PERFORMANCE OF PRE EMERGENCE HERBICIDES UNDER DIFFERENT METHODS OF SOWING IN SUMMER SESAME (*Sesamum indicum* L.)

By

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B.Sc. (Hons.) Ag.

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DECLARATION

I, Ms. RAPELLY BHAVANI, hereby declare that the thesis entitled "**PERFORMANCE OF PRE EMERGENCE HERBICIDES UNDER DIFFERENT METHODS OF SOWING IN SUMMER SESAME (*Sesamum indicum* L.)"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** in the major field of **Agronomy** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place : Tirupati

Date : 23.08.2022

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CERTIFICATE

Ms. RAPELLY BHAVANI has satisfactorily prosecuted the course of research and that thesis entitled "**PERFORMANCE OF PRE EMERGENCE HERBICIDES UNDER DIFFERENT METHODS OF SOWING IN SUMMER SESAME "(*Sesamum indicum* L.)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part there of has been previously submitted by her for a degree of any university.

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This is to certify that the thesis entitled **“PERFORMANCE OF PRE EMERGENCE HERBICIDES UNDER DIFFERENT METHODS OF SOWING IN SUMMER SESAME (*Sesamum indicum* L.)”** submitted in partial fulfillment of the requirements for the degree of **‘Master of Science in Agriculture’** of the Acharya N.G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by **Ms. R. BHAVANI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all the assistance received during the course of investigations have been duly acknowledged by the author of the thesis.

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Rapelly Bhavani...

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

LIST OF PLATES

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
a.i	:	Active ingredient
B:C ratio	:	Benefit-cost ratio
BLW	:	Broad leaved weeds
°C	:	Degree centigrade
CD (P=0.05)	:	Critical difference at 5 per cent level of significance
cm	:	Centimeter
DAS	:	Days after sowing
dS m^{-1}	:	Deci siemen per meter
EC	:	Electrical conductivity
et al.	:	And other people
Fig.	:	Figure
g	:	Gram
g m^{-2}	:	Gram per square meter
ha	:	Hectare
kg	:	Kilogram
kg ha^{-1}	:	Kilogram per hectare
l ha^{-1}	:	Litre per hectare
m^{-2}	:	Per square meter
mm day^{-1}	:	Millimeter per day
No.m^{-2}	:	Number per square meter
NS	:	Non-significant
pH	:	Potential of hydrogen ion concentration
₹ ha^{-1}	:	Rupees per hectare
SEm ±	:	Standard error of mean
viz.,	:	Namely
WAS	:	Weeks after sowing

ABSTRACT

Name of the Author	:	**RAPELLY BHAVANI**
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A field experiment to evaluate the "Performance of pre emergence herbicides under different methods of sowing in summer sesame (*Sesamum indicum* L.)" was conducted during summer, 2022 on sandy loam soils of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh.

Treatments comprised of three methods of sowing *viz*., line sowing (M_1), broadcasting (M_2) and broadcasting with 1.5 times higher seed rate (M_3) as main plots and four weed management practices *viz*., pre emergence application of butachlor 1.0 kg ha^{-1} (W_1), pre emergence application of oxyfluorfen at 0.075 kg ha^{-1} (W_2), hand weeding at 20 and 40 DAS (W_3) and unweeded check (W_4) as sub-plots were tested in split plot design, replicated thrice.

At all the stages of observations, among the methods of sowing, lowest density and dry weight of weeds was with broadcasting using higher seed rate (M_3) which was significantly lesser than that due to line sowing (M_1). Broadcast sowing (M_2) resulted in significantly highest weed density and dry weight of weeds relative to line sowing.

Among the weed management practices, at 20 DAS, lowest density and dry weight of weeds was due to pre emergence application of oxyfluorfen (W_2) and it was significantly lesser than that due to butachlor application (W_1). Significantly highest density and dry weight of weeds was with unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding was not imposed by that time). At all other stages of observations, significantly lowest density and dry weight of weeds were with hand weeding followed by pre emergence application of oxyflourfen.

Methods of sowing could not influence the plant height of sesame at 20 DAS to a statistically perceptible magnitude. At 40 DAS taller plants was noticed with line sowing (M_1) which was at par with broadcasting using higher seed rate (M_3). The lower plant height was recorded with broadcasting (M_2). At all other stages of observation viz., 60 DAS and at harvest, higher plant height was noticed with line sowing (M_1) which was significantly superior over the rest of the treatments investigated. The lower plant height was recorded with broadcasting with higher seed rate (M_3) which was at par with broadcasting (M_2).

Significantly higher plant height at 20 DAS was recorded with pre emergence application of butachlor (W_1). The lower plant height of sesame was obtained with unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding not imposed at the

time of sampling). Lowest plant height was recorded with oxyfluorfen (W_2). At all other stages of observation *viz*., 40, 60 DAS and at harvest, the highest plant height was resulted in hand weeding, which was at par with pre emergence application of butachlor (W_1). The lower plant height was recorded with unweeded check (W_4). Pre emergence application of oxyfluorfen (W_2) recorded lowest plant height.

Methods of sowing could not significantly vary the leaf area of sesame at 20 DAS. At 40 and 60 DAS and at harvest, higher leaf area was with line sowing (M_1) which was significantly higher over other treatments.

At 20 DAS, leaf area of sesame was higher due to pre emergence application of butachlor (W_1). Lower leaf area was with unweeded check (W_4), which was comparable with that of hand weeding (W_3) (Hand weeding not imposed at the time of sampling). At 40 and 60 DAS and at harvest, highest leaf area was with hand weeding (W_3), which was significantly higher than other weed management practices. Lowest leaf area was with oxyfluorfen (W_2).

Methods of sowing could not significantly vary the **dry matter production** of sesame at 20 DAS. At 40, 60 DAS and at harvest, higher dry matter production was with broadcasting using higher seed rate (M_3), which was significantly higher over rest of the treatments.

Significantly higher dry matter production at 20 DAS was due to pre emergence application of butachlor (W_1). Lower dry matter production of sesame was due to unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding not imposed at the time of sampling). At 40, 60 DAS and at harvest, highest dry matter production was with hand weeding (W_3), which was significantly higher than rest of the weed management practices. Lowest dry matter production was with oxyfluorfen (W_2) which was significantly lower than other weed management practices.

Highest number of **branches plant^{-1}, capsules plant^{-1} and number of seeds capsule^{-1}** were due to line sowing (M_1) which was significantly higher over broadcasting (M_2). Broadcasting with higher seed rate (M_3) resulted in lowest values. Among the weed management practices, these three attributes were significantly highest with hand weeding (W_3) followed by butachlor application (W_1). Lowest number of branches plant^{-1}, capsules plant^{-1} and number of seeds capsule^{-1} were with oxyfluorfen (W_2) which was significantly lesser than rest of the weed management practices.

Among the methods of sowing, higher **seed, stalk yields and gross, net returns** of sesame were due to broadcasting using higher seed rate (M_3) which was significantly higher over line sowing and broadcasting. Among the weed management practices, highest seed, stalk yields and gross returns of sesame were with hand weeding (W_3). Pre emergence application of butachlor (W_1) was the next best weed management practice. Since oxyfluorfen (W_2) was phytotoxic to sesame crop, resulted in very low seed and stalk yields of sesame leading to heavy monetary loss.

Higher net returns due to hand weeding (W_3), which did not significantly differed from that due to pre emergence application of butachlor (W_1). Highest benefit-cost ratio with pre emergence application of butachlor (W_1) which was significantly higher than the hand weeding (W_3). Pre emergence application of oxyfluorfen (W_2) recorded significantly lower net returns and benefit-cost ratio which were significantly lower, relative to other weed management practices.

Hence, the present study concluded that effective control of weeds and higher seed yield, gross and net returns were obtained with broadcasting with 1.5 times seed rate (7.5 kg ha^{-1}) along with hand weeding at 20 and 40 DAS. However, the highest benefit-cost ratio was realized with pre emergence application of butachlor 1.0 kg ha^{-1} in summer sesame.

Chapter –I

Introduction

Chapter I

INTRODUCTION

The oilseed sector occupies an important place in the Indian economy. India is importing edible oil in large quantities and it accounts for largest drain on nation's exchequer. Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops next to groundnut, rapeseed and mustard in India. It is popularly known as "Queen of Oilseeds" due to its high degree of resistance to oxidation and rancidity. Sesame oil contains significant amount of polyunsaturated fatty acids, such as oleic and linolenic acids ranging from 30.9 to 52.5 %. India ranks first in world with 19.47 lakh ha area and 8.66 lakh tonnes production. Average productivity of sesame (413 kg ha^{-1}) in India is low, relative, to other countries in the world (535 kg ha^{-1}) during 2020-21 (*www.indiastat.com*).

Major constraint limiting the productivity of sesame is its slow growth during seedling stage, ideal for heavy weed infestation to smother the crop leading to heavy yield loss. (Channappagoudar *et al*., 2008). The other major reasons for low productivity of sesame are its rainfed cultivation in marginal and sub-marginal lands under poor management and input starved conditions. Therefore, weed management is essential in sesame to minimize the losses due to weeds.

Weeds can be effectively managed by preventive, cultural, mechanical, chemical and biological methods. Mechanical weed control is often difficult during the initial stage of the crop where conventional methods like manual weeding are most commonly practiced by the farmers to control weeds in sesame. But it is labour intensive, expensive and not feasible under all situations due to non-availability of labour during peak periods of agricultural operations. Chemical method is more favourable and effective due to their quick action, selectivity and cost effectiveness. With weak seedling vigor, limited competitive ability and lack of inexpensive and affordable labour, use of pre emergence and/or post-emergence herbicides is essential for sesame production.

Thus, alternative weed control could be an important way to increase sesame yield by reducing the initial cost of investment and maintaining environmental integrity. Both crop and weeds compete for limited resources in the field (light, water, nutrients etc.). Crop density significantly influences the incidence of weeds due to their competition for resources. As a consequence, the contribution of each individual plant to the overall may not be optimized. Indeed, higher plant densities result in reduced branch and seed numbers per plant even though the overall yield per unit area may remain the same (Lemerle *et al.*, 1996). Thus, optimal plant density and weeding regimes need to be established to reduce crop-weed competition.

In the present investigation, information is sought to be obtained on the effect of methods of seeding and seeding density relative to pre emergence application of herbicides and manual weeding regime on the performance of summer sesame crop.

Present investigation was undertaken to evaluate relative efficiency of methods of sowing and pre emergence herbicides on summer sesame crop with the following objectives.

1. To evaluate the performance of different methods of establishment for enhanced productivity in summer sesame
2. To know the effect of different pre emergence herbicides on weed growth and yield of summer sesame
3. To trace out the interaction effect between the methods of establishment and pre emergence herbicides in summer sesame

Chapter – II

Review of Literature

Chapter II

REVIEW OF LITERATURE

A field experiment entitled "Performance of pre emergence herbicides under different methods of sowing in summer sesame (*Sesamum indicum* L.)" was conducted at dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, to study the performance of pre emergence herbicides under different methods of sowing during summer. Work done and the research results on weed flora in sesame and their competitive effect on growth, yield and nutrient uptake with different pre emergence herbicides including hand weeding are presented hereunder. However, the literature available on the performance of pre emergence herbicides in sesame is very limited. Hence, literature on soybean, mustard and groundnut is also included wherever necessary.

2.1 WEED FLORA

Aruna *et al*. (2020) found that dominant weed flora of the experimental field were *Cyperus rotundus, Digera arvensis, Phyllanthus maderaspatensis, Trichodesma indicum, Panicum repens and Dactyloctenium aegyptium* in sesame on sandy loam soils of Kadapa, Andhra Pradesh during summer.

Dominant weed flora of the experimental field were *Cyperus rotundus, Cynodon dactylon, Echinochloa crusgalli, Echinochloa colona*, *Dinebra arabica, Digitaria longifolia*, *Dactylactenium aegyptium* and *Cleome viscosa* in sesame on sandy loam soils of Paralakhemundi, Odisha during *rabi* (Patnaik *et al*., 2020).

Chaudhuri and Ghosh (2019) reported that the predominant weed flora observed in sesame field during pre-*kharif* were *Digitaria sanguinalis, Echinochloa colona, Cynodon dactylon, Cyperus iria*, *Cyperus rotundus, Eclipta alba*, *Trianthema portulacastrum* and *Spilanthes acmella* on sandy loam soils of Sriniketan, West Bengal.

Singh *et al.* (2018) reported that the most dominant broad leaved weeds during summer were *Alternanthera philoxeroides, Cichorium intybus, Euphorbia geniculata* and grassy weeds were *Digitaria sanguinalis, Dinebra retroflexa, Echinochloa colona* in sesame on clay loam soils at Jabalpur, Madhya Pradesh.

Dominant weed flora observed in sesame field during *kharif* were *Convolvulus arvensis, Cyperus rotundus, Prosopis farcta* and *Sorghum halepense* on sandy loam soils of Agricultural Research Station in Estahban, Iran (Madandoust and Ranjbar, 2017).

Babu *et al.* (2015) reported that the most dominant weed flora observed during summer in sesame were *Cyperus rotundus, Commelina benghalensis, Cleome viscosa, Boerhavia diffusa, Phyllanthus niruri, Dactyloctenium aegyptium* and *Digitaria sanguinalis* on sandy loam soils of Tirupati, Andhra Pradesh.

Dominating dicot weeds during kharif were Ipomoea spp., Phyllanthus maderaspatensis, Convolvulus arvensis, Euphorbia hirta, Parthenium hyseterophorus, Digera arvensis and Acalypha indica. In grassy species Cynodon dactylon and Bracheria eruciformis and in sedges Cyperus rotundus was recorded in sesame on black cotton soils of Raigarh, Chhattisgarh (Jadhav, 2015).

