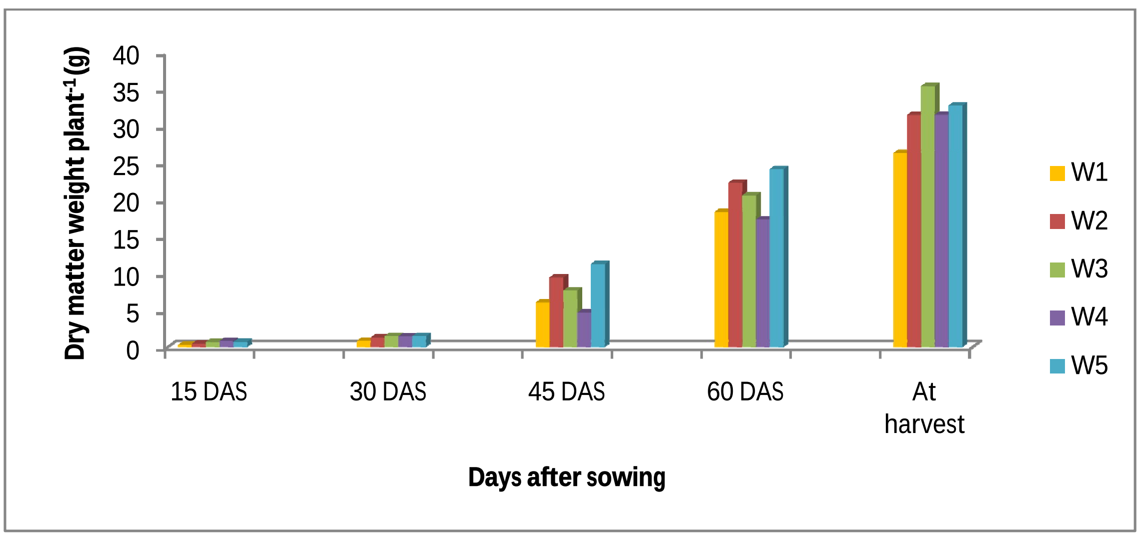

Figure 6. Effect of weed control methods on above ground dry matter weight Plant^{-1} of sesame at different days after sowing ($LSD_{0.05}$ = 0.09, 0.09 0.43, 1.67 and 1.43 at 15, 30, 45, 60 DAS and harvest, respectively)

W_1 =

W_2 = 1 hand weeding at 20 DAS

W_3 = 2 hand weeding at 20 and 40 DAS

W_4 = Pre emergence herbicide, Sunup spraying after land preparation

W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.2.3.3 Combined effect of variety and weed management

Significant influence was observed by combination of variety and weeding methods on above ground dry weight plant^{-1} (Table 6). Results indicated that the highest above ground dry weight plant^{-1} (0.87 g at 15 DAS) was observed in the treatment combination of V_2W_4 which was closely followed by V_1W_3 (0.73g), V_1W_4 (0.80 g) and V_2W_3 (0.78 g) whereas the lowest above ground dry weight plant^{-1} was obtained in V_3W_1 (0.06 g). At 30 DAS, V_3W_4 gave the highest (1.76g) above ground dry weight plant^{-1} which was similar with V_1W_5 (1.63 g), V_2W_3 (1.63 g) and V_3W_2 (1.63 g), But the lowest above ground dry weight plant^{-1} was obtained with V_3W_1 (0.75 g and 25.29 g at 30 DAS and at harvest) which was statistically similar with V_1W_1 (0.79 g at 30DAS and 25.60 at harvest) and V_2W_1 (0.88 g at 30 DAS and 28.0 g at harvest). At 45, 60 DAS and at harvest maximum above ground dry matter weight plant^{-1} (12.76 g, 25.83 g and 35.60 g) were obtained from V_2W_5 . .It might be due to application of Post emergence herbicide or hand weeding resulting in reduced crop weed competition that was associated with greater resource uptake and photo assimilate production at a time partitioning that leads to higher above ground dry matter production. Bennett *et al.* (2003) concluded that sufficient weed control increased sesame dry matter accumulation. The lowest above ground dry weight plant^{-1}(4.35 g) was obtained in V_1W_4 at 45 DAS which was statistically similar with V_2W_4 (4.86 g), V_3W_1 (5.13 g) and V_3W_4 (4.73 g). At 60 DAS lowest above ground dry weight plant^{-1}(16.67 g) was found in V_3W_4 which was statistically similar with V_1W_1 (17.93 g), V_1W_4 (16.93 g), V_2W_1 (19.33 g) V_2W_4 (18.24 g) and V_3W_1 (17.60 g). The results obtained from all other treatment combinations were significantly different compared to others.

Table 6. Combined effect of variety and weed management on above ground dry matter weight plant^{-1} (g) of sesame

Treatments	Dry matter weight plant^{-1} (g) at				
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**At Harvest**
V_1W_1	0.35 ef	0.79 h	5.99 hi	17.93 e-h	25.60 g
V_1W_2	0.53 cd	1.02 fg	9.04 de	22.29 b-d	29.16 f
V_1W_3	0.73 ab	1.34 cd	7.89 fg	19.997 d-f	35.13 a-c
V_1W_4	0.80 ab	1.34 cd	4.35 j	16.93 gh	29.80 ef
V_1W_5	0.67 bc	1.63 ab	11.12 b	24.39 ab	33.11 a-d
V_2W_1	0.40 d-f	0.88 gh	6.97 gh	19.33 d-h	28.00 fg
V_2W_2	0.54 cd	1.13 ef	10.49 bc	23.52 a-c	33.01 b-d
V_2W_3	0.78 ab	1.63 ab	8.26 ef	21.70 b-d	35.56 a
V_2W_4	0.87 a	1.16 ef	4.86 j	18.24 e-h	34.12 a-c
V_2W_5	0.69 bc	1.48 bc	12.76 a	25.83 a	35.60 a
V_3W_1	0.06 g	0.75 h	5.13 ij	17.60 f-h	25.29 g
V_3W_2	0.25 f	1.63 ab	8.70 ef	20.93 c-e	32.21 c-e
V_3W_3	0.41 de	1.41 cd	6.82 gh	19.97 d-g	35.39 ab
V_3W_4	0.696 bc	1.76 a	4.73 j	16.67 h	30.53 d-f
V_3W_5	0.65 bc	1.27 de	9.82 cd	22.07 b-d	29.47 f
LSD $_{(0.05\%)}$	0.17	0.16	1.08	3.07	2.98
CV (%)	16.42	7.12	5.66	8.38	4.67

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying 15 DAG

4.2.4 Number of leaves plant^{-1}

4.2.4.1 Effect of variety

At 15 DAS, the maximum number of leaves plant^{-1} (8.02) was obtained from V_2 which was statistically similar with V_3 and minimum number of leaves plant^{-1} (7.51) was obtained from V_1. At 30 DAS, the maximum number of leaves plant^{-1} (23.45) was obtained from V_3 and minimum number of leaves plant^{-1} (18.56) was obtained from V_1. At 45 DAS, the maximum number of leaves plant^{-1} (41.14) was obtained from V_3 and minimum number of leaves plant^{-1} (35.29) was obtained from V_2 which was statistically similar with V_1 (35.62)**.** At harvest the maximum number of leaves plant^{-1} (57.60) was obtained from V_1 and minimum number of leaves plant^{-1} (53.58) from V_3. Mahmud (2006) found the lowest number of leaves in BINA til-1 as compared to some sesame genotypes like SM-5, SM-9, SM-12, and SM-13.