Mruthul *et al.* (2015) noticed that dominant weed flora of the experimental field during *kharif* were *Agropyron repens*, *Cyperus rotundus*, *Cynodon dactylon*, *Abutilon indicum*, *Acalypha indica*, *Ageratum conyzoides*, *Commelina benghalensis*, *Cyanotis* spp, *Parthenium hysterophorus*, *Phyllanthus maderaspatensis*, *Portulaca oleracea*, *Tribulus terrestris* and *Xanthium strumarium* in sesame on medium black soils of Raichur, Karnataka.

Mahajan and Hirwe (2014) observed that weed flora present in the sesame crop was dominated by broad leaved weeds *viz*., *Amaranthus spinosus, Amaranthus polygamous, Euphorbia geniculata, Euphorbia thymifolia,* *Commelina benghalensis* and *Celosia argentia* on clay loam soils at Jalgaon, Maharashtra.

Mathukia *et al.* (2013) reported that predominant weed species associated with sesame crop in clay loam soils of Junagadh, Gujarat were *Echinochloa colona*, *Digitara sanguinalis* and *Cynodon dactylon* in grasses, *Trianthema portulacastrum* and *Digera arvensis* in broad leaved weeds and only one sedge *Cyperus rotundus* among sedges.

Sasikala *et al.* (2013) reported that the major weed flora associated with irrigated sesame were *Echinochloa colona* and *Cynodon dactylon* in grasses, *Cyperus rotundus* and *Cyperus difformis* in sedges and *Eclipta alba* and *Trianthema portulacastrum* among the broad leaved weeds at Madhurai, Tamil Nadu.

The predominant weed flora associated with sesame in sandy loam soils of Birbhum, West Bengal were Digitaria sanguinalis, Echinochloa colona, Eleusine indica and Dactyloctenium aegyptium among grasses, Spilanthus acmella, Trianthema portulacastrum, Tephrosia purpurea and Ageratum conyzoides in broad leaved weeds (Duary and Hazra, 2013).

Bhadauria *et al.* (2012) observed that the composition of weed flora associated with sesame in sandy loam soils of Gwalior, Madhya Pradesh were *Digera arvensis*, *Echinochloa crusgalli*, *Cyperus rotundus*, *Commelina benghalensis* and *Phyllanthus niruri* during summer.

Sheoran *et al.* (2012) reported that the predominant weed flora associated with sesame in loamy sands of Ludhiana, Punjab were *Cynodon dactylon* and *Eleusine aegyptium* in grassy weeds, while *Commelina benghalensis* and *Digera arvensis* among the broad leaved weeds and *Cyperus rotundus* a sedge. On an average, broad leaved weeds accounted for 43-51 per cent and sedges for 41-46 per cent and grassy weeds for only 6-12 per cent of the total weed population.

Sukhadia *et al.* (2004) observed that composition of weed flora associated with sesame in black calcareous soils of Junagadh, Gujarat were *Digera arvensis* (37 per cent), *Echinochloa colona* (6 per cent), *Cyperus rotundus* (6 per cent), *Leucas aspera* (5 per cent), *Indigofera glandulosa* (5 per cent), *Eluropus villosus* (24 per cent) and *Dactyloctenium aegyptium* (8 per cent).

The predominant weed species noticed in sesame crop at Tiruchirapalli, Tamil Nadu were *Cleome viscosa*, *Euphorbia prostrata*, *Trianthema portulacastrum*, *Panicum repens* and *Cyperus rotundus* (Kavimani *et al*., 2000).

2.2 YIELD LOSS DUE TO WEEDS

Fatima et al. (2020) found that sesame crop is heavily infested by weeds and thereby resulting in heavy yield loss ranging from 16 - 68 per cent on sandy loam soils of Birbhum, West Bengal during summer.

Patnaik et al. (2020) revealed that insufficient weed control during early growth period of sesame causes yield reduction between 35.5 to 70 per cent in sesame on sandy loam soils of Paralakhemundi, Odisha during rabi.

Weed control during the early growth period caused 35 to 70 per cent yield reduction in sesame on sandy loam soils of Kadapa, Andhra Pradesh during summer (Aruna *et al*., 2020).

Chaudhuri and Ghosh (2019) reported that most of the areas of sesame crop is heavily infested by weeds and thereby resulting in heavy yield loss ranging from 16-68 per cent during pre-*kharif* at Sriniketan, West Bengal.

Yield reduction due to weeds during summer was observed to the tune of 55 to 65 per cent in sesame on clay loam soils at Jabalpur, Madhya Pradesh (Singh *et al*., 2018).

Rajpurohit *et al.* (2017) conducted a field experiment during summer on clay soils of Navsari, Gujarat and reported that weeds are one of the major constraints for the poor yield of sesame crop as they compete with the crop plants for moisture, nutrients, light and space cause 50-75 per cent yield reduction.

Dhaka *et al*. (2015) estimated the loss in seed yield of sesame due to uncontrolled weed growth throughout the growth period during *kharif* in sandy loam soils of Hisar, Haryana to be 50 per cent.

Jadhav (2015) noticed that yield reduction was 30-60 per cent in sesame during *kharif* on black cotton soils of Raigarh, Chattisgarh.

Mruthul *et al.* (2015) reported that yield losses due to crop - weed competition in sesame was 50 - 75 per cent on medium black soils of Raichur, Karnataka during *kharif*.

The loss in seed yield of sesame due to heavy weed competition between crop and weeds during the crop growth period was estimated up to 65 per cent in clay loam soils of Isfahan, Iran (Vafaei *et al*., 2013).

Tyagi et al. (2013) noticed that yield reduction in sesame was 70 per cent due to uncontrolled growth of weeds in sandy loam soils of Tikamgarh, Madhya Pradesh.

Bhadauria *et al.* (2012) observed that yield losses during summer due to crop - weed competition was 16-68 per cent in sesame on sandy loam soils of Gwalior, Madhya Pradesh.

Season long weed competition has been found to reduce the sesame seed yield to the extent of 50 to70 per cent depending upon the type of weed flora in sandy loam soils of Indore, Madhya Pradesh (Dungarwal *et al*., 2003).

2.2.1 Critical Period of Crop-Weed Competition

Controlling of weeds during the critical period of crop-weed competition is an important principle of integrated weed management. It is the time period in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield loss.

Critical period of weed control appeared to be between 2 and 6 weeks after planting in sesame on sandy loam soils of Kadapa, Andhra Pradesh during summer (Aruna *et al*., 2020).

Patnaik *et al*. (2020) revealed that critical period of weed control in sesame appeared to be between 15 to 45 DAS in sesame on sandy loam soils of Paralakhemundi, Odisha during *rabi*.

Chaudhuri and Ghosh (2019) reported that critical period of weed competition in sesame was 15 to 30 DAS during pre-*kharif* at Sriniketan, West Bengal.

Sangeetha and Chinnamuthu (2019) found that critical period of weed competition in sesame on sandy loam soils of Coimbatore, Tamil Nadu during *rabi* was found to be from 15 to 30 DAS.

Singh *et al*. (2018) reported that critical period for weed control in sesame during summer was found to be from 15 to 30 DAS on clay loam soils of Jabalpur, Madhya Pradesh.

Madandoust and Ranjbar (2017) found that critical period of weed control in sesame was between 20 and 50 days after the emergence of sesame on sandy loam soils of Estahban, Iran during *kharif*.

Mruthul *et al*. (2015) reported that critical period for weed control in sesame on black soils of Raichur, Karnataka during summer was found to be from 15 to 30 DAS.

Keeping, the field weed free up to 30 DAS was considered as critical period for crop-weed competition in sesame grown on clay soils during kharif at Jalagon, Maharashtra (Mahajan and Hirwe, 2014).

Duary and Hazra (2013) reported that critical period for weed control in sesame on sandy loam soils of Sriniketan, West Bengal during summer was found to be from 15 to 45 DAS.

Tyagi *et al*. (2013) reported that critical period for weed control in sesame in sandy loam soils of Tikamgarh, Madhya Pradesh during *kharif* was found to be from 15 to 45 DAS.

2.3 METHODS OF SOWING

2.3.1 Effect of Methods of Sowing on Weed Growth

2.3.1.1 Line sowing

Imoloame *et al.* (2017) reported that, the best weed suppression was obtained from drilling method in sesame during *kharif* on sandy loam soils of Maiduguri, Nigeria.

Katanga *et al.* (2017) reported that weed density and weed dry weight were affected by methods of sowing in sesame. Line sowing produced lower weed density and weed dry weight compared to broadcasting during *kharif* on sandy loam soils at Bayero University, Kano.

Svathi *et al.* (2005) found that weed density was influenced by methods of sowing. Lower weed density was noticed with line sowing in sesame on sandy loam soils of Karaikal, Pondicherry during summer.

2.3.1.2 Broadcasting

Broadcasting method of sowing results in higher weed cover and weed dry matter in sesame compared with drilling method during *kharif* on sandy loam soils at Maiduguri, Nigeria (Imoloame *et al*., 2017).

Broadcasting method of sowing resulted in higher weed cover and weed dry matter compared with drilling method during *kharif* on sandy loam soils at Dhaka, Bangladesh during summer (Umed *et al*., 2009).

2.3.1.3 Broadcasting with 1.5 times seed rate

Increasing the soybean-seeding rate from 124 to 494 kg ha^{-1} reduced weed interference and increased soybean yield by 48 per cent in clay soils of Wisconsin, United States (Buhler and Oplinger, 2017).

Higher seeding rate played an important role in increasing the competitiveness of the crop against weeds, which minimized weed pressure and reduces dependence on herbicide use in direct seeded rice in sandy loam sois of Faisalabad, Pakistan (Ahmed *et al.*, 2014).

Sharma and Kumar (2011) revealed that increasing seed rate from 75 to 150 kg ha^{-1} decreasing weed population in wheat on clay loam soils of Varanasi, Uttar Pradesh.

2.3.2 Effect of Methods of Sowing on Growth and Yield Components

Ndor and Nasir (2019) reported that line sowing had positive effects on number of capsules $plant^{-1}$ and no. of seeds $capsule^{-1}$ in sesame compared with broadcasting method of sowing on clay loam soils during *kharif* at Nasarawa, Nigeria.

Imoloame *et al.* (2017) reported that broadcasting method of sowing produced taller plants, greater number of flowers and pods per plant compared with drilling method during *kharif* on sandy loam soils at Maiduguri, Nigeria.

Kandil **(**2017) reported that broadcasting method of sowing produced higher yield components in sesame during summer on sandy loam soils at Jordan, Egypt.

Pods $plant^{-1}$ was affected by the methods of sowing in sesame. Broadcasting method produced higher pods $plant^{-1}$ compared to line sowing during *kharif* on sandy loam soils at Bayero, Kanas (Katanga *et al*., 2017).

Adanan *et al*. (2013) found that broadcasting method of sowing recorded taller plants and higher number of leaves, branches and capsules $plant^{-1}$ when compared to line sowing in sesame on sandy loam soils of Jammu and Kashmir during summer.

Islam *et al.* (2008) reported that performance of line sowing was superior to broadcasting in terms of yield components such as number of primary and secondary branches $plant^{-1}$, number of capsules $plant^{-1}$ and number of seeds capsule^{-1} in sesame on dark grey floodplain soils during *kharif* at Mymensingh, Bangladesh.

Line sowing had positive effects on number of capsules plant^{-1} and number of seeds capsule^{-1} in sesame compared with broadcasting on clay loam soils during *rabi* at Istanbul, Turkey (Caliskan *et al*., 2004).

Svathi *et al*. (2005) found that line sowing registered more number of branches plant^{-1} than broadcasting method in sesame on sandy loam soils of Karaikal, Pondicherry during summer.

Hamid and Kamel (2002) found that line sowing had positive effects on number of capsules plant^{-1} and number of seeds capsule^{-1} in sesame compared with broadcasting method of sowing on sandy loam soils at Jammu and Kashmir during summer.

2.3.3 Effect of Methods of Sowing on Yield

Khanam *et al.* (2021) found that line sowing was superior to broadcasting in terms of seed yield in sesame on non-calcareous dark grey floodplain soil during *kharif* at Dhaka, Bangladesh.

Ndor and Nasir (2019) found that line sowing method was superior in seed yield than broadcasting method of sowing on clay loam soils during *kharif* at Nasarawa, Nigeria.

Drilling produced higher seed yield compared to broadcasting in sesame during *kharif* on sandy loam soils at Maiduguri, Nigeria (Imoloame *et al*., 2017).

Kandil (2017) reported that broadcasting method of sowing produced higher seed yield in sesame during summer on sandy loam soils at Jordan, Egypt.

The increased seed rate resulted in a higher plant population providing less space for weeds to grow and offering much higher competition for light, nutrient and other growth factors. These factors collectively increased competitive ability of sesame crop with weeds resulted in lower weed density and higher seed yield Northern Guinea, Nigeria (Daniya *et al*., 2015).

Islam *et al.* (2014) found that higher seed yield was obtained with higher seed rate of 9 kg ha^{-1}, coupled with manual weeding twice under broadcasting method of sowing in sesame on sandy loam soils of Jinju, Korea during summer.

Islam *et al.* (2008) reported that performance of line sowing method is superior to broadcast method in terms of seed yield in sesame on dark grey floodplain soils at Mymensingh, Bangladesh during *kharif*.

Svathi *et al*. (2005) found that higher seed yield was obtained in line sowing against broadcasting method in sesame on sandy loam soils of Karaikal, Pondicherry during summer.

Caliskan *et al.* (2004) reported that line sowing had positive effects on yield of sesame and produce higher seed yield compared to broadcasting method of sowing on clay loam soils during *rabi* at Istanbul, Turkey.

2.4 WEED MANAGEMENT PRACTICES

2.4.1 Hand Weeding

Hand weeding is one of the best methods of weed management in sesame, but now a days it is not economical due to increased labour wages and non-availability of labour during peak periods of agricultural operations.

Taller plants and higher seed yield were recorded with hand weeding at 15 and 30 DAS on sandy loam soils of Kadapa, Andhra Pradesh during summer in sesame (Aruna *et al*., 2020).

Sangeetha and Chinnamuthu (2019) revealed that hand weeding twice at 20 and 40 DAS recorded significantly higher yield in sesame on sandy loam soils of Coimbatore, Tamil Nadu during *rabi*.

Onkar and Angadi (2018) revealed that pre emergence application of pendimethalin @ 38.7 % CS + HW at 30 DAS was found most effective weed management practice in summer under irrigation and also recorded lower total dry matter of weeds m^{-2} and higher weed control efficiency at Dharwad, Karnataka.

Babu *et al.* (2015) reported that among the different weed management practices tried, two hand weedings at 20 and 40 DAS has recorded the lower weed dry weight in sesame on sandy loam soils of Tirupati, Andhra Pradesh during summer.

Mruthul *et al.* (2015) reported that higher number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, seed yield, stalk yield and harvest index were recorded with hand weeding at 15 and 30 DAS in sesame on black soils of Raichur, Karnataka during summer.

The lowest density of weeds was obtained with hand weeding twice at 20 and 40 DAS in sesame on loamy sand soils during kharif at Hissar, Haryana (Dhaka et al., 2015).

Hand weeding at 15 DAS and 30 DAS resulted in the higher seed yield and net returns with higher nitrogen, phosphorus and potassium uptake by sesame crop during summer at Gwalior, Madhya Pradesh (Bhadauria et al., 2012).

Hand weeding thrice significantly reduced the weed density by 78.3 per cent in sesame compared to unweeded check in loamy sands of Ludhiana, Punjab (Sheoran *et al*., 2012).

Gnanavel and Anbhazhagan (2006) noticed that pre emergence application of oxyfluorfen 0.15 kg ha^{-1} supplemented with one hand weeding at 30 DAS resulted in reduced weed biomass, higher weed control efficiency and seed yield in irrigated sesame on clay loam soils of Annamalainagar, Tamil Nadu.

Sukhadia *et al*. (2004) observed that the higher seed yield of sesame was recorded with two intercultivations and two hand weedings at 20 and 40 DAS compared to rest of the weed management practices tested on black calcareous soils of Junagadh, Gujarat.

Baskaran and Solaimalai (2002) conducted an experiment in rice fallow sesame and results revealed that the maximum plant height, leaf area index, dry matter production were produced with two HW at 15 and 30 DAS in sesame on sandy loam soils of Vridhachalam, Tamilnadu.

2.4.2 Pre emergence Herbicides

Herbicides are most effective in controlling the weeds and reduce the total energy requirement for manual weeding in sesame production. Very limited herbicides are being used for weed management in sesame globally, due to small seeds and shallow depth of sowing and phytotoxicity of soil applied herbicides. Very limited number of pre and post-emergence herbicides were tested to control the weeds in sesame in general and broadcasted sesame in particular.

Due to availability of good number of pre emergence herbicides in recent years necessitiates the identification of an effective and economical weed management practice in sesame.

2.4.2.1 Effect of pre emergence herbicides on weed growth

2.4.2.1.1 Butachlor

Ezebuiro *et al*. (2021) revealed that pre emergence application of butachlor 2.0 kg ha^{-1} during *kharif* exhibited effective weed control in soyabean on clay loam soils of Usmanu Danfodiyo University, Sokoto.

Pre emergence application of butachlor 1.0 kg ha^{-1} could be used as alternative to hoe weeding for effective weed control in sesame during summer on clay loam soils of Adamawa state, Nigeria (Audu *et al*., 2021).

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted in higher weed control efficiency in groundnut on sandy loam soils of Bhubaneswar, Odisha during *kharif* (Sahoo *et al*., 2017).

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted in higher weed control efficiency in sesame on black cotton soils of Raigarh, Chhattisgarh during *kharif* (Jadhav, 2015).

Pre emergence application of butachlor 2.0 kg ha^{-1} or metolachlor 1.5 kg ha^{-1} recorded lower weed dry weight compared to rest of the pre emergence herbicides tried in sesame at Borno, Nigeria on sandy loam soils (Imoloame *et al.*, 2011).

Mondal *et al.* (2008) revealed that among the herbicides tested, pre emergence application of butachlor 1.0 kg ha^{-1} with one HW recorded higher weed control efficiency in sesame on black cotton soils of Sriniketan, West Bengal during *kharif.*

2.4.2.1.2 Oxyfluorfen

Oxyfluorfen is a selective contact herbicide belonging to diphenyl ether group. It is absorbed more rapidly by the foliage (and especially the shoots) than by the roots with very little translocation.

Pre emergence application of oxyfluorfen 0.15 to 0.25 kg ha^{-1} resulted in reduced weed density and dry weight of weeds with higher weed control efficiency in sesame on sandy loam soils of Paralakhemundi, Odisha during *rabi* (Patnaik *et al.*, 2020).

Sangeetha and Chinnamuthu (2019) revealed that pre emergence application of oxyfluorfen 0.2 kg ha^{-1} and HW at 30 DAS resulted in reduced weed density and dry weight of weeds with higher weed control efficiency in sesame on sandy loam soils of Coimbatore, Tamil Nadu during *rabi*.

Sing *et al.* (2018) reported that population of *Digitaria sanguinalis* was significantly reduced with the application of oxyfluorfen 0.15 kg ha^{-1} in sesame on clay loam soils at Jabalpur, Madhya Pradesh during summer.

Babu *et al.* (2015) revealed that pre emergence application of oxyfluorfen 0.75 kg ha^{-1} + quizalofop 0.50 kg ha^{-1} during summer resulted in reduced weed density and dry weight of weeds with higher weed control efficiency in sesame on sandy loam soils of Tirupati, Andhra Pradesh.

Pre emergence application of oxyfluorfen 0.15 kg ha^{-1} supplemented with hand weeding at 30 DAS resulted in reduced weed density, dry weight of weeds with higher weed control efficiency in sesame on clay loam soils of Annamalainagar, Tamil Nadu (Gnanavel and Anbhazhagan, 2006).

Pre emergence application of oxyfluorfen 0.25 kg ha^{-1} resulted in reduced weed density and dry weight of weeds with higher weed control efficiency compared to pre emergence application of pendimethalin 0.75 kg ha^{-1} in mustard on *alluvial* soils of Gwalior, Madhya Pradesh (Chauhan *et al*., 2005).

Pre emergence application of oxyfluorfen 0.125 kg ha^{-1} along with pendimethalin 0.5 kg ha^{-1} resulted in reduction of weed density and dry weight in soybean on sandy loam soils of Tirupati, Andhra Pradesh (Reddy *et al*., 2003).

Pre emergence application of oxyfluorfen 0.25 kg ha^{-1} supplemented with one hand weeding at 35 DAS resulted in reduced weed dry weight and higher weed control efficiency in groundnut on clay loam soils of Raigarh, Chhattisgarh (Patel and Thakur, 2003).

Pre emergence application of oxyfluorfen 0.12 to 0.15 kg ha^{-1} gave effective control of broad leaved weeds and grasses up to 60 DAS on sandy loam soils at Hebbal, Bangalore. (Prasad *et al*., 1987).

Kondap *et al*. (1983) noticed that lower dosages of oxyfluorfen (0.25 to 0.50 kg ha^{-1}) resulted in reduced plant mortality and weed density and oxyfluorfen was relatively safe for sesame at lower doses on sandy loam soils of Kumulur, Tamil Nadu.

2.4.2.1.3 Other pre emergence herbicides

Aruna *et al*. (2020) found that among the different herbicides tested pre emergence application of pendimethalin 0.75 kg ha^{-1} recorded lower weed density and weed dry weight in sesame on sandy loam soils of Utukur, Andhra Pradesh during summer.

Lins *et al*. (2020) found that among the different herbicides tested pre emergence application of diuron and flumioxazin recorded better weed control in sesame on sandy soils of Francisco, Brazil during summer.

Pre emergence application of trifluralin 0.72 kg ha^{-1} resulted in reduced density of weeds in sesame by 72.8 per cent compared to unweeded check on clay loam soils at Isfahan, Iran (Vafaei *et al*., 2013).

Pre emergence application of alachlor 1.5 kg ha^{-1} was found to be significantly superior in reducing the density and dry weight of weeds with higher weed control efficiency compared to pre-plant incorporation of fluchloralin or trifluralin applied each at 1.0 kg ha^{-1} in sesame on loamy sands of Ludhiana, Punjab (Sheoran *et al*., 2012).

Pre-plant incorporation of fluchloralin 0.75 kg ha^{-1} recorded significantly lower weed population and dry weight of weeds than with three hand weedings at 20, 40 and 60 DAS in sesame on sandy loam soils of Gwalior, Madhya Pradesh (Chauhan and Gurjar, 1998).

2.4.2.2 Effect of pre emergence herbicides on growth and yield components

2.4.2.2.1 Butachlor

Audu *et al*. (2021) found that pre emergence application of butachlor 1.0 kg ha^{-1} resulted in appreciably higher number of capsules plant^{-1} in sesame on clay loam soils of Adamawa state, Nigeria, during summer.

Chaudhuri and Ghosh (2019) revealed that butachlor 1.0 kg ha^{-1} as pre emergence *fb* HW at 30 DAS showed increasing yield attributes like number of capsules plant^{-1} and number of seeds capsules^{-1} in sesame during pre-*kharif* at Sriniketan, West Bengal.

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted higher yield attributing characters in groundnut on sandy loam soils of Bhubaneswar, Odisha during *kharif* (Sahoo *et al*., 2017).

Pre emergence application of butachlor 2.0 kg ha^{-1} or metolachlor 1.5 kg ha^{-1} recorded higher number of capsules plant^{-1}, compared to rest of the pre emergence herbicides tried in sesame at Borno, Nigeria (Imoloame *et al.*, 2011).

2.4.2.2.2 Oxyfluorfen

Singh *et al*. (2018) reported that higher stunting was observed with oxyfluorfen 0.l5 kg ha^{-1} in sesame on clay loam soils of Jabalpur, Madhya Pradesh, during summer.

Babu *et al.* (2015) revealed that pre emergence application of oxyfluorfen 0.75 kg ha^{-1}+ quizalofop 0.50 kg ha^{-1} resulted in more number of branches plant^{-1}, capsules plant^{-1} and seeds capsules^{-1} in sesame on sandy loam soils of Tirupati, Andhra Pradesh during summer.

Gnanavel and Anbhazhagan (2006) observed that pre emergence application of oxyfluorfen 0.15 kg ha^{-1} supplemented with hand weeding at 30 DAS resulted in the higher stature of yield components *viz*., number of branches plant^{-1}, capsules plant^{-1}, and seeds capsule^{-1} in sesame on clay loam soils of Annamalainagar, Tamil Nadu.

Pre emergence application of oxyfluorfen 0.25 kg ha^{-1} in combination with two hand weedings at 25 and 40 DAS resulted in more number of branches plant^{-1} capsule plant^{-1} and seeds capsules^{-1} which were on par with pre-plant incorporation of fluchloralin 1.0 kg ha^{-1} in mustard on *alluvial* soils of Gwalior, Madhya Pradesh **(**Chauhan *et al*., 2005).

2.4.2.2.3 Other pre emergence herbicides

Singh *et al*. (2018) reported that pendimethalin alone and in combination with lower dose of imazethapyr caused less injury to the sesame and recorded higher yield components in sesame on clay loam soils at Jabalpur, Madhya Pradesh, during summer.

Jha and Soni (2013) found that pre emergence application of pendimethalin 0.75 kg ha^{-1} followed by imazethapyr 0.1 kg ha^{-1} resulted in taller plants, more number of branches and number of pods plant^{-1} in soybean on clay loam soils of Jabalpur, Madhya Pradesh.

Pre emergence application of trifluralin 0.72 kg ha^{-1} recorded the highest dry matter production and harvest index in sesame on silty clay loam soils loam soils at Isfahan, Iran (Vafaei *et al*., 2013).

Bhadauria et al. (2012) observed that trifluralin 0.75 kg ha-1 followed by one hand weeding at 30 DAS recorded higher yield components in sesame on sandy loam soils of Gwalior, Madhya Pradesh during summer sesame.

Sheoran *et al*. (2012) reported that pre emergence application of alachlor 1.5 kg ha^{-1} supplemented with hand weeding at 4 WAS recorded higher stature of plants and more number of capsules plant^{-1} in sesame on loamy sands of Ludhiana, Punjab.

Baskaran and Solaimalai (2002) observed that pre emergence application of pendimethalin 0.75 kg ha^{-1} or pre-plant incorporation of fluchloralin 1.0 kg ha^{-1} produced higher stature of growth and yield components of sesame compared to rest of the weed management practices on sandy loam soils of Vridhachalam, Tamilnadu.

2.4.2.3 Effect of pre emergence herbicides on yield

Pre emergence application of butachlor 1.0 kg ha^{-1} could be used as alternative to hoe weeding for effective weed control in sesame with higher seed yield on clay loam soils of Adamawa state, Nigeria, during summer (Audu *et al*., 2021).

Patnaik *et al*. (2020) revealed that pre emergence application of oxyfluorfen 0.15 to 0.25 kg ha^{-1} resulted in higher seed yield in sesame on sandy loam soils of Paralakhemundi, Odisha during *rabi*.

Chaudhuri and Ghosh (2019) revealed that butachlor 1.0 kg ha^{-1} with one HW at 30 DAS recorded higher seed yield in sesame during pre-*kharif* at Sriniketan, West Bengal.