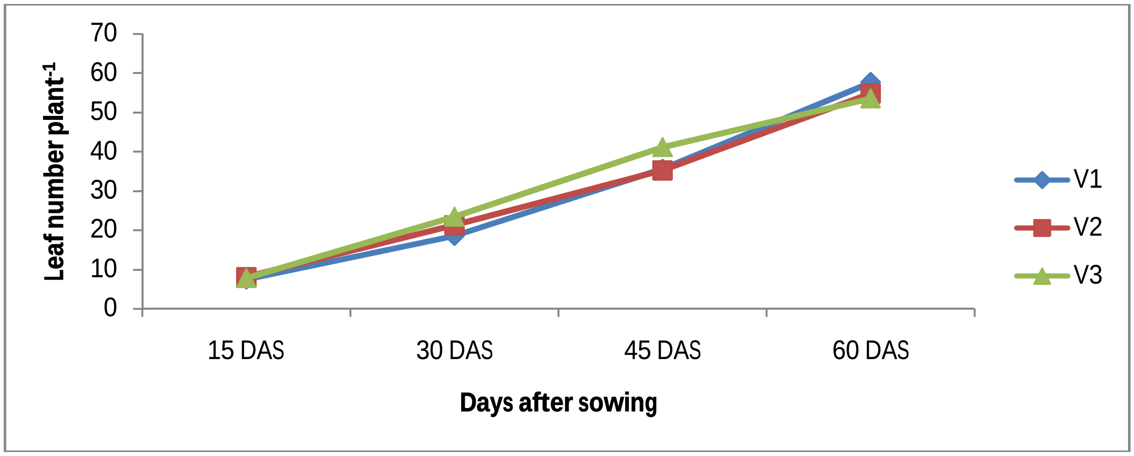

Figure 7. Effect of variety on the no. of leaves plant^{-1} of sesame at different days ($LSD_{0.05}$ = 0.52, 1.4, 2.15 and 1.56 at 15, 30, 45 and 60 DAS, respectively)

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

4.2.4.2 Effect of weed management

Leaves plant^{-1} was significantly influenced by number of weeding at all growth stages of sesame (Fig.7). The maximum number of leaves plant^{-1} (9.28, 26.04 and 68.93) was obtained from W_4 at 15, 30 and 60 DAS, respectively. At 45 DAS, the maximum number of leaves plant^{-1} (43.02) was obtained from W_3. The minimum number of leaves plant^{-1} (6.35, 16.01, 30.37 and 42.54) was obtained from W_1 at 15, 30, 45 and 60 DAS, respectively.

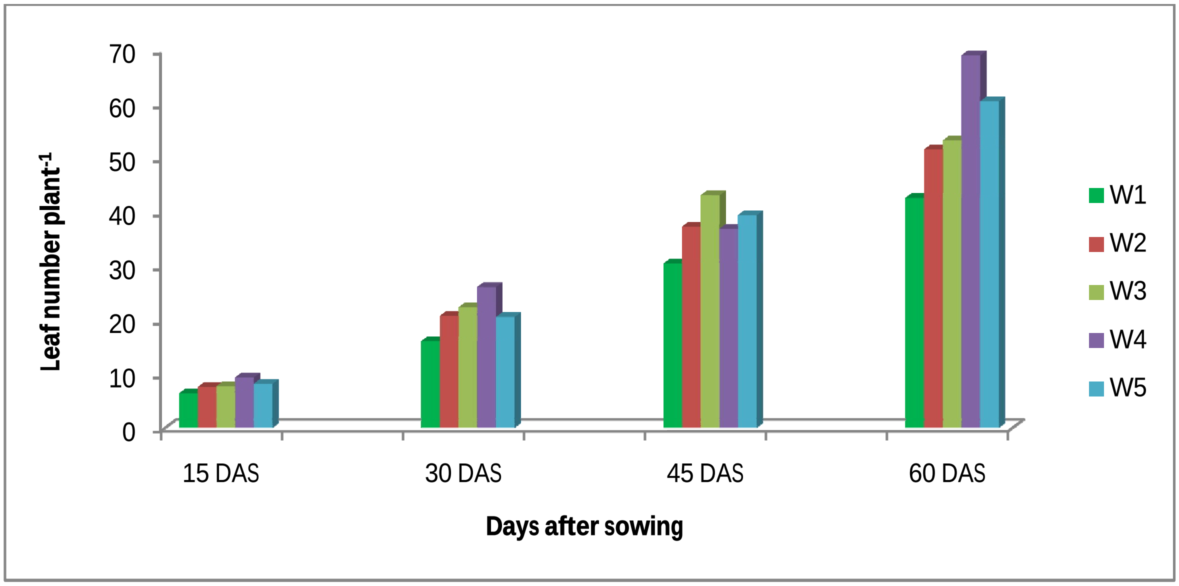

Figure 8. Effect of weeding on the no. of leaves plant^{-1} of sesame at different days ($LSD_{0.05}$ = 0.41, 1.27, 1.83 and 1.33 at 15, 30, 45 and 60 DAS, respectively)

W_1	=	No weeding
W_2	=	1 hand weeding at 20 DAS
W_3	=	2 hand weeding at 20 and 40 DAS
W_4	=	Pre emergence herbicide, Sunup spraying after land preparation
W_5	=	Post emergence herbicide, Release spraying at 15 DAG

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4.2.4.3 Combined effect of variety and weed management

Significant influence was observed by combination of variety and weeding methods on number of leaves plant^{-1} (Table 7). Results indicated that the highest number of leaves plant^{-1} (10.00 at 15 DAS) was observed in the treatment combination of V_2W_4 whereas the lowest number of leaves plant^{-1} (5.63) was obtained in V_1W_1. At 30 DAS, V_2W_4 gave the highest number of leaves plant^{-1} (28.26) which was statistically similar with V_1W_4 (26.40) but the lowest number of leaves plant^{-1} (11.06) was obtained with $V_1W_{1.}$ At 45 DAS the maximum number of leaves plant^{-1} (50.23) was obtained from V_2W_3 and the lowest number of leaves plant^{-1} (22.00) was obtained from V_2W_4 which was statistically similar with V_1W_1 (22.40). At 60 DAS highest number of leaves plant^{-1} (71.50) was found in V_1W_5 which was statistically similar with V_2W_4 (69.26) and the minimum number of leaves plant^{-1} (40.73) was obtained from V_3W_1 which was statistically similar with V_1W_1 (42.46). The results obtained from all other treatment combinations were significantly different compared to others.

4.2.5 Crop growth rate (CGR)

4.2.5.1 Effect of variety

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. The increase can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to variety shown in (Fig.9). There was trend to increase CGR with advancement of days up to 45-60 DAS and then declined. Under the present study, at 15-30 DAS, the highest CGR (4.23 g m^{-2} day^{-1}) was obtained from V_3 and lowest CGR (2.65 g m^{-2} day^{-1}) was obtained from V_2 which was statistically similar with V_3. At 30-45 DAS, the highest CGR (32.93 g m^{-2} day^{-1}) was obtained from V_2 and lowest CGR (25.23 g m^{-2} day^{-1}) was obtained from V_3 which was statistically similar with V_1. At 45-60 DAS, there was no significant difference within the varieties but statistically highest CGR (58.05 g m^{-2} day^{-1}) obtained from V_2 and lowest CGR (55.14 g m^{-2} day^{-1}) was obtained from V_3. At 60-90 DAS, highest CGR (25.66 g m^{-2} day^{-1}) was obtained from V_2 which was statistically similar with V_3 and lowest CGR (22.78 g m^{-2} day^{-1}) was obtained from V_1.

Table 7. Combined effect of variety and weed management on leaves number plant^{-1} of sesame at different days after sowing

Treatments	Leaf number plant^{-1}			
	15 DAS	30 DAS	45 DAS	60 DAS
V_1W_1	5.63 g	11.06 h	22.40 g	42.46 hi
V_1W_2	6.83 f	17.06 g	36.60 e	54.46 e
V_1W_3	7.13 ef	20.10ef	36.40 e	58.03 d
V_1W_4	9.00 b	26.40 ab	45.46 b	61.56 c
V_1W_5	8.96 b	18.20 fg	37.26 e	71.50 a
V_2W_1	6.70 f	16.56 g	27.23 f	44.43 gh
V_2W_2	7.86 c-e	20.20 ef	37.13 e	54.43 e
V_2W_3	8.26 bc	21.53 de	50.23 a	50.06 f
V_2W_4	10.00 a	28.26 a	22.00 g	69.26 a
V_2W_5	7.40 d-f	19.86 ef	39.86 c-e	55.60 de
V_3W_1	6.73 f	20.40 ef	41.50 c	40.73 i
V_3W_2	7.86 c-e	24.80 bc	37.90 de	45.63 g
V_3W_3	7.66 c-e	25.20 bc	42.43 bc	51.43 f
V_3W_4	8.86 b	23.46 cd	43.00 bc	66.03 b
V_3W_5	8.00 cd	23.40 cd	40.86 cd	64.10 bc
LSD $_{(0.05)}$	o.81	2.20	3.52	2.56
CV (%)	5.40	6.19	5.02	2.47