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted higher yield in groundnut on sandy loam soils of Bhubaneswar, Odisha during *kharif* (Sahoo *et al*., 2017).

Babu *et al.* (2015) revealed that pre emergence application of oxyfluorfen 0.75 kg ha^{-1} + quizalofop 0.50 kg ha^{-1} during summer recorded higher seed yield in sesame on sandy loam soils of Tirupati, Andhra Pradesh.

Jadhav (2015) reported that pre emergence application of butachlor 1.5 kg ha^{-1} found superior seed yield over rest of the treatments in sesame on black cotton soils of Raigarh, Chhattisgarh.

Pre emergence application of butachlor 2.0 kg ha^{-1} or metolachlor 1.5 kg ha^{-1} recorded higher seed yield compared to rest of the pre emergence herbicides tried in sesame at Borno, Nigeria (Imoloame *et al*., 2011).

Mondal *et al.* (2008) revealed that among the herbicides tested, pre emergence application of butachlor 1.0 kg ha^{-1} with one HW recorded higher seed yield in sesame on black cotton soils of Sriniketan, West Bengal during *kharif.*

Pre emergence application of oxyfluorfen 0.15 kg ha^{-1} followed by supplemented with HW at 30 DAS produced higher seed yield of sesame and it was closely followed by pre emergence application of pendimethalin 1.0 kg ha^{-1} + HW at 30 DAS on clay loam soils of Annamalainagar, Tamil Nadu. (Gnanavel and Anbhazhagan, 2006).

2.5 PHYTOTOXICITY

Audu *et al.* (2021) found that higher dose of butachlor 1.5 kg ha^{-1} results in suppressed crop growth in sesame on clay loam soils of Adama University of Technology, Adamawa state, Nigeria during summer.

Lins *et al.* (2020) reported that oxyfluorfen at higher doses 0.48 kg ha^{-1} caused phytotoxicity leading to mortality in sesame and thereby severe reduction in seed yield on sandy soils of Francisco, Brazil during summer.

Pre emergence application of butachlor 1.5 kg ha-1 resulted less phytotoxic effect due to its greater translocation ability in groundnut on sandy loam soils of Bhubaneswar, Odisha during kharif (Sahoo et al., 2017).

Babu *et al*. (2016) revealed that among the herbicides tested, pre emergence application of oxyfluorfen 0.075 kg ha^{-1} showed phytotoxicity rating of **'4'** in pot culture experiment conducted at Tirupati, Andhra Pradesh.

Imoloame *et al.* (2011) reported that pre emergence application of all the rates of butachlor, except at 2.0 kg ha^{-1} and 2.5 kg ha^{-1} at 2 WAS had least phytotoxicity in sesame on sandy loam soils of Borno, Nigeria (In 1-10 scale, where 1= no crop injury and 10 = complete crop kill).

Padmaja *et al.* (1994) reported that oxyfluorfen at higher doses (0.2 kg ha^{-1}) caused phytotoxicity leading to 58.9 per cent mortality in sesame and thereby severe reduction in seed yield on clay soils of Hyderabad, Telangana.

Brar and Methra (1989) reported that pre emergence application of oxyfluorfen 0.2 kg ha^{-1} showed slight phytotoxicity to the sesame crop leaves during initial stages, but the crop recovered within 10-15 days of oxyfluorfen application on clay soils of Chennai, Tamil Nadu.

2.6 NUTRIENT UPTAKE

2.6.1 Nutrient Uptake by Crop

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted higher yield due to high nutrient uptake in groundnut on sandy loam soils of Bhubaneswar, Odisha during *kharif* (Sahoo *et al*., 2017).

Rao and Chauhan (2015) reported that pre emergence application of oxyfluorfen increased nutrients uptake in sesame at Hyderabad, Telangana during summer.

Rao and Nagamani (2010) reported that herbicides use in combination with hand weeding leads to the weed suppression and increased nutrients uptake in sesame during summer at Hyderabad, Telangana.

Das *et al*. (2003) reported that oxyfluorfen provided greater microbial stimulated and stimulates the population and activities of phosphate solubilizing microorganisms and also the availability of phosphorus in the rhizosphere soil in rice on sandy soils of Haringhata, West Bengal.

2.6.2 Nutrient Uptake by Weeds

Weedy check recorded lower pod yield over other treatments which might be due to greater weed competition that resulted in higher uptake of N, P and K by weeds in weedy check of groundnut crop on sandy loam soils of Bhubaneswar, Odisha during *kharif* (Sahoo *et al.*, 2017).

Bhadauria *et al*. (2012) noticed that unchecked weed growth in sesame removed 45.0, 6.9 and 36.0 kg ha^{-1} of nitrogen, phosphorus and potassium respectively in sandy loam soils at Gwalior, Madhya Pradesh during summer.

Broadcasting method of sowing resulted in higher nutrient uptake by weeds due to more weed population compared with drilling method during *kharif* on sandy loam soils at Jammu & Kashmir during summer (Umed *et al*., 2009).

2.7 ECONOMICS

Patnaik *et al*. (2020) revealed that pre emergence application of oxyfluorfen 0.15 to 0.25 kg ha^{-1} resulted in higher benefit cost ratio in sesame during *rabi* on sandy loam soils of Paralakhemundi, Odisha.

Chaudhuri and Ghosh (2019) revealed that butachlor with one HW at 30 DAS recorded higher higher gross and net returns in sesame during pre-*kharif* at Sriniketan, West Bengal.

Pre emergence application of oxyfluorfen 0.2 kg ha^{-1} and HW at 30 DAS recorded higher net return and benefit-cost ratio than hand weeding twice even though lower yield was recorded compared to hand weeding twice in sesame on sandy loam soils of Coimbatore,Tamil Nadu during *rabi* (Sangeetha and Chinnamuthu, 2019).

Pre emergence application of butachlor 1.5 kg ha^{-1} resulted in the higher benefit-cost ratio in sesame on black cotton soils of Raigarh, Chhattisgarh (Jadhav, 2015).

Islam *et al.* (2014) found that broadcasting method of sowing resulted in higher benefit-cost ratio when compared to line sowing on sandy loam soils during summer at Jinju, Korea.

Mondal *et al.* (2008) revealed that among the herbicides tested, pre emergence application of butachlor 1.0 kg ha^{-1} with one hand weeding recorded higher net returns in sesame during *kharif* on black cotton soils of Sriniketan, West Bengal.

Caliskan *et al.* (2004) reported that line sowing had positive effects on yield and produced higher net returns in sesame on clay loam soils during *rabi* at Istanbul, Turkey.

Chapter – III

Material and Methods

Chapter III

MATERIAL AND METHODS

A field experiment was conducted at dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, to study the performance of pre-emergence herbicides under different methods of sowing in summer sesame, 2022. The material used and the methods employed during the course of investigation are presented in this chapter.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The experiment entitled "Performance of pre-emergence herbicides under different methods of sowing in summer sesame (*Sesamum indicum* L.) was conducted during summer, 2022, in field no. 99, dryland block of S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University, which is geographically situated at 13.5°N latitude and 79.5°E longitude, at an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh.

3.2 WEATHER DURING THE CROP GROWTH PERIOD

Weather data during the crop growth period, recorded at the S.V. Agricultural College Meteorological Observatory, Tirupati is presented in Table 3.1 and depicted in Fig. 3.1.

The weekly mean maximum temperature during the crop growth period ranged from 30.3 to 37.9°C, with an average of 33.7˚C. The decennial mean maximum temperature for the corresponding period ranged from 29.2 to 37.8°C with an average of 33.6°C. The weekly mean minimum temperature during the crop period ranged from 16.6 to 24.9°C, with an average of 20.3°C, whereas the decennial weekly mean minimum temperature for the corresponding period ranged from 17.9 to 24.6°C, with an average of 20°C.

Table 3.1. Standard week wise meteorological data during the crop growth period of sesame (19-01-2022 to 15-04-2022)

Standard week	Date and month	Temperature (°C)				Mean relative humidity (%)		Rainfall (mm)		Number of rainy days		Mean evaporation (mm day^{-1})		Mean bright sunshine (Hours)	
		Maximum		Minimum											
		A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
3	15 Jan. - 21 Jan.	30.4	0.60	18.9	2.40	66.8	-1.20	0.0	-0.10	0.0	0.00	4.4	0.20	6.9	0.20
4	22 Jan. - 28 Jan.	30.3	0.27	20.4	3.11	67.5	-1.29	5.43	5.43	2.00	1.90	4.3	-0.18	6.5	-1.18
5	29 Jan. - 04 Feb.	31.1	0.76	19.3	2.64	64.4	-1.36	0.00	-2.96	0.0	-0.10	4.2	-0.76	6.8	-0.69
6	05 Feb. - 11 Feb.	31.1	-0.47	18.8	1.47	65.4	1.33	0.00	-0.08	0.0	0.00	5.3	0.32	7.9	0.01
7	12 Feb. - 18 Feb.	30.8	-1.28	17.4	-1.80	63.4	1.05	0.00	-5.55	0.0	0.00	5.2	-0.07	8.1	0.25
8	19 Feb. - 25 Feb.	33.0	0.51	17.6	-0.56	56.1	-4.68	0.00	-15.50	0.0	-0.40	5.7	-0.28	8.8	0.59
9	26 Feb. - 04 Mar.	32.8	-1.30	16.6	-1.88	55.9	2.34	0.00	-4.90	0.0	-0.10	6.3	0.39	8.7	0.41
10	05 Mar. - 11 Mar.	33.6	-1.50	19.3	-2.95	52.8	-4.83	0.00	-4.43	0.0	-0.30	5.8	-0.94	8.1	0.29
11	12 Mar. - 18 Mar.	36.4	2.14	17.4	-3.17	45.0	-14.33	0.14	-5.90	0.0	-0.10	6.6	0.27	8.4	0.83
12	19 Mar. - 25 Mar.	36.8	-0.39	24.9	3.15	58.8	4.52	0.00	-0.42	0.0	-0.20	6.2	-0.49	5.8	-2.25
13	26 Mar. - 01 April	37.9	0.65	25.4	2.64	59.0	6.61	0.00	-3.48	0.0	0.00	6.9	0.22	8.1	0.19
14	2 April - 08 April	37.0	-1.70	24.4	-0.03	55.6	4.01	0.00	0.00	0.0	0.00	7.2	0.28	8.6	0.64
15	9 April - 15 April	37.6	-0.23	24.5	0.63	54.1	2.32	0.00	-0.12	0.0	-0.20	8.1	1.21	9.0	0.84
Total								**5.57**		**2.0**					

A: Actual; DN: Deviation from normal (decennial mean)

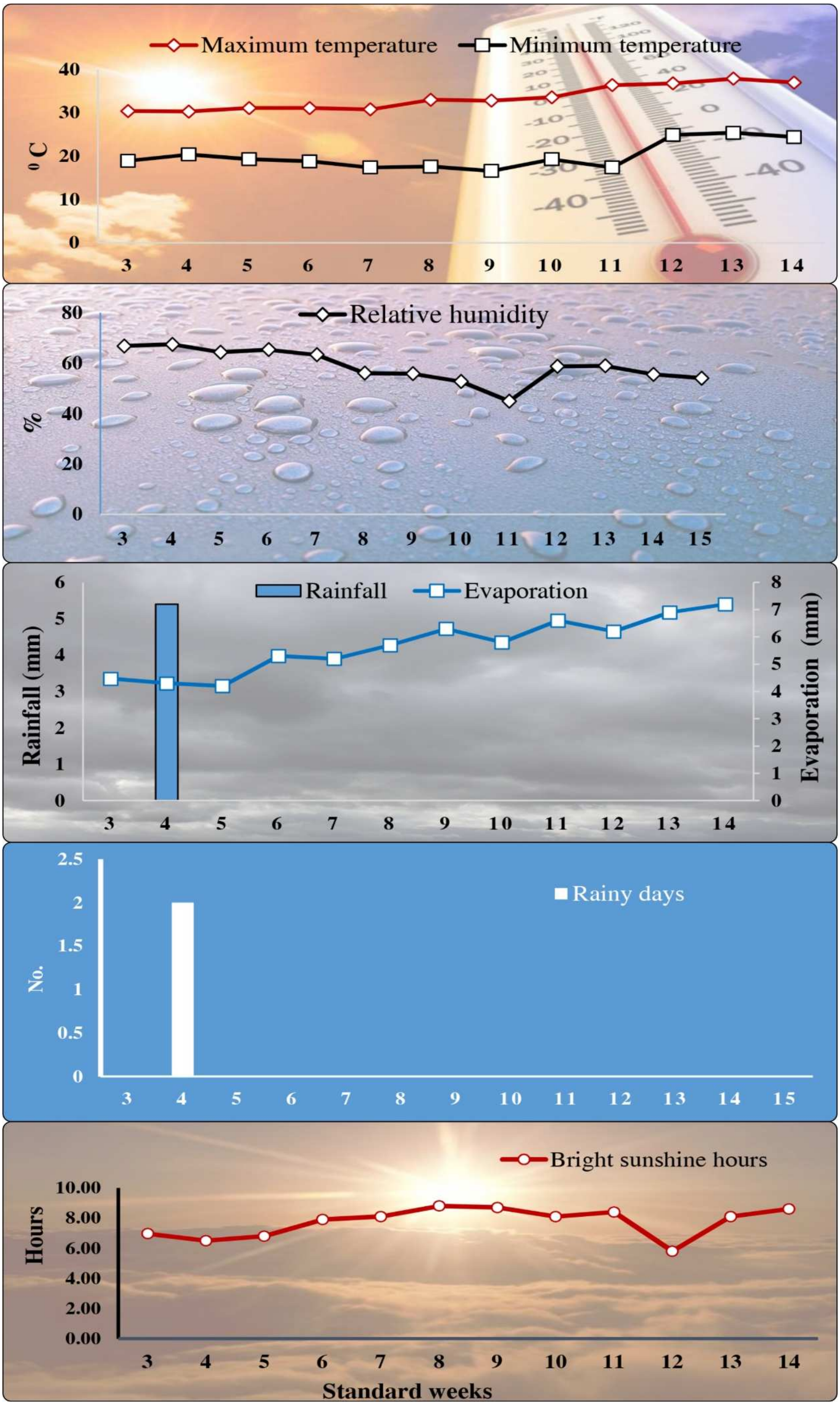


Fig. 3.1. Standard week wise meteorological data during the crop growth period of sesame (19-01-2022 to 15-04-2022).

The weekly mean relative humidity during the crop growth period ranged from 45 to 67.5 per cent, with an average of 58.8 per cent, while the decennial mean relative humidity for the corresponding period ranged from 51.7 to 72.3 per cent, with an average of 63.8 per cent. The weekly mean sunshine hours day^{-1} during the crop growth period ranged from 5.8 to 9.0, with an average of 7.8, whereas the decennial mean sunshine hours for the corresponding period ranged from 7.13 to 8.64, with an average of 8.07 hours day^{-1}.

During the crop growth period, total amount of 5.6 mm of rainfall was received in two rainy days as against the decennial average of 1.7 mm received in 0.12 rainy days for the corresponding period.

During the crop growth period, the evaporation from USWB Class-A open pan evaporimeter ranged from 4.2 to 8.1 mm day^{-1}, with an average of 5.8 mm day^{-1}, whereas the decennial mean for the corresponding period ranged from 4.13 to 7.21 mm day^{-1}, with an average of 5.9 mm day^{-1}.

3.3 SOIL

The composite soil sample was collected at random from 0-30 cm soil depth of the experimental field and analyzed for different physico-chemical properties prior to start of the experiment. The results of the soil analysis revealed that soil of the experimental field was sandy loam in texture, neutral in reaction, low in organic carbon (0.48 %) and nitrogen (150 kg ha^{-1}), high in available phosphorus (77 kg ha^{-1}) and medium in potassium (221 kg ha^{-1}) (Table 3.2).

3.4. CROPPING HISTORY OF THE EXPERIMENTAL FIELD

Details of the crops grown during the preceding three years in the experimental field are given below:

Year	*Kharif*	*Rabi*	Summer
2018-19	Groundnut	Horsegram	Fallow
2019-20	Bajra	Greengram	Fallow
2020-21	Horsegram	Blackgram	Fallow
2021-22	Fallow	Korra	**Sesame (Present experiment)**

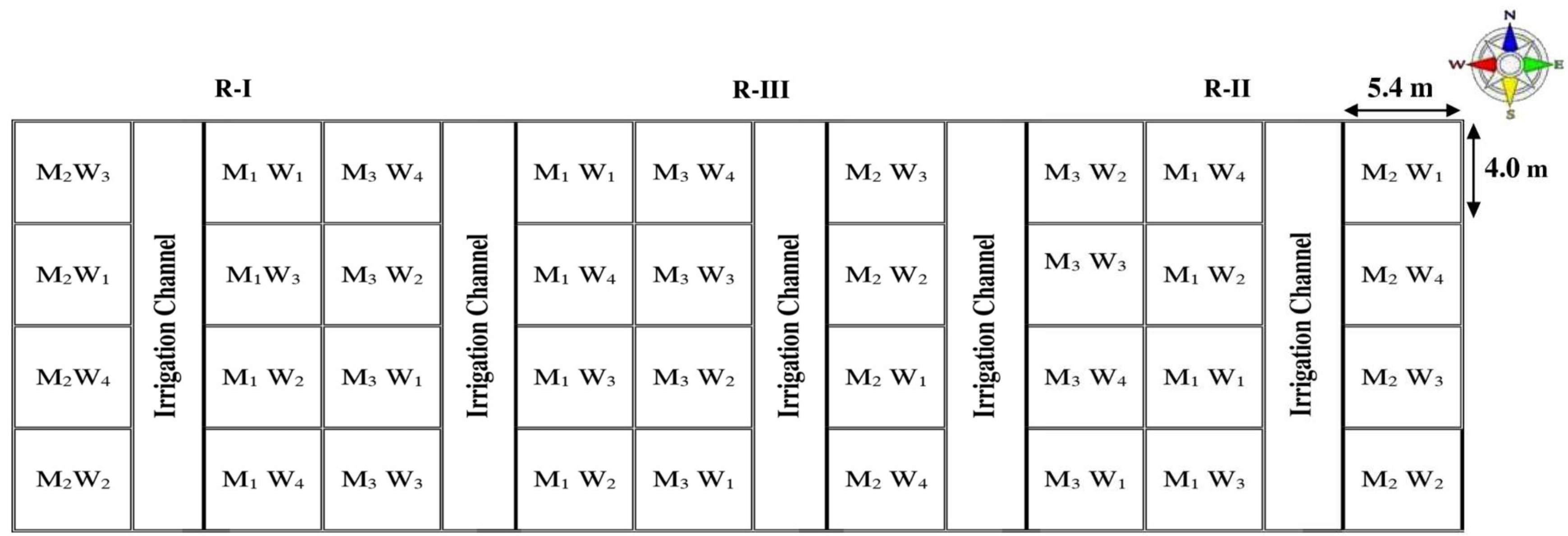
Table 3.2. Physico-chemical properties of the experimental field

Particulars	Value	Method adopted
A. Physical characteristics		
Sand (%)	65.4	Bouyoucos Hydrometer (Piper, 1950)
Silt (%)	27.2	
Clay (%)	07.4	
Textural class	Sandy loam	
B. Chemical characteristics		
Soil pH (1:2.5 Soil water suspension)	6.84	Glass electrode pH meter (Jackson, 1973)
EC (dS m^{-1}) at 25°C	0.24	Conductivity bridge (Jackson, 1973)
Organic carbon (%)	0.48	Rapid Titration Method (Walkley and Black, 1934)
Available N (kg ha^{-1})	150	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	77	Olsen's method (Olsen *et al.*, 1954)
Available K_2O (kg ha^{-1})	221	Flame photometry (Jackson, 1973)

3.5 EXPERIMENTAL DETAILS

3.5.1 Design and Layout

The experiment was laid out in a split-plot design with three main plots and four sub-plot treatments, replicated thrice. The layout plan of the experiment is depicted in Fig. 3.2.



Design: Split-plot **Gross plot: 5.4 m x 4.0 m** **Net plot: 3.6 m x 3.1 m**

Treatment details

Main plots: Methods of sowing (3)

M_1 : Line sowing (30 cm x 15 cm) (4 kg ha^{-1})
M_2 : Broadcasting with normal seed rate (5 kg ha^{-1})
M_3 : Broadcasting with 1.5 times seed rate (7.5 kg ha^{-1})

Sub plots: Weed management practices (4)

W_1 : Pre emergence application of butachlor 1.0 kg ha^{-1}
W_2 : Pre emergence application of oxyfluorfen 0.075 kg ha^{-1}
W_3 : Hand weeding (HW) at 20 and 40 DAS
W_4 : Unweeded check (control)

Fig. 3.2. Lay out plan of the experimental field.

3.5.2 Treatments

Main plots: **Methods of sowing (3)**

M_1 - Line sowing (30 cm x 15 cm) (4 kg ha^{-1})

M_2 - Broadcasting with normal seed rate (5 kg ha^{-1})

M_3 - Broadcasting with 1.5 times higher seed rate (7.5 kg ha^{-1})

Sub-plots: **Weed management practices (4)**

W_1 - Pre-emergence application of butachlor at 1.0 kg ha^{-1}.

W_2 - Pre-emergence application of oxyfluorfen at 0.075 kg ha^{-1}

W_3 - Hand weeding at 20 and 40 DAS

W_4 - Unweeded check (control)

3.5.3 Plot size

Gross : 5.4 m x 4.05 m

Net : 3.6 m x 3.15 m

3.5.4 Spacing

Spacing : 30 cm x 15 cm

3.5.5 Variety

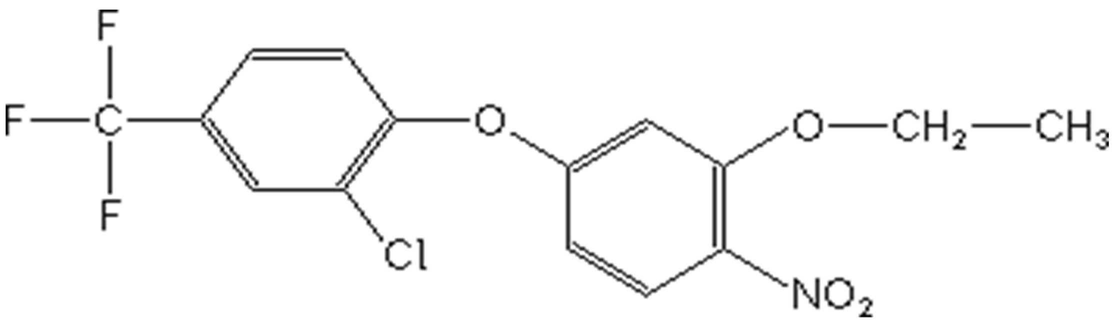
The test variety of sesame was Sarada (YLM-66), a promising variety released from Agricultural Research Station, Yellamanchili of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. It has high yield potential of 10 q ha^{-1} with duration of 80-85 days. It is tolerant to phyllody and Alternaria leaf spot. It has an average oil content of 50-51 per cent.

3.5.6 Details of Herbicides Used in the Study

3.5.6.1 Oxyfluorfen

Chemical group	:	Diphenyl ethers
Trade name	:	Goal
Formulation	:	Emulsifiable concentrate (EC)
Active ingredient	:	23.5 %
Chemical name	:	2 - Chloro -1-(3-ethoxy-4-nitrophenoxy) - 4 - (trifluoromethyl) benzene
Molecular formula	:	$C_{15} H_{11} Cl F_3NO_4$

Chemical structure

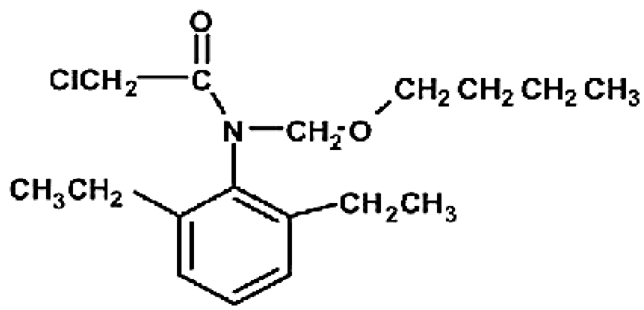


Oxyfluorfen is a selective pre and early post-emergence herbicide used to control many annual broadleaved and grassy weeds in vegetables, fruits, cotton, ornamentals and on non-cropped areas. Oxyfluorfen penetrates into the cytoplasm, causes the formation of peroxides and free electrons which destroy the cell membrane immediately.

3.5.6.2 Butachlor

Chemical group	:	Chloroacetanilide
Trade name	:	Machete
Formulation	:	Emulsifiable concentrate (EC)
Active ingredient	:	50 % EC
Chemical name	:	N (Butoxy methyl) - 2 - chloro - 2, 6 - diethyl acetamide
Molecular formula	:	$C_{17} H_{26} Cl NO_2$

Chemical structure



Butachlor is a herbicide of acetanilide class aromatic amide. It is used as a pre - emergence control of annual grasses and some broad leaved weeds. It has a low aqueous solubility and low volatility. Depending on local conditions it may be moderately persistent in some soils. It is moderately toxic to flora and fauna the main exception being honey bees for which butachlor has low toxicity. Mode of action of the chloro acetanilides are germination inhibitors and any seedling that emerge are stunted or malformed and cell division is inhibited. Chloroacetanilides effects the protein and lipid synthesis, ion transport and membrane functioning.

3.5.6.3 Herbicide Application

The required quantities of pre-emergence herbicides (butachlor, Oxyfluorfen) were applied one day after sowing by using spray fluid @ 500 l ha^{-1} with the help of knapsack sprayer fitted with flat fan nozzle as per the treatments.

3.6 CULTIVATION DETAILS

3.6.1 Main Field Preparation

The main field was ploughed twice with tractor drawn cultivator to obtain fine tilth. Then, the field was laid out into plots according to lay-out.

3.6.2 Sowing

The required quantity of sesame seed was treated with mancozeb @ 3.0 g kg^{-1} to prevent seed borne diseases.

3.6.2.1 Line sowing

Recommended seed rate of 4 kg ha^{-1} with spacing of 30 cm x 15 cm was adopted. Sesame seed mixed with sand (1:7) for uniform distribution.

3.6.2.2 Broadcasting

Sowing was carried out manually by broadcasting using recommended seed rate of 5 kg ha^{-1}. Sesame seed was mixed with sand (1:7) for uniform distribution.

3.6.2.3 Broadcasting with 1.5 times seed rate

Sowing was carried out manually by broadcasting with 1.5 times seed rate (7.5 kg ha^{-1}). Sesame seed was mixed with sand (1:7) for uniform distribution.

3.6.3 Thinning

Thinning was done on fifteenth day after sowing by retaining only one healthy and vigorous seedling $hill^{-1}$.

3.6.4 Fertilizers

A uniform dose of 40 kg N, 20 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied through urea, single super phosphate and muriate of potash respectively to all the plots. Nitrogen was applied in two splits. Half the dose of nitrogen along with entire dose of phosphorus and potassium were applied as basal at the time of sowing and the remaining half the dose of nitrogen was top dressed at 30 DAS.

3.6.5 Irrigation

In total, six irrigations were given to the crop during the crop growth period. Post sowing irrigation was given after sowing for good germination and better establishment. Five irrigations were given on 7^{th}, 20^{th}, 35^{th}, 45^{th} and 60^{th} day after sowing.