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

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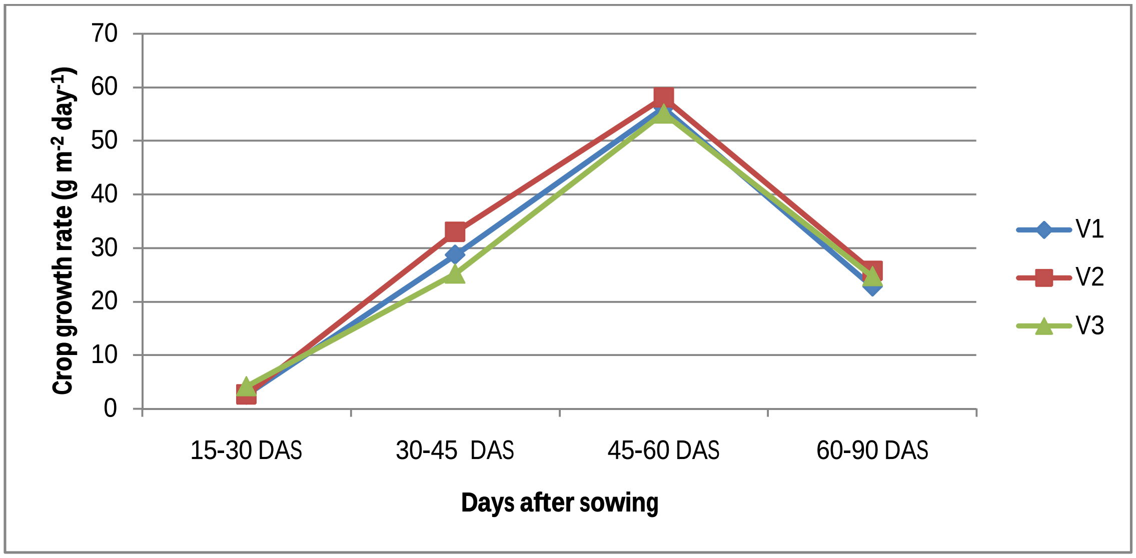

Figure 9. Effect of variety on the crop growth rate of sesame at different days ($LSD_{0.05}$ = 0.48, 2.03, NS and 1.56 at 15-30, 30-45, 45-60 and 60-90 DAS, respectively)

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

4.2.5.2 Effect of weed management

Significant variation was recorded for CGR due to weed management at all the stages except 40-60 DAS (Fig. 10). At 15-30 DAS, the maximum CGR (3.62 g plant^{-1}day^{-1}) was recorded from W_2 and W_3 which was statistically similar with W_5 while the minimum CGR (2.37 g plant^{-1} day^{-1}) in W_1 which was as per W_4. At 30-45 DAS, the highest value (43.44 g m^{-2} day^{-1}) was recorded from W_5 the lowest value of CGR (14.34 g m^{-2} day^{-1}) was recorded from W_4. At 45-60 DAS, there was no significant variation within the treatments but numerically W3 gave the highest CGR (57.33 g m^{-2} day^{-1}) and W_5 while the lowest CGR (54.48 g m^{-2} day^{-1}) was recorded from $W_{1.}$ At 60-90 DAS, highest CGR value (32.90 g m^{-2} day^{-1}) was recorded from W_3 which was statistically similar with W_4 and the lowest CGR (17.779 g m^{-2} day^{-1}) was recorded from W_1 which was statistically similar with W_5.

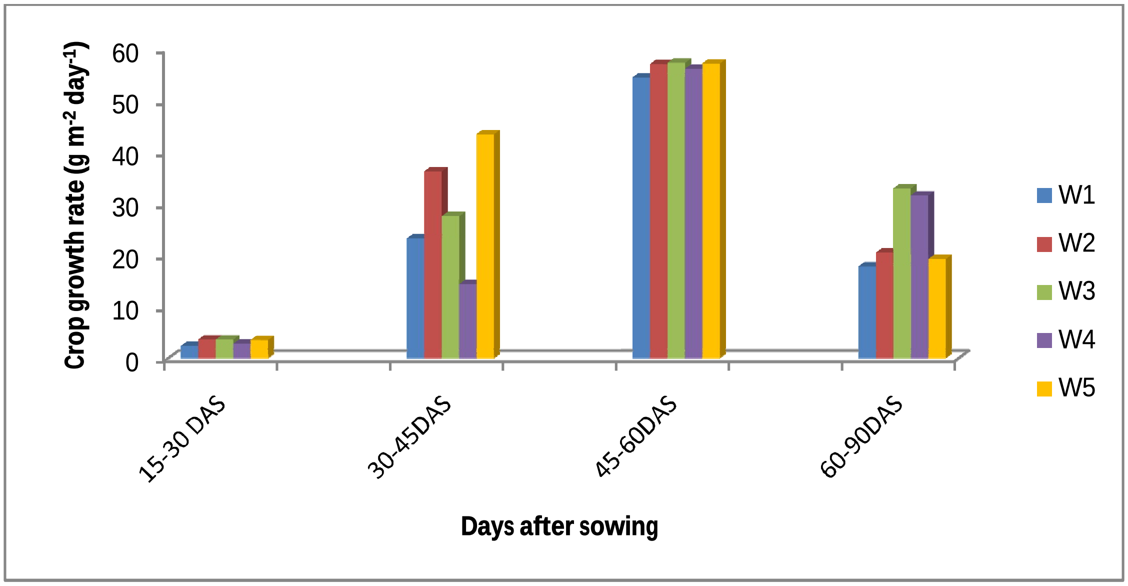

Figure 10. Effect of weeding on the crop growth rate of sesame at different days ($LSD_{0.05}$ = 0.58, 3.67, NS and 1.5 at 15-30, 30-45, 45-60 and 60-90 DAS, respectively)

W_1	=	No weeding
W_2	=	1 hand weeding at 20 DAS
W_3	=	2 hand weeding at 20 and 40 DAS
W_4	=	Pre emergence herbicide, **Sunup** spraying after land preparation
W_5	=	Post emergence herbicide, **Release** spraying at 15 DAG

4.2.5.3 Combined effect of variety and weed management

The combination of weed control treatments and variety significantly influenced the CGR throughout the growing period (Table 8). In most of the treatment combinations, CGR increased gradually up to 45-60 DAS and then declined. At the beginning of the crop growth (15-30 DAS), V_3W_2 showed the highest CGR (6.13 g m^{-2} day^{-1}) whereas the lowest CGR (1.29 g m^{-2} day^{-1}) was found in V_2W_4 which was as per V_1W_1, V_1W_2 and V_2W_1. At 30-45 DAS, V_2W_5 showed the highest CGR (50.13 g m^{-2} day^{-1}) and the lowest CGR (13.20 g m^{-2} day^{-1}) was obtained from V_3W_4 which was statistically similar with V_1W_4 and V_2W_4. At 45-60 DAS, there was no significant variation among the treatments. At 60-90 DAS, V_2W_4 gave the highest CGR value (35.28 g m^{-2} day^{-1}) which was statistically similar with V_1W_3 and V_3W_3 and the lowest CGR value (15.25g m^{-2} day^{-1})

was found in V_1W_2 which was similar to V_3W_1 and V_3W_5. The results obtained from all other treatment combinations were significantly different compared to others.

Table 8. Combined effect of variety and weed management on crop growth rate (CGR) of sesame at different days

Treatments	Crop growth rate ($gm^{-2}day^{-1}$)			
	15-30 DAS	**30-45 DAS**	**45-60 DAS**	**60-90 DAS**
V_1W_1	1.93 gh	23.14 fg	53.05	17.04 fg
V_1W_2	2.13 f-h	35.69 cd	58.87	15.25 g
V_1W_3	2.68 e-g	29.11 e	53.81	33.63 a
V_1W_4	2.39 fg	13.41 i	55.91	28.58 b
V_1W_5	4.25 bc	42.19 b	58.96	19.39 df
V_2W_1	2.12 f-h	27.04 ef	54.96	19.26 ef
V_2W_2	2.59 e-g	41.59 b	57.93	21.08 de
V_2W_3	3.75 b-d	29.47 e	59.75	30.80 b
V_2W_4	1.29 h	16.42 hi	59.496	35.28 a
V_2W_5	3.48 c-e	50.13 a	58.12	21.87 d
V_3W_1	3.06 d-f	19.48 gh	55.42	17097 fg
V_3W_2	6.13 a	31.44 de	54.37	25.06 c
V_3W_3	4.43 bc	24.03 f	58.44	34.27 a
V_3W_4	4.74 b	13.20 i	53.04	30.80 b
V_3W_5	2.77 d-g	37.99	54.44	16.45 g
LSD $_{(0.05\%)}$	1.01	4.79	NS	2.78
CV (%)	18.67	7.22	13.87	6.32

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.2.6 Relative growth rate (RGR)

4.2.6.1 Effect of variety

Relative growth rate is the increase of materials per unit of plant materials per unit of time. RGR was higher at early stage of growth and declined with time. At 15-30 DAS, highest RGR (0.09) was obtained from V_3 and lowest RGR (0.04) was obtained from V_2 which was statistically similar with V_1. At 30-45 DAS, the highest RGR (0.13) was obtained from V_2 which was statistically similar with V_1 and lowest RGR (0.11) was obtained from V_3. At 45-60 and 60-90 DAS, non-significant differences were obtained for relative growth rate (RGR) for different varieties. (Fig. 11).