3.6.6 Weeding

The weed management practices were imposed as per treatments mentioned in 3.5.2.

3.6.7 Plant Protection

Spraying of Thiodicarb @ 3g litre^{-1} of water was done at 20 DAS against tobacco caterpillar (*Spodoptera litura* L.). Wettable sulphur @ 3.0 g litre^{-1} of water was sprayed to control the incidence of powdery mildew (*Leveillula taurica* L.) at 55 DAS.

3.6.8 Harvesting and Threshing

The crop was considered to be matured, when the leaves, stems and capsules began to turn yellow and the lower leaves start shedding. Initially, the border plants were cut close to the ground level and kept separately for further processing. Randomly selected five plants in each plot were harvested separately. The plants in net plot were harvested, dried for 2 days and then threshing was done manually by beating with sticks. The collected seeds were winnowed, cleaned and sun dried. The seed and stalk yields from each net plot were recorded separately and expressed as kg ha^{-1}. The yield obtained from sample plants was added to net plot yield.

3.7 OBSERVATIONS ON WEEDS

Observations on weed growth at different growth stages viz., 20, 40, 60 DAS and at harvest were recorded from three randomly selected quadrat areas (0.25 m^2) in each plot.

3.7.1 Weed Flora

Weed flora of the experimental site was identified and categorized as grasses, sedges and broad leaved weeds in all the treatments.

3.7.2 Weed Density

Weed counts were taken at 20, 40, 60 DAS and at harvest. At every stage of the sampling, weeds were categorized into grasses, sedges and broad leaved weeds and expressed as number m^{-2}.

3.7.3 Weed Dry Weight

The weeds collected from 0.25 m^2 quadrat area, outside the net plot were dried under shade for 24 hours, followed by oven drying at 60°C to a constant weight and the dry weight of all the categories of weeds and at all the stages of observation were expressed as g m^{-2}.

3.7.4 Weed Index (WI)

Weed index was calculated based on the yield in various treatments by using the following formula as suggested by Gill and Vijay Kumar (1969).

$$\text{Weed index}(\%) = \frac{\text{Yield from the best treatment plot - Yield from the treatment imposted plot}}{\text{Yield from the best treatment plot}}$$

3.8 BIOMETRIC OBSERVATIONS ON CROP

3.8.1 Initial and Final Plant Population

The initial plant population was counted before thinning at 15 DAS. The final plant population was counted at harvest from the net plot area of 1.0 m^2.

3.8.2 Plant Height

Plant height was measured from the base of the plant to the tip of the growing point, at all the stages of observation from randomly labelled five plants in each net plot area and expressed in cm.

3.8.3 Phytotoxicity Scoring

Phytotoxicity scoring on the crop was observed on 10th day after pre-emergence herbicides application, as per the method suggested by Singh and Rao (1976).

Effect	Rating	Visual symptoms
None	0	No injury, normal growth
	1	Slight stunting injury or discolouration
	2	Some stand loss, stunting or discoloration
	3	Injury more pronounced but not persistent
Moderate	4	Moderate injury, recovery is possible
	5	Injury more persistent recovery is doubtful
	6	Near severe injury, no recovery possible
	7	Severe injury, stand loss
	8	Almost destroyed, few plants surviving
	9	Very few plants alive
Complete	10	Complete destruction

3.8.4 Leaf Area

Leaf area was recorded from five randomly selected plants from sampling area outside the net plot at 20, 40, 60 DAS and at harvest, using LI-COR model, LT-300 portable leaf area meter with transparent conveyor belt and electronic display. The leaf area was averaged and expressed as cm^2 $plant^{-1}$.

3.8.5 Number of Branches Plant^{-1}

The numbers of branches of tagged individual plants in each net plot area were counted, averaged and expressed as number of branches $plant^{-1}$.

3.8.6 Dry Matter Production

Five plants at random from the border rows leaving the extreme row were destructively sampled at 20, 40, 60 DAS and at harvest for the estimation of dry matter production. The samples were sun dried and then oven dried at 60°C to a constant weight and expressed as kg ha^{-1}.

3.9 POST-HARVEST OBSERVATIONS

3.9.1 Number of Capsules $Plant^{-1}$

The total number of capsules $plant^{-1}$ from the five labeled plants were counted, averaged for each treatment and expressed as number of capsules $plant^{-1}$.

3.9.2 Number of Seeds $Capsule^{-1}$

The total number of seeds $capsule^{-1}$ from five randomly selected plants were counted and averaged for each treatment expressed as number of seeds $capsule^{-1}$.

3.9.3 Test Weight

A small sample of seeds from net plot produce for each treatment was drawn and counted 1000 seeds from the sample, weighed and expressed in g.

3.9.4 Seed Yield

The seed obtained from each net plot area was thoroughly sun dried, cleaned and weighed. The seed yield from the five sampled plants was also added to net plot yield and the total seed was weighed and expressed in kg ha^{-1}.

3.9.5 Stalk Yield

The stalk yield obtained from net plot area along with five sampled plants was sundried, weighed and expressed in kg ha^{-1}.

3.9.6 Harvest Index

It is the ratio between economical and biological yield and it was calculated by using the formula and expressed in per cent (%).

$$\text{Harvest Index}\left(\%\right)=\frac{\text{Economic yield }\left(\text{kg ha}^{-1}\right)}{\text{Biological yield }\left(\text{kg ha}^{-1}\right)}\times 100$$

3.10 NUTRIENT UPTAKE BY WEEDS AND CROP AT HARVEST

Composite plant samples of crop as well as weeds from all the plots were collected at harvest and these samples were dried, ground into fine powder and used for estimation of N, P and K by using standard procedures outlined by Jackson (1973). The uptake of nitrogen, phosphorus and potassium at harvest by the crop and its associated weeds were calculated by multiplying the respective nutrient content with corresponding dry weights and expressed as kg ha^{-1}.

3.11 ECONOMICS

The total cost of cultivation of sesame was calculated for all the treatments on the basis of inputs used. Gross returns were computed considering the existing market price of the output *i.e.*, seed. Net returns were arrived by subtracting the cost of cultivation of respective treatments from gross returns for the corresponding treatments. Benefit-cost ratio was worked out for different treatments by dividing the gross returns with corresponding cost of cultivation of the respective treatment.

3.12 STATISTICAL ANALYSIS

The data recorded on various parameters of crop as well as weeds during the course of investigation in the field experiment was statistically analyzed following the analysis of variance for split – plot design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with ‘F’ test at 5 per cent level of probability and compared the treatmental means with critical difference. Due to larger variation in density and dry weight of weeds, the corresponding data were transformed using square root transformation $\left(\sqrt{x}+0.5\right)$ before subjecting to statistical analysis as suggested by Gomez and Gomez (1984).

Chapter – IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

Results and discussion of the field experiment “Performance of pre emergence herbicides under different methods of sowing in summer sesame (*Sesamum indicum* L.)” conducted during summer, 2022 on sandy loam soils of dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh are presented.

4.1 WEATHER

Weather during the crop growth period was ideal for the sesame crop. Weather parameters did not deviate much from the normal decennial mean of the location. (Table 3.1 and Fig. 3.1).

4.2 WEED DYNAMICS AS INFLUENCED BY DIFFERENT WEED MANAGEMENT PRACTICES

Weed flora of the experimental field was classified into grasses, sedges and broad leaved weeds (BLW). Category wise weed density and dry weight were recorded at 20, 40, 60 DAS and at harvest.

4.2.1 Weed Flora of the Experimental Field

Weed flora of the experimental field consisted of eight taxonomic families of which four species were grasses, twelve broad leaved weeds and only two species of sedges. Predominant weed species in the field were *Cyperus rotundus* (40.0 %), *Commelina benghalensis* (10.0 %), *Cleome viscosa* (8.0 %), *Boerhavia diffusa* (5.0 %), *Phyllanthus niruri* (5.0 %) *Dactyloctenium aegyptium* (5.0 %), and *Digitaria sanguinalis* (4.0 %) in unweeded check plots.

Among all the weeds, *Cyperus rotundus* L. was dominant. It might have become more persistent due to intensive cropping by eliminating other weed species. Further, there was no lowland rice cultivation in the field which can suppress *Cyperus rotundus*. Weeds observed in the experimental field were similar to those reported by Patnaik *et al*. (2020) and Aruna *et al*. (2020) (Table 4.1).

Table 4.1. Weed flora of the experimental field

S. No	Botanical Name	Common Name	Family
I	**Grasses**		
1	*Brachiaria reptans* L.	Running grass	Poaceae
2	*Dactyloctenium aegyptium* L.	Crow foot grass	Poaceae
3	*Digitaria sanguinalis* L.	Large crab grass	Poaceae
4	*Sporobolus indicus* L.	Rat tail grass	Poaceae
II	**Sedges**		
1	*Cyperus rotundus* L.	Purple nutsedge	Cyperaceae
2	*Cyperus difformis* L.	Umbrella sedge	Cyperaceae
III	**Broad leaved weeds**		
1	*Commelina benghalensis* L.	Day flower	Commelinaceae
2	*Cleome viscosa* L.	Spider flower	Capparaceae
3	*Boerhavia diffusa* L.	Spiderling	Nyctaginaceae
4	*Euphorbia hirta* L.	Garden spurge	Euphorbiaceae
5	*Digera arvensis* L.	False amaranth	Amaranthaceae
6	*Phyllanthus niruri* L.	Niruri	Euphorbiaceae
7	*Celosia argentea* L.	White cock’s comb	Amaranthaceae
8	*Physalis minima* L.	Ground cherry	Solanaceae
9	*Amaranthus viridis* L.	Slender amaranth	Amaranthaceae
10	*Datura stramonium* L.	Jimson weed	Solanaceae
11	*Trichodesma indicum* L.	Indian borage	Boraginaceae
12	*Tridax procumbens* L.	Coat buttons	Asteraceae

Weed density at 20, 40, 60 DAS and at harvest was significantly influenced by methods of sowing and weed management practices. Interaction between methods of sowing and weed management practices was not significant.

4.2.2 Weed Density at 20 DAS

Weed density significantly varied due to methods of sowing and weed management practices. Interaction between methods of sowing and weed management practices was not significant (Table 4.2 and Fig. 4.1).

4.2.2.1 Grasses

Among the methods of sowing, lowest density of grasses (3.72 m^{-2}) was due to broadcasting with higher seed rate (M_3) followed by line sowing (M_1) (3.96 m^{-2}). Highest density of grasses (4.29 m^{-2}) was with broadcasting using recommended seed rate (M_2) which was significantly higher than the rest of the sowing methods.

Density of grasses varied significantly among weed management practices. Significantly lowest weed density of grasses (2.90 m^{-2}) was with pre emergence application of oxyfluorfen (W_2) followed (4.11 m^{-2}) by butachlor (W_1). Differences in weed density due to hand weeding (W_3) (4.39 m^{-2}) and control (W_4) (4.57 m^{-2}) were not significant.

4.2.2.2 Sedges

Density of sedges at 20 DAS significantly differed due to methods of sowing and weed management practices.

Broadcasting with 1.5 times higher seed rate (M_3) significantly reduced the weed density (6.69 m^{-2}) compared with line sowing (M_1) (7.46 m^{-2}) and broadcasting (M_2) (8.46 m^{-2}). Difference between line sowing and broadcasting with higher seed (M_3) rate was also significant.

Table 4.2. Weed density (No. m^{-2}) at 20 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	3.96 (15.83)	7.46 (56.58)	6.70 (48.91)	10.80 (121.32)
M_2 : Broadcasting	4.29 (18.58)	8.46 (71.75)	7.11 (54.25)	11.88 (144.58)
M_3 : Broadcasting with 1.5 times seed rate	3.72 (13.91)	6.69 (46.25)	5.90 (38.33)	9.70 (98.49)
SEm$\pm$	0.060	0.171	0.081	0.170
CD (P = 0.05)	0.23	0.70	0.34	0.69
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	4.11 (16.77)	6.97 (50.33)	6.20 (38.22)	10.18 (105.32)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	2.90 (8.00)	6.32 (40.55)	3.46 (11.77)	7.71 (60.32)
W_3 : Hand weeding at 20 and 40 DAS	4.39 (19.78)	8.20 (67.11)	8.06 (65.66)	12.69 (152.55)
W_4 : Unweeded check (control)	4.57 (20.66)	8.67 (74.77)	8.56 (73.00)	12.98 (168.43)
SEm$\pm$	0.091	0.212	0.161	0.211
CD (P = 0.05)	0.27	0.64	0.50	0.62
Interaction				
M at W				
SEm$\pm$	0.151	0.372	0.262	0.334
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm$\pm$	0.166	0.382	0.293	0.363
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

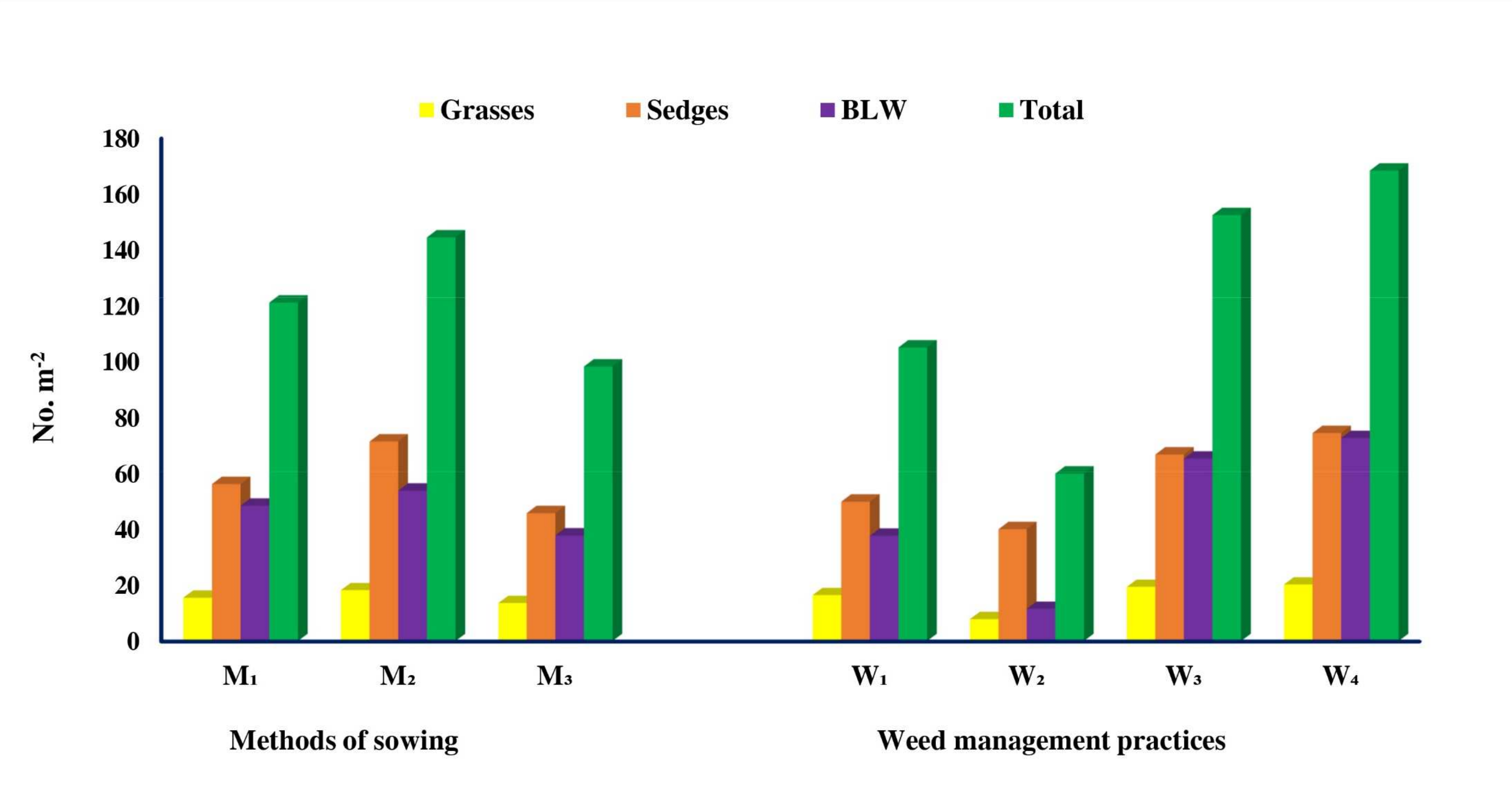


Fig. 4.1. Weed density (No. m^{-2}) at 20 DAS of sesame as influenced by methods of sowing and weed management practices.

Among the weed management practices, weed density was significantly low (6.32 m^{-2}) with oxyflourfen (W_2), relative to butachlor (W_1) (6.97 m^{-2}) and hand weeding (W_3) (8.20 m^{-2}).

4.2.2.3 Broad leaved weeds

Among the methods of sowing, lowest density of broad leaved weeds (5.90 m^{-2}) was recorded with broadcasting using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment with lower density (6.70 m^{-2}) of broad leaved weeds was line sowing (M_1). While broadcasting recommended seed rate (M_2) (7.11 m^{-2}) recorded significantly higher density of broad leaved weeds.

Density of broad leaved weeds significantly differed among weed management practices. Lowest density of broad leaved weeds was (3.46 m^{-2}) with pre emergence application of oxyfluorfen (W_2) followed by pre emergence application (6.20 m^{-2}) of butachlor (W_1). The highest density (8.56 m^{-2}) of broad leaved weeds was with unweeded check (W_4), which was however, comparable with hand weeding twice (W_3) (8.06 m^{-2}) (Hand weeding was not imposed by that time).

4.2.2.4 Total weeds

Lowest density (9.70 m^{-2}) of total weeds was with broadcasting with higher seed rate (M_3) which was significantly lesser followed by line sowing (M_1) (10.80 m^{-2}) and broadcasting with recommended seed rate (11.88 m^{-2}) (M_2). Differences due to these treatments was also significant.

Density of total weeds varied significantly due to weed management practices. Lowest total weed density (7.71 m^{-2}) was with pre emergence application of oxyfluorfen (W_2) followed by pre emergence application (10.18 m^{-2}) of butachlor (W_1). Highest density of total weeds (12.98 m^{-2}) was with unweeded check (W_4), which was at par with hand weeding twice (W_3) (12.69 m^{-2}) (hand weeding was not imposed by that time).

4.2.3 Weed Density at 40 DAS

Weed management practices significantly influenced the density of grasses, sedges, broad leaved weeds and total weeds at 40 DAS. Interaction between methods of sowing and weed management practices was not significant (Table 4.3 and Fig. 4.2).

4.2.3.1 Grasses

Significantly, the lowest grasses count (3.84 m^{-2}) was with broadcasting with higher seed rate (M_3) which was significantly lesser than the other sowing methods. The next treatment having lower density of grasses (4.30 m^{-2}) was line sowing (M_1). Broadcasting with recommended seed rate (M_2) resulted in significantly highest weed density (4.91 m^{-2}).

The lowest grasses count (2.44 m^{-2}) was with hand weeding (W_3) followed by pre emergence application (3.70 m^{-2}) of oxyfluorfen (W_2). Butachlor (W_1) was the next best weed management practice in suppressing the grassy weeds.

The highest density of grasses (6.60 m^{-2}) was with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.3.2 Sedges

Sedge density was significantly lower (9.44 m^{-2}) with broadcasting using higher seed rate (M_3) followed by line sowing (M_1) (9.73 m^{-2}). Significantly highest sedge density (9.99 m^{-2}) was with seed broadcasting (M_2).

Hand weeding (W_3) recorded lowest weed density (7.21 m^{-2}), which was significantly lower (8.26 m^{-2}) than with oxyfluorfen (W_2). The next best treatment was butachlor (10.71 m^{-2}) (W_1) followed by control (W_4) (12.42 m^{-2}), which recorded significantly higher weed density.

4.2.3.3 Broad leaved weeds

Broadcasting using higher seed rate (M_3), resulted in significantly lower (6.49 m^{-2}) density of broad leaved weeds relative to line sowing (M_1)

Table 4.3. Weed density (No. m^{-2}) at 40 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	4.30 (21.25)	9.73 (97.16)	7.10 (51.5)	13.02 (169.91)
M_2 : Broadcasting	4.91 (26.50)	9.99 (101.00)	7.54 (56.41)	13.59 (183.9)
M_3 : Broadcasting with 1.5 times seed rate	3.84 (16.05)	9.44 (92.75)	6.49 (46.16)	12.44 (154.96)
SEm±	0.101	0.030	0.082	0.033
CD (P = 0.05)	0.40	0.13	0.34	0.14
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	4.65 (21.41)	10.71 (114.4)	7.49 (55.77)	13.82 (191.58)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	3.70 (13.75)	8.26 (68.44)	6.45 (41.00)	11.14 (123.19)
W_3 : Hand weeding at 20 and 40 DAS	2.44 (5.55)	7.21 (51.60)	3.26 (10.22)	8.22 (67.37)
W_4 : Unweeded check (control)	6.60 (43.60)	12.42 (154.00)	9.89 (97.44)	17.18 (295.11)
SEm±	0.144	0.071	0.131	0.101
CD (P = 0.05)	0.41	0.23	0.41	0.32
Interaction				
M at W				
SEm±	0.230	0.131	0.222	0.161
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	0.244	0.131	0.242	0.181
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

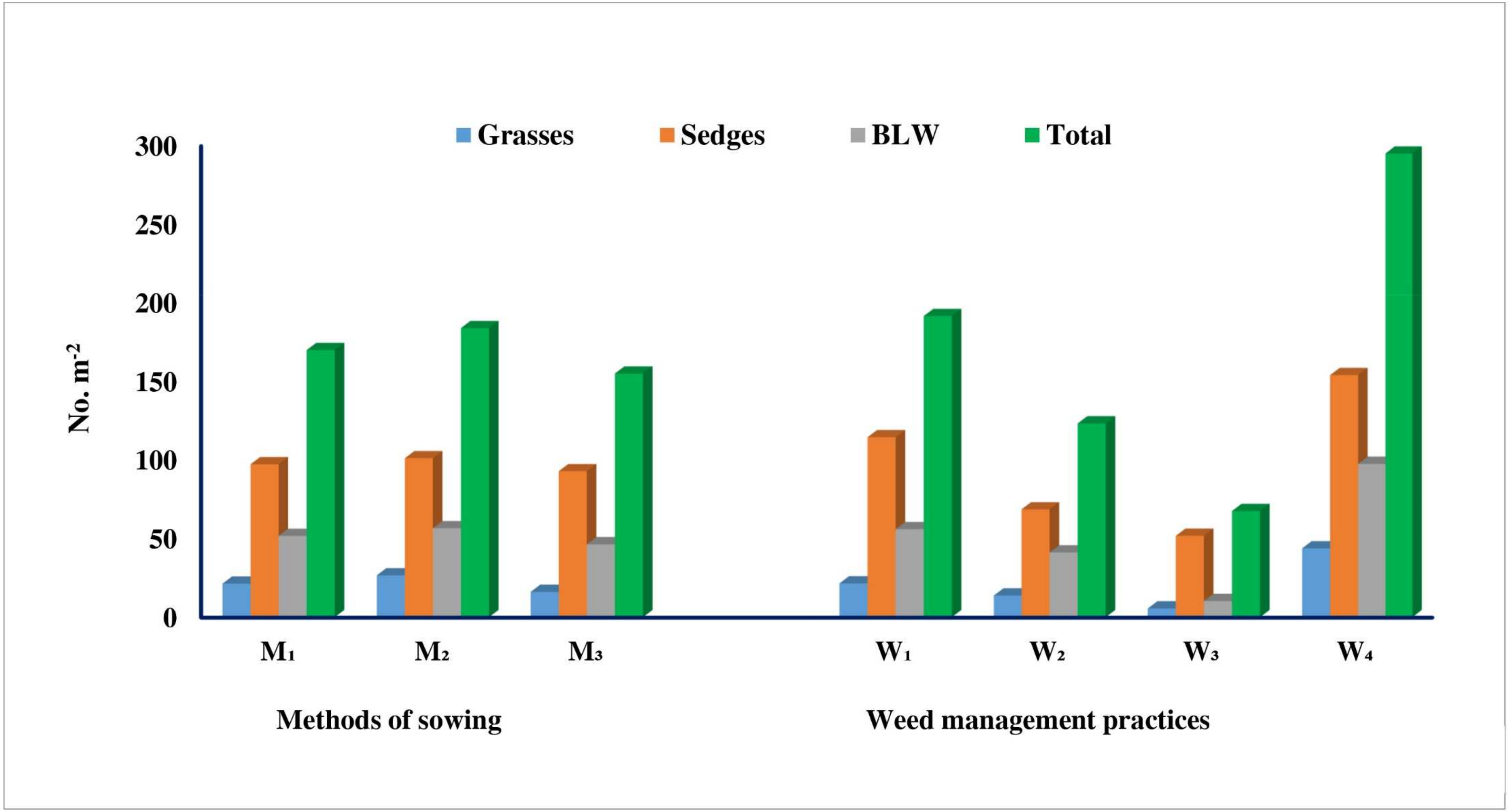


Fig. 4.2. Weed density (No. m^{-2}) at 40 DAS of sesame as influenced by methods of sowing and weed management practices.

(7.10 m^{-2}). Significantly higher density of broad leaved weeds (7.54 m^{-2}) was with broadcasting (M_2) the seed.

Hand weeding (W_3) significantly reduced (3.26 m^{-2}) the broad leaved weed density, relative to the application of oxyflourfen (W_2) (6.45 m^{-2}). Butachlor (W_1) recorded significantly lower broad leaved weed density (7.49 m^{-2}) as compared to control (W_4) (9.89 m^{-2}).

4.2.3.4 Total weeds

Total density of weeds was significantly highest (13.59 m^{-2}) with seed broadcasting (M_2) as compared with line sowing (M_1) (13.02 m^{-2}). Broadcasting using higher seed rate (M_3), recorded significantly lower weed density (12.44 m^{-2}), relative to the other two methods of seeding.

Unweeded check (W_4) resulted in significantly higher weed density (17.18 m^{-2}) relative to other treatments. Differences due to butachlor (W_1) (13.82 m^{-2}) and oxyflourfen (W_2) (11.14 m^{-2}) were also significant. Significantly lowest weed density was due to hand weeding (W_3) (8.22 m^{-2}).

4.2.4 Weed Density at 60 DAS

At 60 DAS, weed density differed due to methods of seeding and weed management practices. Interaction effect of these two management practices could not significantly vary the weed density (Table 4.4 and Fig. 4.3).

4.2.4.1 Grasses

Significantly highest density of grasses (5.43 m^{-2}) was due to seed broad casting (M_2). Difference in weed density due to line sowing (M_1) (4.91 m^{-2}) and broadcasting using higher seed rate (M_3) (4.48 m^{-2}) was also significant.