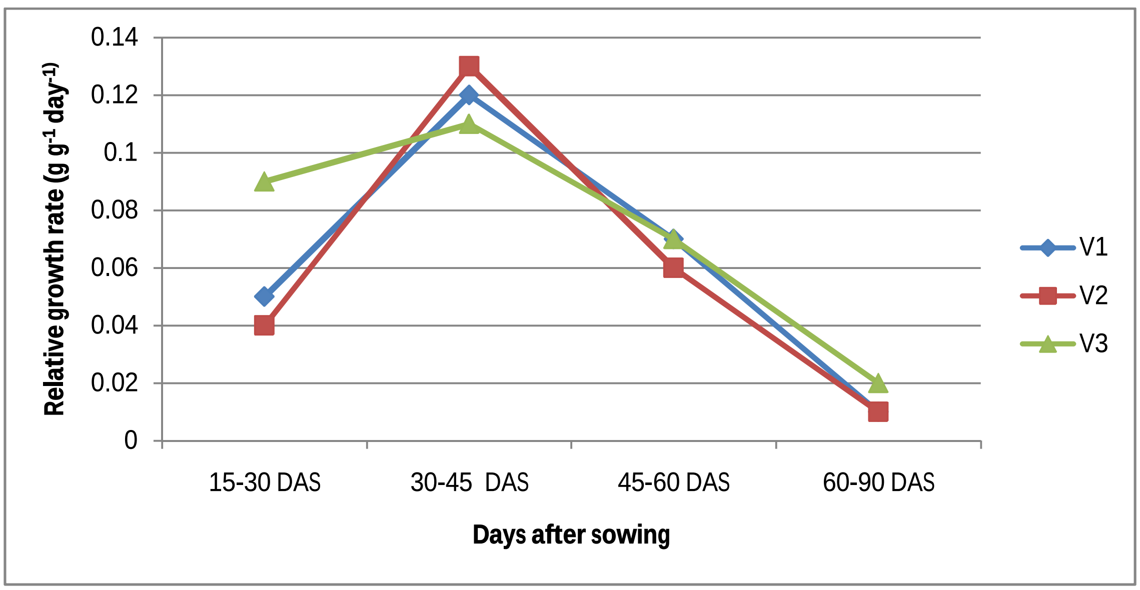

Figure 11. Effect of variety on the Relative growth rate of sesame at different days after sowing ($LSD_{0.05}$ =0.03, 0.01, NS and NS at 15-30, 30-45, 45-60 and 60-90 DAS, respectively)

V_1	=	BARI til 3
V_2	=	BARI til 4
V_3	=	Lal til (Local)

4.2.6.2 Effect of weed control treatments

Relative growth rate was significantly affected by different weed control treatments over time. At 15-30 DAS, the highest RGR (0.10 g g^{-1} day^{-1}) was obtained from W_1 and lowest RGR (0.04 g g^{-1} day^{-1}) was obtained from W_4. At 30-45 DAS, the highest RGR (0.14 g $g^{-1}day^{-1}$) was obtained from V_2 and V_5 which was statistically similar with V_1 and lowest RGR (0.07 g $g^{-1}day^{-1}$) was obtained from W_4. At 45-60 DAS, the highest RGR (0.09 g g^{-1} day^{-1}) was obtained from W_4 and lowest RGR (0.05 g g^{-1} day^{-1}) was obtained from W_5 which was statistically similar with W_2. At 60-90 DAS, the highest RGR (0.02 g g^{-1} day^{-1}) was obtained from W_3 and W_4 and lowest RGR (0.01 g g^{-1} day^{-1}) was obtained from W_1, W_2 and W_5.

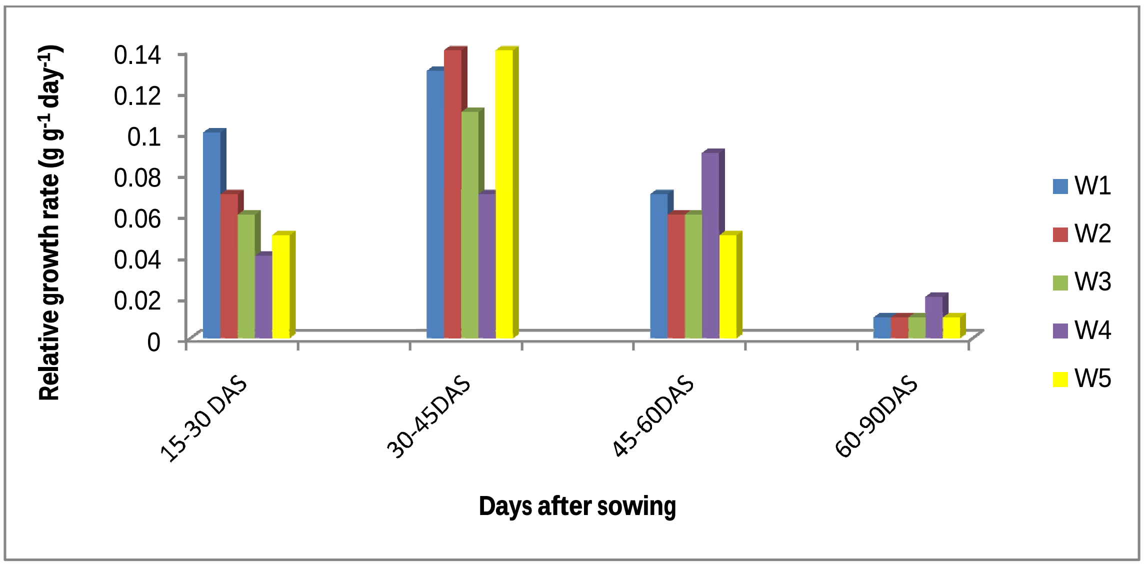

Figure 12. Effect of weeding on Relative growth rate of sesame at different days after sowing ($LSD_{0.05}$ = 0.03, 0.01, 0.01 and 0.01 at 15-30, 30-45, 45-60 and 60-90 DAS, respectively)

W_1	=	No weeding
W_2	=	1 hand weeding at 20 DAS
W_3	=	2 hand weeding at 20 and 40 DAS
W_4	=	Pre emergence herbicide, Sunup spraying after land preparation
W_5	=	Post emergence herbicide, Release spraying at 15 DAG

4.2.6.3 Combined effect of variety and weed management

RGR was significantly influenced by the combined effect of the weed control treatments and variety in all the dates of observations except 60-90 DAS (Table 9). Results showed that at 15-30 DAS, V_3W_1 gave the highest RGR (0.13 g g^{-1} day^{-1}) while the lowest RGR (0.02 g g^{-1} day^{-1}) was found in V_2W_4 which was as per V_1W_2 , V_1W_3, V_1W_4, V_1W_5 , V_2W_2, V_2W_3, V_3W_4 and V_3W_5 . At 30-45 DAS, the maximum RGR (0.07 g g^{-1} day^{-1}) was found in V_3W_4 which was closed to V_1W_2 , V_2W_1, V_2W_5 and V_3W_5 whereas the lowest result was observed in V_3W_4 (0.07 g g^{-1} day^{-1}). At 40-60 DAS, the highest RGR (0.09 g g^{-1} day^{-1}) was recorded from V_2W_4 which was statistically similar with V_3W_1 and V_3W_4 whereas the lowest result was obtained from V_2W_5 which was closed to V_1W_2 , V_1W_5, V_2W_2, V_3W_2 and V_3W_5.

4.3 Yield contributing parameters

4.3.1 Capsules plant^{-1} (no.)

4.3.1.1 Effect of variety

Number of capsules plant^{-1} is a key factor for determining the yield performance in oil seed plants. The productive capacity of sesame plant is ultimately considered by the number of capsules plant^{-1}. Table 10 showed that number of capsule plant^{-1} was significantly varied due to variety. Under the present study, V_2 produced the highest number of capsules plant^{-1} (69.80) as significantly different from other and V_3 had minimum value i.e. 45.86 capsules plant^{-1}. Second highest number of capsules plant^{-1} (50.64) was obtained from V_1.

4.3.1.2 Effect of weed management

Number of capsules plant^{-1} was significantly influenced by weed management at all growth stages of sesame (Table 10). It was observed from the present study that the increasing number of weeding significantly increased number of capsules plant^{-1}. W_3 produced maximum number of capsules plant^{-1} (70.88). Second highest number of capsules plant^{-1} (62.82) was obtained from W_4 followed by W_5 (54.62) and W_2 (50.77). The lowest number of capsules plant^{-1} was achieved with W_1 (38.06). Bhadauria *et al.*

(2012) found that two hand-weeding at 15 and 30 DAS resulted in significantly highest value in capsules plant^{-1}.

Table 9. Combined effect of variety and weed management on Relative growth rate ($g\ g^{-1}\ day^{-1}$) of sesame

Treatments	Relative growth rate ($g\ g^{-1} day^{-1}$) at			
	15-30 DAS	**30-45 DAS**	**45-60 DAS**	**60-90 DAS**
V_1W_1	0.08 bc	0.14 bc	0.07 b-d	0.01 cd
V_1W_2	0.04 cd	0.15 ab	0.06 d-g	0.01 d
V_1W_3	0.04 cd	0.12 de	0.06 d-f	0.02 ab
V_1W_4	0.03 cd	0.08 h	0.09 a	0.02ab
V_1W_5	0.06 cd	013 cd	0.05 fg	0.01 d
V_2W_1	0.05 cd	0.14 a-c	0.07 c-e	0.01cd
V_2W_2	0.05 cd	0.15 a	0.05 fg	0.01 cd
V_2W_3	0.05 cd	0.11 ef	0.06 d-f	0.02 a-c
V_2W_4	0.02 d	0.095 g	0.09 a	0.02 a
V_2W_5	0.05 cd	0.14 ab	0.05 g	0.01 d
V_3W_1	0.18 a	0.13 cd	0.08 a-c	0.01 cd
V_3W_2	0.13 b	0.11 ef	0.06 e-g	0.01 b-d
V_3W_3	0.09 bc	0.11 fg	0.07 b-d	0.02 ab
V_3W_4	0.06 cd	0.07 i	0.08 ab	0.02 a
V_3W_5	0.04 cd	0.18 a-c	0.05 fg	0.01 d
$LSD_{(0.05\%)}$	0.05	0.01	0.01	0.01
CV (%)	43.10	5.79	11.50	22.57

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.3.1.3 Combined effect of variety and weed management

Significant influence was observed by combined effect of variety and weed management on number of capsules plant^{-1} (Table 10). Results indicated that the highest number of capsules plant^{-1} (85.00) was observed in the treatment combination of V_2W_3 which was significantly similar with V_2W_4 (80.87). It may be due to efficiency of photosynthesis. Because of maximum uptake of water, nutrients and light by plants, increased photo assimilates allocation into reproductive parts that leads to increased capsules plant^{-1}. Serogy (1992) and Zubair *et al.*, (2011) found similar result. The lowest number of capsules plant^{-1} was obtained with V_3W_1 (29.73) which was statistically similar with V_1W_1 (30.46). The results obtained from all other treatment combinations were significantly different compared to other treatments.

4.3.2 Seeds capsule^{-1}(no.)

4.3.2.1 Effect of variety

Number of seeds capsule^{-1} is considered an important factor that directly imparts in exploiting potential yield recovery in oil seed crops. Data regarding number of seeds capsule^{-1} given in Table 10 stated that different variety had a significant effect on the number of seeds capsule^{-1}. Under the present study, the highest number of seeds capsule^{-1} (78.20) was achieved by V_2 where as the lowest number of seeds capsule^{-1} was observed in V_3 (45.00).

4.3.2.2 Effect of weed management

Results presented in Table 10 on number of seeds capsule^{-1} influenced by number of weeding were statistically significant. It is evident from the present study that the highest number of seeds capsule^{-1} (72.00) was recorded in W_3 which was statistically similar with W_4 (68.33) and the lowest number of seeds capsule^{-1} was achieved by W_1 (45.33). The second highest number of seeds capsule^{-1} (59.66) was obtained from W_5 which was statistically similar with W_2 (54.00).

4.3.2.3 Combined effect of variety and weed management

Table 10 showed statistically significant results from the combined effect of variety and weeding methods on number of seeds capsule^{-1}. Results indicated that the highest number of seeds capsule^{-1} (97.00) was observed in the treatment combination of V_2W_3 and V_2W_4 respectively. On the other hand, the lowest number of seeds capsule^{-1} was obtained with V_3W_1 (38.00) which was statistically similar with V_1W_1 (45.00), V_3W_2 (42.00), V_3W_4 (48.00) and V_3W_5 (45.00) but significantly different from all other treatment combinations.

4.3.3 Weight of 1000 seeds (g)

4.3.3.1 Effect of variety

Among the various parameters contributing towards final yield of a crop, 1000-seeds weight is of most importance. Data presented in Table 10 stated that weight of 1000-seeds was significantly influenced by different variety. Under the present study, the highest 1000- seeds weight (3.18 g) was achieved by V_2 where the lowest was achieved by V_3 (2.56 g). The results obtained from V_1 showed intermediate results compared to highest and lowest 1000- seeds weight.

4.3.3.2 Effect of weed management

Results presented in Table 10 on 1000- seeds weight influenced by number of weeding were statistically significant. It is evident from the present study that the highest 1000-seed weight (3.30 g) was recorded in W_3 which was statically similar with W_4 (3.18), whereas the lowest 1000- seed weight was achieved by W_1 (2.41 g). The second highest 1000-seed weight obtained from W_5 (2.86 g) followed by W_2 (2.63 g). Islam *et al.* (2014) mentioned that the highest 1000-seed weight was recorded in the weed free conditions followed by single weeded condition.

4.3.3.3 Combined effect of variety and weed management

Table 10 showed statistically significant results influenced by combined effect of variety and weeding methods on 1000- seed weight. Results indicated that the maximum 1000-seed weight (3.90 g) was observed in the treatment combination of V_2W_4 which was significantly different from all other treatment combinations. The highest 1000- seed weight with application of pre emergence herbicide or two hand weeding might be due to increased in growth that was associated with greater resource uptake and photo assimilate production finally translocation to the reproductive organ. On the other hand, the lowest 1000- seeds weight was obtained with V_3W_1 (2.23 g) which was as per with V_1W_1 (2.46), V_1W_2 (2.56), V_2W_1 (2.53), V_3W_2 (2.33) and V_3W_5 (2.50).

4.4 Yield parameters

4.4.1 Seed yield (t ha^{-1})

4.4.1.1 Effect of variety

Dry matter production and its translocation into economic parts is the ultimate outcome of various physiological, biochemicals, phenological and morphological events occurring in the plant system is seed yield. Seed yield of a variety is the result of interplay of its genetic makeup and environmental factors in which plant grow. Seed yield was not significantly influenced by different variety (Table 11). Under the present study, numerically the highest seed yield (0.95 t ha^{-1}) was achieved by V_2 where as the lowest was achieved by V_3 (0.90 t ha^{-1}).

4.4.1.2 Effect of weeding

Results presented in Table 11 on seed yield influenced by number of weeding were statistically significant. The highest seed yield (1.51 t ha^{-1}) was recorded in W_3 while the lowest seed yield was achieved by W_1 (0.41 t ha^{-1}). The results from W_4 (1.05) on seed yield also gave encouraging result. Narkhede *et al.* (2000) observed that two hand weeding and hoeing in sesame significantly gave higher seed yield than rest of the integrated weed management practices.

4.4.1.3 Combined effect of variety and weed management

Table 11 showed statistically significant results influenced by the combined effect of variety and weeding methods on seed yield. Results indicated that the highest seed yield (1.73 t ha^{-1}) was observed in the treatment combination of V_2W_3. This might be due to

Table 10. Effect of variety, weed management and their combination on yield contributing characters of sesame

Treatments	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	1000-seeds weight (g)
Effect of variety			
V_1	50.64 b	56.40 b	2.90 b
V_2	69.80 a	78.20 a	3.18 a
V_3	45.86 c	45.00 c	2.56 c
LSD $_{(0.05)}$	3.46	4.79	0.24
CV%	5.19	8.19	8.27
Effect of weed management			
W_1	38.06 e	45.33 c	2.41 d
W_2	50.77 d	54.00 b	2.63 c
W_3	70.88 a	72.00 a	3.30 a
W_4	62.82 b	68.33 a	3.18 a
W_5	54.62 c	59.66 b	2.86 b
LSD $_{(0.05)}$	3.53	6.40	0.19
CV%	6.69	10.99	7.12
Interaction effect of Variety and weed management			
V_1W_1	30.46 g	45.00 f-h	2.46 ef
V_1W_2	48.13 de	55.00 d-f	2.56 ef
V_1W_3	63.33 b	67.00 c	3.40 b
V_1W_4	56.66 c	60 c-e	3.06 b-d
V_1W_5	55.33 c	55.00 d-f	3.00 cd
V_2W_1	54.00 cd	53.00 e-g	2.53 ef
V_2W_2	63.33 b	65.00 c-d	3.00 d
V_2W_3	85.00 a	97.00 a	3.36 bc
V_2W_4	80.87 a	97.00 a	3.90 a
V_2W_5	66.00 b	79.00 b	3.10 b-d
V_3W_1	29.73 g	38.00 h	2.23 f
V_3W_2	40.86 f	42.00 gh	2.33 ef
V_3W_3	64.33 b	52.00 e-g	3.13 b-d
V_3W_4	51.13 cd	48.00 f-h	2.60 e
V_3W_5	42.53 ef	45.00 f-h	2.50 ef
LSD $_{(0.05\%)}$	6.42	11.03	0.39
CV (%)	6.69	10.99	7.12

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

prolonged weed free crop growth produced higher number of capsules plant^{-1}, seeds capsule^{-1} and 1000 seed weight that leads to higher seed yield. Serogy(1992), Zewdie (1996), Shamna and Mishra (1997), Narkhede *et al.*(2000) and Amare *et al.* (2009) reported a higher seed yield in sesame under prolonged weed free conditions after crop emergence. The lowest seed yield was obtained with V_3W_1 (0.37 t ha^{-1}) which was also significantly similar with V_1W_1 (0.42 t ha^{-1}) and V_2W_1 (0.45 t ha^{-1}) but different from all other treatment combinations.

4.4.2 Stover yield (t ha^{-1})

4.4.2.1 Effect of variety

There was significant variation observed for stover yield due to variety (Table 11). The higher stover yield (6.89 t ha^{-1}) was recorded from V_1 and the lower Stover yield (6.0 t ha^{-1}) from V_2 which was statistically similar with V_3 (6.25 t ha^{-1}).

4.4.2.2 Effect of weed management

Stover yield of sesame varied significantly due to different weed managements (Table 11). The highest Stover yield (7.81 t ha^{-1}) was observed from W_3 followed by W_4 (7.01 t ha^{-1}) and W_5 (6.47 t ha$^{-1)}$ while the lowest Stover yield (4.73 t ha^{-1}) recorded from W_1.

4.4.2.3 Combined effect of variety and weed managements

The stover yield varied significantly due to different variety and weed managements combinations (Table 11). The highest stover yield (8.43 t ha^{-1}) was observed from V_1W_3 followed by V_1W_4 (7.62 t ha^{-1}) and V_3W_3 (7.62 t ha^{-1}) those were statistically similar with V_2W_3 (7.40 t ha^{-1}) and V_1W_5 (7.20 t ha^{-1}) this might be due to prolonged weed free period at early stage of crop growth leads to better vegetative growth thus increased stover yield. Whereas the lowest Stover yield (4.30 t ha^{-1}) from V_2W_1 (4.74 t ha^{-1}) which was similar with V_1W_1 (4.74 t ha^{-1}).

4.4.3 Biological yield (t ha^{-1})

4.4.3.1 Effect of variety

Biological yield is the total biomass of the above ground plant parts including economic and uneconomic portions of a crop. It represents the total dry matter accumulation capacity of a crop and is a combination of its vegetative and reproductive parts. The productivity of a crop is largely determined by the biological yield. Under the present study, the highest biological yield (7.84 t ha^{-1}) was achieved by V_1 where as the lowest was recorded in V_2 (6.92 t ha^{-1}) which was statistically similar with V_3 (7.15 t ha^{-1}).

4.4.3.2 Effect of weeding

Biological yield was significantly influenced by number of weeding (Table 11). It is evident from the present study that the increasing number of weeding significantly increased biological yield. The maximum biological yield (9.33 t ha^{-1}) was recorded in W_3 and the minimum biological yield was achieved by W_1 (5.15 t ha^{-1}). The second highest biological yield (8.07 t ha^{-1}) was obtained from W_4 followed by W_5 (7.37 t ha^{-1}) and W_2 (6.62 t ha^{-1}). Dhaka *et al.*(2013) showed that two hand weeding treatments produced the maximum biological yield of sesame over rest of the treatments except two hand weeding and alachlor at 1.5 kg/ha + HW at 30 DAS.

4.4.3.3 Combined effect of variety and weed management

Table 11 showed statistically significant results influenced by interaction between variety and weed management on biological yield. Results indicated that the highest biological yield (9.89 t ha^{-1}) was observed in the treatment combination of V_1W_3 which was significantly different from other treatment combinations. On the other hand, the lowest biological yield was obtained from V_2W_1 (4.76 t ha^{-1}) which was statistically similar with V_1W_1 (5.17 t ha^{-1}). The highest biological yield obtained in plots subjected to no weed competition was due to better plant growth and biomass production under weed free conditions. These results are supported by the findings of Muhammad and Ahmad (1999) who got minimum biological yield from those plots where weed competition was prolonged up to 50 days after emergence in mungbean.

4.4.4 Harvest index (%)

4.4.4.1 Effect of variety

Harvest index is a measure of physiological productivity potential of a crop variety. It is the ability of a crop plant to convert the dry matter into economic yield. The calculated values of Harvest index presented in Table 11 indicated that variety differed significantly on account of conversion efficiency of assimilates. The maximum value of harvest index (12.63%) was achieved by V_2 which was statistically similar with V_3 (12.13%) whereas the lowest was achieved by V_1 (11.72%). Chowdhury (2005) showed that BINA TIL-1 exhibited higher harvest index and local variety (T-6) exhibited lower harvest index.

4.4.4.2 Effect of weeding

Harvest index was significantly influenced by weeding (Table 11). It stated from the present study that the highest harvest index (16.25%) was recorded in W_3 and the lowest harvest index was achieved by W_1 (8.19%). The second highest harvest index was obtained from W_4 (13.14%) followed by W_5 (12.12%) and W_2 (11.09%).

4.4.4.3 Combined effect of variety and weed management

Table 11 showed statistically significant results influenced by interaction between variety and weeding on harvest index. Results indicated that the highest harvest index (18.97%) was observed in the treatment combination of V_2W_3 which was significantly different from all other treatment combinations due to prolonged weed free condition produced highest seed yield and biological yield which determined harvest index. On the other hand, the lowest harvest index (6.79%) was obtained from V_3W_1 which was significantly similar with V_1W_1 (8.25%) but different from all other treatment combinations. The results obtained from all other treatment combinations were significantly different compared to highest and lowest harvest index.

Table 11. Effect of variety, weed management and their combination on yields and harvest index of sesame

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha-1)	Biological yield (t ha^{-1})	Harvest Index (%)
Effect of Variety				
V_1	0.91 a	6.89 a	7.84 a	11.72 b
V_2	0.95 a	6.00 b	6.92 b	12.63 a
V_3	0.90 a	6.25 b	7.15 b	12.13 ab
LSD $_{(0.05)}$	NS	0.42	0.43	0.90
CV (%)	6.85	6.50	5.75	7.26
Effect of weed management				
W_1	0.41 e	4.73 e	5.15 e	8.19 e
W_2	0.73 d	5.87 d	6.62 d	11.09 d
W_3	1.51 a	7.81 a	9.33 a	16.25 a
W_4	1.05 b	7.01 b	8.07 b	13.14 b
W_5	0.89 c	6.47 c	7.37 c	12.12 c
LSD $_{(0.05)}$	0.05	0.37	0.38	0.78
CV (%)	5.21	5.95	5.29	6.61
Interaction effect of Variety and weed management				
V_1W_1	0.42 j	4.74 hi	5.17 fg	8.25 fg
V_1W_2	0.87 gh	6.48 cd	7.36 d	11.87 c
V_1W_3	1.45 b	8.43 a	9.89 a	14.73 b
V_1W_4	0.97 ef	7.62 b	8.59 bc	11.33 cd
V_1W_5	1.02 e	7.20 b	8.22 c	12.44 c
V_2W_1	0.45 j	4.30 i	4.76 g	9.53 ef
V_2W_2	0.63	5.63 e-g	6.27 e	10.15 de
V_2W_3	1.73 a	7.40 b	9.13 b	18.97 a
V_2W_4	0.92 fg	6.40 cd	7.32 d	12.60 c
V_2W_5	0.84 gh	6.26 de	7.10 d	11.87 c
V_3W_1	0.37 j	5.15 gh	5.53 f	6.79 g
V_3W_2	0.70 i	5.51 eg	6.21 e	11.26 cd
V_3W_3	1.35 c	7.62 b	8.97 b	15.06 b
V_3W_4	1.26 d	7.03 bc	8.29 c	15.49 b
V_3W_5	0.81 h	5.96 d-f	6.77 de	12.05 c
LSD $_{(0.05)}$	0.09	0.70	0.72	1.49
CV (%)	5.21	5.95	5.29	6.61

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

4.4.5 Economic performance of different combination of variety and weeding methods

This economic analysis stated the performance of weed control methods. Cost of production mainly varied due to weed management. As number of labors varied differently with weed management treatments. No weeding, one hand weeding, two hand weeding required 0, 28 and 56, respectively number of labor(s) for one hectare of land when herbicide spraying with Release 9 EC and Sunup 480 SL required only three labors in each case. The highest cost of production was (Tk. 62095.00 ha^{-1}) for the treatment V_1W_3 (two hand weeding) and the lowest cost of production was (Tk. 43360.00) for the treatment V_3W_1 (Table 12). It might be due to higher number of labors was required in case of two hand weeding than herbicide application.

4.4.5.1 Gross return

The highest gross return (Tk. 160600 ha^{-1}) was obtained from the treatment V_2W_3 (two hand weeding with BARI til-4) and the lowest gross return (Tk. 43200ha^{-1}) was obtained from treatment V_3W_1 (no weeding with local variety Lal til).The second highest gross return (Tk. 141290 ha^{-1}) was obtained from V_1W_3. In present study highest yield was obtained from V_2W_3 treatment which is responsible for obtained highest gross return from this treatment.

4.4.5.2 Net return

Net return varied in different weed control treatments (Table 12). The highest net return (Tk. 98980ha^{-1}) was obtained from the treatment V_2W_3. The second highest net return (Tk. 79159 ha^{-1}) was obtained from the treatment V_1W_3. Lowest net return (Tk. 840 ha^{-1}) was achieved from V_3W_1. It might be due to highest gross return and highest cost of production was obtained from this treatment.

4.4.5.3 Benefit cost ratio

Benefit cost ratio is the ratio of gross return and cost of production**.** It was varied in different weed control treatments. Two hand weeding treated plots gave the higher BCR ranged from 2.21-2.60 than the other treatments. Two hand weeding with BARI til-4 gave the highest BCR (2.60). It might be due to highest gross return and highest cost of production was obtained from this treatment. The treatment V_1W_1 showed the lowest BCR (1.06).

Table 12. Cost of production, return and Benefit cost ratio (BCR) of sesame under different treatments

Treatments	Cost of production (Tk ha^{-1})			Gross return (TK. ha^{-1})			Gross margin (Tk ha^{-1})	BCR
	Fixed cost	Weeding cost	Total	From grain	From straw	Total		
V_1W_1	45295	0	45295	33600	14220	47820	2525	1.06
V_1W_2	45295	8400	58795	69600	19440	89040	35345	1.65
V_1W_3	45295	16800	62095	116000	25290	141290	79195	2.28
V_1W_4	45295	3490	48785	77600	22860	100460	51675	2.05
V_1W_5	45295	2980	48275	81600	21600	103200	54925	2.14
V_2W_1	44820	0	44820	36000	12900	48900	4080	1.09
V_2W_2	44820	8400	58320	50400	16890	67290	8970	1.15
V_2W_3	44820	16800	61620	138400	22200	160600	98980	2.60
V_2W_4	44820	3490	48310	73600	19200	92800	44490	1.92
V_2W_5	44820	2980	47800	67200	18780	85980	38180	1.79
V_3W_1	42360	0	43360	27750	15450	43200	840	1.00
V_3W_2	42360	84000	56860	52500	16530	69030	12170	1.21
V_3W_3	42360	16800	59160	108000	22860	130860	71700	2.21
V_3W_4	42360	3490	46850	94500	21090	115590	68740	2.46
V_3W_5	42360	2980	46340	60750	17880	78630	32290	1.70

V_1 = BARI til 3
V_2 = BARI til 4
V_3 = Lal til (Local)

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, Sunup spraying after land preparation
W_5 = Post emergence herbicide, Release spraying at 15 DAG

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2014 to find out the influence of different variety along with weed control methods on the growth and yield of sesame.

The experiment was laid out in a split plot design having 3 replications. The unit plot size was 3.6 m^2 (2m×1.8m) and the total numbers of plots were 45. The experiment comprised with two factors viz. (1) Variety and (2) weed management. Three variety (V_1 = BARI til- 3, V_2 = BARI til - 4, V_3 = Lal til) and five weeding treatments no weeding (W_1), one hand weeding at 20 DAS (W_2), two hand wedding at 20 DAS and 40 DAS (W_3), Sunup 480 SL (Glyphoset) @ 3.7 l ha^{-1} (W_4) and Release 9 EC (Phenoxprop-p-ethayel) @ 650 ml ha^{-1}(W5). Sunup 480 SL, a pre-emergence herbicide was applied after final land preparation. Relese 9 EC, a post-emergence herbicide was applied at 15-20 DAS when weeds were 2-3 leaf stge. There were 15 treatment combinations. Variety was placed along the main plot and weeding methods were placed along the sub plot. Data on different growth, yield contributing characters and yield were recorded from the experimental field and analyzed statistically.

The data on weed parameters were collected from 20 DAS to harvest. Weed parameters such as total weed population (no. m^{-2}); weed biomass (g m^{-2}) were examined. The data on growth parameters viz. plant height, above ground dry matter weight $plant^{-1}$, branches $plant^{-1}$, no. of leaves $plant^{-1}$, crop growth rate (CGR) and relative growth rate (RGR) were recorded during the period from 15 DAS to harvest. Yield contributing characters and yield parameters like number of capsules $plant^{-1}$, no. seeds $capsule^{-1}$, 1000 seeds weight, seed yield, stover yield, and biological yield and harvest index were recorded.

10 weed species infested the experimental plots belonging to eight families were found to infest the experimental crop. The most important weeds of the experimental plots were *Eleusine indica, Cyperus rotundus, Cynodon dactylon, Digitaria sanguinalis,*

Alternanthera philoxeroides, respectively. Weed density, relative weed density and weed biomass were significantly influenced by the weed control treatments.

Results revealed that variety of sesame like BARI til- 4 stand superior than other in respect of branches plant^{-1}, dry matter content plant^{-1}, no. of leaves plant^{-1}, no. of capsules plant^{-1}, seeds capsule^{-1}, 1000 seeds weight, seed yield, stover yield, harvest index. Among the weed management practices, the highest plant height, dry matter content plant^{-1} and no. of leaves plant^{-1} was obtained by the application of pre emergence herbicide at land preparation time (W_4) while maximum result of yield contributing characters and yield parameter was obtained from two hand weeding treatment (W_3).

In combination, it was observed that the lowest number of weed species and total number of weeds m^{-2} was found in V_1W_3 (two hand weeding at 20 DAS and 40 DAS respectively). On the other hand the highest number of weed species and total number of weeds m^{-2} was obtained from V_3W_1. Different weed control treatments had significant effect on crop growth parameters viz. The highest plant height (17.54cm, 104.10cm) was observed in V_2 with pre emergence herbicide for weed management (V_2W_4). At 45 DAS, the highest no. of branches plant^{-1} (2.83) was observed in V_2W_5. At 60 DAS, maximum no. of branches plant^{-1} (10.70) was observed with V_1W_2. But at harvest, the highest no. of branches plant^{-1} (4.27) was found in V_2W_4. the highest above ground dry weight plant^{-1} (0.87 g at 15 DAS) was observed in the treatment combination of V_2W_4, At 30 DAS, V_3W_4 gave the highest above ground dry weight plant^{-1} (1.76g), At 45, 60 DAS and at harvest maximum AGDM weight plant^{-1} (12.76 g, 25.83 g and 35.60 g) were obtained from V_2W_5 .. The highest number of leaves plant^{-1} (10.00 at 15 DAS) was observed in the treatment combination of V_2W_4. At 30 DAS, V_2W_4 gave the highest number of leaves plant^{-1} (28.26), the maximum number of leaves plant^{-1} (50.23) was obtained from V_2W_3 at 45 DAS. At 15-30 DAS, V_3W_2 showed the highest CGR (6.13 g m^{-2} day^{-1}), At 30-45 DAS, V_2W_5 showed the highest CGR (50.13 g m^{-2} day^{-1}), At 45-60 DAS, there was no significant variation among the treatments. At 60-90 DAS, V_2W_4 gave the highest CGR value (35.28 g m^{-2} day^{-1}). At 15-30 DAS, V_3W_1 gave the highest RGR (0.13 g g^{-1} day^{-1}). At 30-45 DAS, the maximum RGR (0.07 g g^{-1} day^{-1}) was found in V_3W_4. At 40-60 DAS, the highest RGR (0.09 g g^{-1} day^{-1}) was recorded from V_2W_4. Variety and weed control treatments had significant effect on the yield and yield contributing characters viz. highest capsule $plant^{-1}$, seed yield and harvest index were obtained from V_2W_3 that means BARI til-4 and two hand weeding. No. of seeds $capsule^{-1}$ was obtained from V_2W_3 and V_2W_4 treatments that means BARI til-4 and two hand weeding and BARI til-4 with the application of pre emergence herbicide at land preparation time. The highest 1000 seeds weight was obtained from V_2W_4 treatment combination (BARI til-4 with the application of pre emergence herbicide at land preparation time). The highest biological yield and stover was obtained from V_1W_3 (BARI til-3 with Release 9EC herbicide application). It was observed that sesame variety BARI til-4 coupled with two hand weeding at 20 DAS and 40 DAS (V_2W_3) emerged as economically viable treatment for better yield with maximum BCR (2.60).

CONCLUSION

It may be concluded that among the sesame varieties BARI til-4 with two hand weeding at 20 & 40 DAS could be a better treatment for improved yield of sesame.

RECOMMENDATION

This type of experiment could be taken in different sesame growing areas under different growing condition of Bangladesh for further testing the treatment performances.

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APPENDICES

Appendix I. Characteristics of experimental soil was analyzed at soil resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	***Characteristics***
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Levels in the soil plot**
pH	5.9
N	0.071%
K	0.31 meq/100g soil
Ca	6.36 meq/100g soil
P	14.04 µg/g soil
S	15.16 µg/g soil
B	0.30 µg/g soil

Source: Soil Resource Development Institute (SRDI)

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period of March, 2014 to July 2014

Month	Air temperature (^0C)		Relative humidity (%)		Rainfall (mm) (total)
	Maximum	Minimum	Maximum	Minimum	
March, 2014	37.4	20.2	80.2	32.4	3.80
April, 2014	39.4	19.4	80.2	39.2	65.60
May, 2014	38.2	19.3	89.2	40	202
June, 2014	37.2	17.4	88.4	46.3	282.7
July, 2014	35.6	18.2	88.2	55.4	107.8

Source: SAU Meterological Yard, Sher-e Bangla Nagar, Dhaka-1207.

Appendix III. Effect of variety and weed management on plant height (cm) of sesame at different days

Source of variance	Degrees of Freedom	Mean square				
		15DAS	30DAS	45DAS	60DAS	At harvest
Replication	2	3.248	64.699	5.452	2.10	33.23
Variety (V)	2	7.276	127.112	55.413	479.26	246.52
Error (a)	4	4.603	113.918	5.177	48.48	14.27
Weeding (W)	4	55.017	294.857	457.282	1124.88	1405.81
V × W	8	6.460	30.750	109.866	515.08	95.06
Error (b)	24	5.057	67.481	5.223	12.67	22.87

Appendix IV. Effect of variety and weed management on branches plant^{-1} of sesame at different days

Source of variance	Degrees of Freedom	Mean square		
		45DAS	60DAS	At harvest
Replication	2	0.005	0.106	0.054
Variety (V)	2	2.824	6.893	0.032
Error (a)	4	0.026	0.052	0.060
Weeding (W	4	0.390	15.014	1.325
V × W	8	0.740	8.170	0.693
Error (b)	24	0.027	0.126	0.039

Appendix V. Effect of variety and weed management on above ground dry matter weight plant^{-1} (g) of sesame at different days

Source of variance	Degrees of Freedom	Mean square				
		15DAS	30DAS	45DAS	60DAS	At harvest
Replication	2	0.009	0.016	0.371	1.389	2.112
Variety (V)	2	0.267	0.081	10.060	19.880	36.172
Error (a)	4	0.009	0.008	0.721	2.786	4.030
Weeding (W)	4	0.377	0.693	61.781	70.298	97.745
V × W	8	0.019	0.174	0.893	0.904	6.894
Error (b)	24	0.009	0.008	0.195	2.953	2.164

Appendix VI. Effect of variety and weed management on No. of leaves plant^{-1} of sesame at different days

Source of variance	Degrees of Freedom	Mean square			
		15 DAS	30 DAS	45 DAS	60 DAS
Replication	2	0.888	3.975	14.453	3.478
Variety (V)	2	1.077	89.93	161.729	64.102
Error (a)	4	0.264	1.895	4.52	2.378
Weeding (W)	4	10.117	117.616	191.289	885.751
V × W	8	1.289	20.239	197.238	39.540
Error (b)	24	0.177	1.707	3.519	1.871

Appendix VII. Effect of variety and weed management on CGR (g plant^{-1} day^{-1}) of sesame at different days

Source of variance	Degrees of Freedom	Mean square			
		30-15 DAS	45-30 DAS	60-45 DAS	90-60 DAS
Replication	2	0.299	5.20	47.654	1.234
Variety (V)	2	12.248	223.06	32.813	32.384
Error (a)	4	0.227	13.11	36.745	2.370
Weeding (W)	4	2.890	1150.29	12.712	470.650
V × W	8	4.130	12.33	16.704	28.159
Error (b)	24	0.353	4.37	61.293	2.378

Appendix VIII. Effect of variety and weed management on yield contributing characters of sesame

Source of variance	Degrees of Freedom	Mean square		
		Capsules plant^{-1}	Seeds capsule^{-1}	1000 seeds weight (g)
Replication	2	28.42	309.27	0.148
Variety (V)	2	2406.74	4268.60	1.446
Error (a)	4	8.26	24.07	0.056
Weeding (W	4	1389.16	1045.30	1.243
V × W	8	40.38	186.85	0.161
Error (b)	24	13.75	43.30	0.042

Appendix IX. Effect of variety and weed management on yields and harvest index of sesame

Source of variance	Degrees of Freedom	Mean square			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.001	0.157	0.187	0.165
Variety (V)	2	0.009	3.203	3.492	3.060
Error (a)	4	0.004	0.172	0.176	0.779
Weeding (W)	4	1.475	12.244	22.053	77.887
V × W	8	0.074	0.358	0.491	8.842
Error (b)	24	0.002	0.144	0.149	0.645

Appendix X. Cost of production per hectare of sesame excluding weeding cost for BARI til 3 variety

SI. No.	Item	Quantity (kg ha^{-1})	Rate (tk. kg^{-1})	Cost (tk.)
01.	**Cost of seed**	7.5	50	375
02.	**Cost of fertilizer**			
	Urea	125	15	1875
	TSP	150	32	4800
	MOP	50	17	850
			Grand total	= 7900

Appendix XI. Cost of production per hectare of sesame excluding weeding cost for BARI til 4 variety

SI. No.	Item	Quantity (kg ha^{-1})	Rate (tk. kg^{-1})	Cost (tk.)
01.	Cost of seed	7.5	55	412.5
02.	Cost of fertilizer			
	Urea	125	15	1875
	TSP	150	32	4800
	MOP	50	17	850
			Grand total	= 7937.5

Appendix XII. Cost of production per hectare of sesame excluding weeding cost for Lal til (local) variety

SI. No.	Item	Quantity (kg ha^{-1})	Rate (tk. kg^{-1})	Cost (tk.)
01.	Cost of seed	7.5	30	225
02.	Cost of fertilizer			
	Urea	125	15	1875
	TSP	150	32	4800
	MOP	50	17	850
			Grand total	= 7750

Appendix XIII. Weeding cost of different weed control treatments for one hectare of land of sesame

Treatments	No. of labors	Labor cost	Herbicide cost	Total weeding cost
W_1	0	0	--------------	0
W_2	28	8400	---------------	8400
W_3	56	16800	---------------	16800
W_4	3	900	2590	3490
W_5	3	900	2080	2980