The lowest grasses count (3.31 m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (4.33 m^{-2}). Butachlor (W_1) was the next best weed management practice in suppressing the grass density (5.16 m^{-2}). The highest density of grasses (6.97 m^{-2}) was with

Table 4.4. Weed density (No. m^{-2}) at 60 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	4.91 (26.12)	9.96 (102.83)	7.15 (54.16)	13.17 (183.11)
M_2 : Broadcasting	5.43 (31.1)	10.15 (107.66)	7.55 (59.08)	14.04 (197.84)
M_3 : Broadcasting with 1.5 times seed rate	4.48 (21.11)	9.75 (97.41)	6.58 (46.68)	12.71 (165.2)
SEm$\pm$	0.080	0.044	0.073	0.042
CD (P = 0.05)	0.35	0.18	0.31	0.16
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	5.16 (26.41)	10.97 (122.11)	7.67 (58.44)	14.62 (206.96)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	4.33 (19.75)	8.63 (75.11)	6.83 (45.66)	11.83 (140.52)
W_3 : Hand weeding at 20 and 40 DAS	3.31 (10.55)	7.55 (57.66)	3.65 (12.88)	9.04 (81.09)
W_4 : Unweeded check (control)	6.97 (48.66)	12.65 (159.66)	10.02 (100.11)	17.56 (308.43)
SEm$\pm$	0.133	0.072	0.091	0.101
CD (P = 0.05)	0.38	0.22	0.28	0.30
Interaction				
M at W				
SEm$\pm$	0.211	0.121	0.162	0.152
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm$\pm$	0.220	0.131	0.171	0.170
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

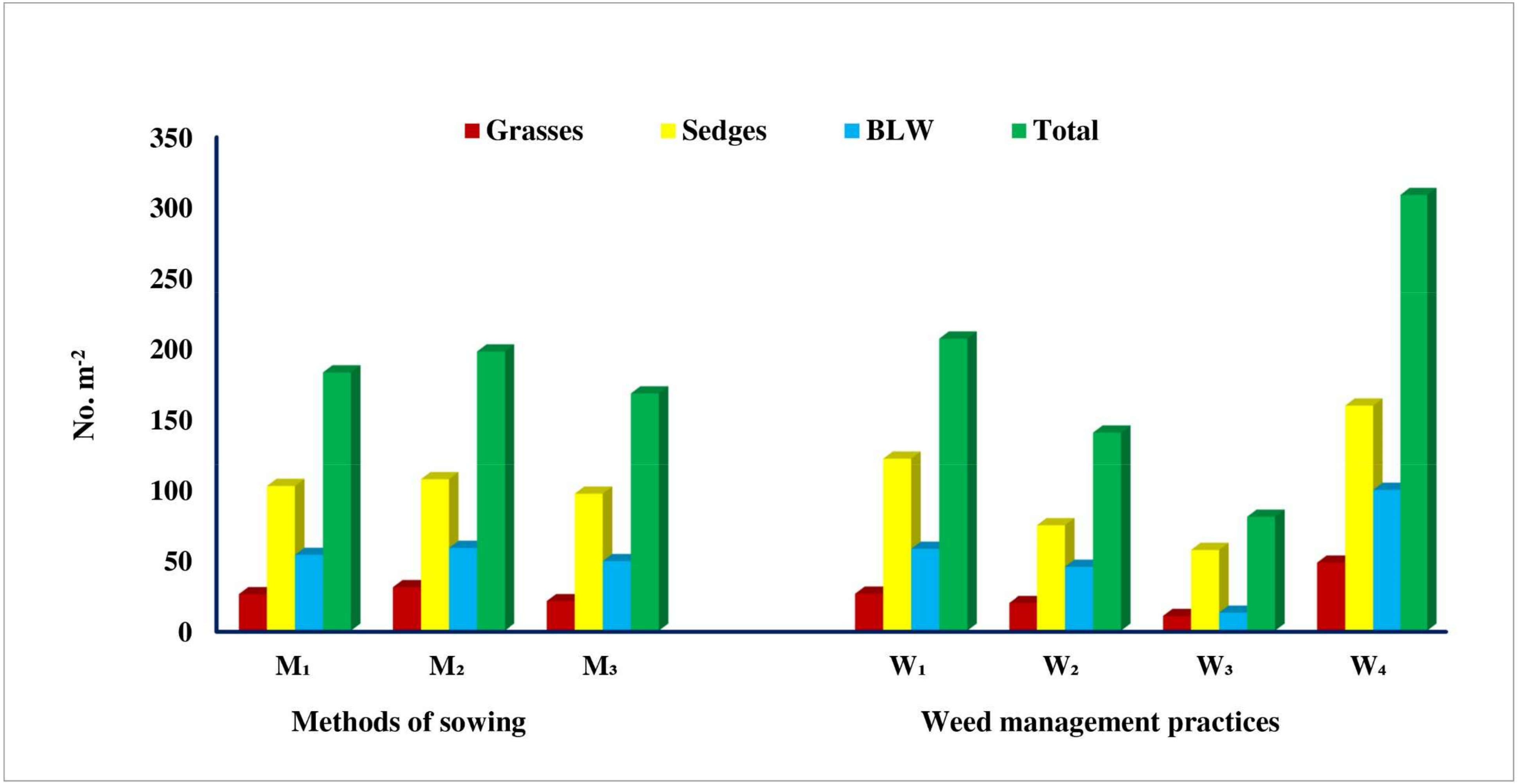


Fig. 4.3. Weed density (No. m^{-2}) at 60 DAS of sesame as influenced by methods of sowing and weed management practices.

unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.4.2 Sedges

Significantly highest density (10.15 m^{-2}) of sedges was with broadcasting (M_2) the seed followed by line seeding (M_1) (9.96 m^{-2}). Broadcasting using higher seed rate (M_3) (9.96 m^{-2}) resulted in significantly lesser weed density.

The lowest sedges count (7.55 m^{-2}) was registered with hand weeding twice (W_3) followed by pre emergence application of oxyfluorfen (W_2) (8.63 m^{-2}). Butachlor (W_1) was the next best weed management practice recorded lower sedge count (10.97 m^{-2}). The highest density of sedges was registered with unweeded check (W_4) (12.65 m^{-2}), which was significantly higher than the rest of the weed management practices.

4.2.4.3 Broad leaved weeds

Highest (7.55 m^{-2}) weed density of broad leaved weeds was observed with broadcast seeding (M_2) which was significantly higher than the other two treatments. Line seeding (M_1) (7.15 m^{-2}) was next best treatment followed by broadcasting with high seed rate (M_3) (6.58 m^{-2}).

Weed density was significantly lowest (3.65 m^{-2}) with hand weeding (W_3) followed by that due to oxyflourfen (W_2) (6.83 m^{-2}). Butachlor (W_1) recorded significantly lower broad leaved weeds (7.67 m^{-2}) related to weedy check (W_4) (10.02 m^{-2}).

4.2.4.4 Total weeds

Among the methods of sowing, broadcasting using higher seed rate (M_3) recorded significantly lower total weed density (12.71 m^{-2}) compared with line sowing (M_1) (13.17 m^{-2}). Broadcasting (M_2) resulted in significantly highest total weed density (14.04 m^{-2}).

Total weed density was significantly lowest (9.04 m^{-2}) with hand weeding (W_3) followed by that due to oxyflourfen (W_2) (11.83 m^{-2}) application. Weedy check (W_4) recorded significantly highest (17.56 m^{-2}) total weed density, which was significantly higher than that due to butachlor application (W_1) (14.62 m^{-2}).

4.2.5 Weed Density at Harvest

Methods of sowing and weed management in sesame significantly influenced the density of grasses, sedges, broad leaved weeds and total weeds at harvest. Interaction between these management practices was not significant (Table 4.5 and Fig. 4.4).

4.2.5.1 Grasses

Among methods of sowing significantly lowest grasses count (4.38 m^{-2}) was with broadcasting with higher seed rate (M_3). Line seeding (M_1) recorded (5.07 m^{-2}) weeds which was significantly lower than broadcast seeding (M_2) (5.66 m^{-2}).

Hand weeding (W_3) recorded significantly lowest grass density (3.36 m^{-2}) compared with other three treatments. Application of oxyflourfen (W_2) resulted in significantly lower number of grasses (4.55 m^{-2}) relative to butachlor (W_1) (5.04 m^{-2}) and weedy check (W_4) (6.84 m^{-2}).

4.2.5.2 Sedges

Lowest sedges (9.58 m^{-2}) count was with broadcast seeding using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment having lower density of sedges was line sowing (M_1) (9.79 m^{-2}). Highest density of sedges (9.99 m^{-2}) with broadcasting using recommended seed rate (M_2).

The lowest sedges count (7.21 m^{-2}) was registered with hand weeding (W_3) followed by oxyfluorfen (W_2) application (8.34 m^{-2}). Butachlor (W_1) (10.74 m^{-2}) was the next best weed management practice. The highest density

Table 4.5. Weed density (No. m^{-2}) at harvest of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	5.07 (23.79)	9.79 (97.83)	7.21 (51.50)	13.15 (173.12)
M_2 : Broadcasting	5.66 (28.77)	9.99 (101.66)	7.64 (56.41)	13.66 (186.84)
M_3 : Broadcasting with 1.5 times seed rate	4.38 (18.72)	9.58 (93.26)	6.79 (47.01)	12.67 (159.99)
SEm$\pm$	0.061	0.041	0.080	0.041
CD (P = 0.05)	0.25	0.18	0.34	0.17
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	5.04 (24.07)	10.74 (115.11)	7.49 (55.77)	14.06 (194.95)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	4.55 (16.42)	8.34 (69.11)	6.51 (42.0)	11.32 (127.53)
W_3 : Hand weeding at 20 and 40 DAS	3.36 (8.22)	7.21 (51.66)	3.26 (10.22)	8.87 (70.11)
W_4 : Unweeded check (control)	6.84 (46.33)	12.45 (154.66)	9.89 (97.44)	17.77 (298.43)
SEm$\pm$	0.121	0.070	0.141	0.133
CD (P = 0.05)	0.37	0.22	0.41	0.39
Interaction				
M at W				
SEm$\pm$	0.221	0.172	0.221	0.131
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm$\pm$	0.232	0.182	0.243	0.161
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

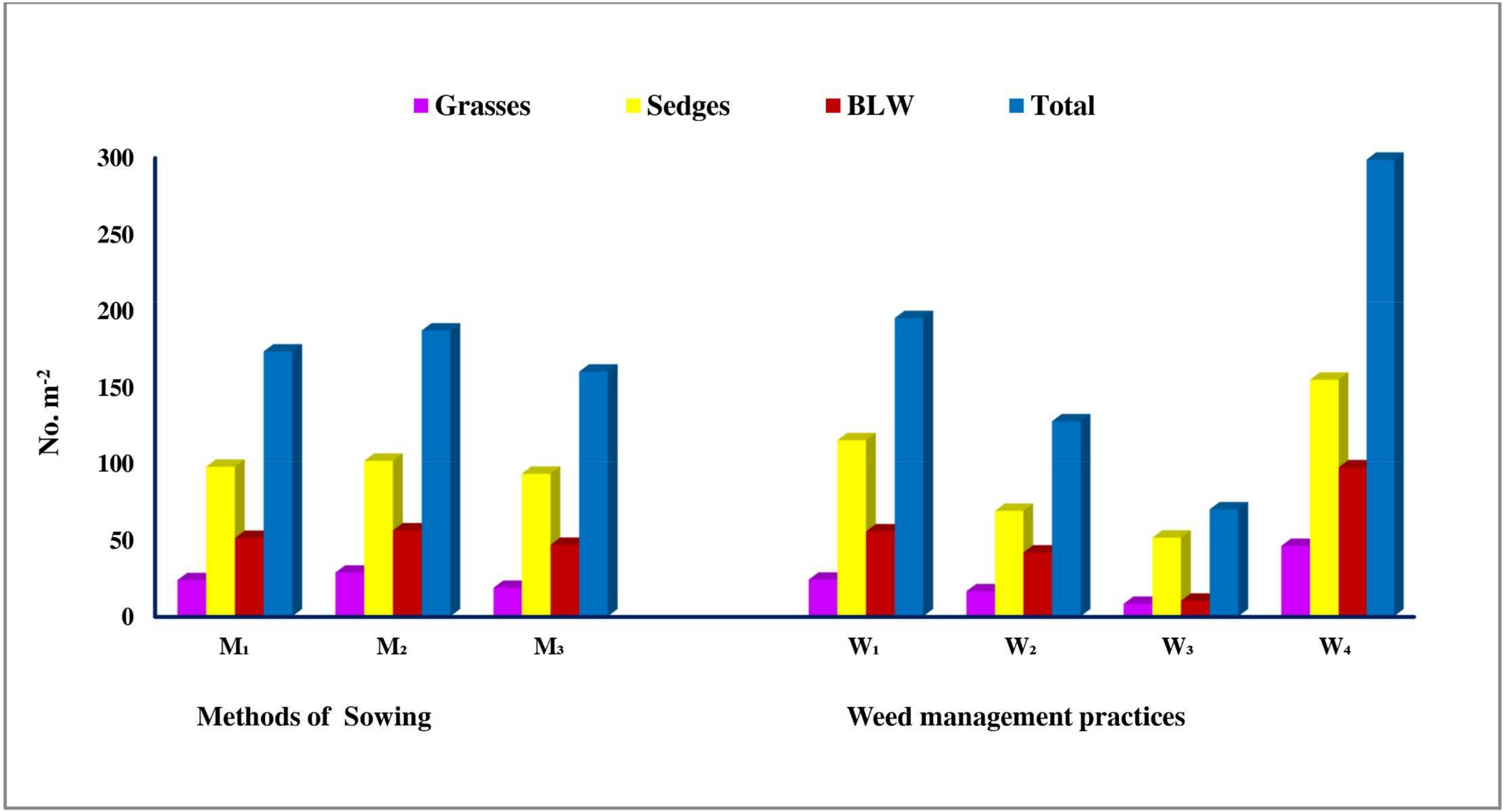


Fig. 4.4. Weed density (No. m^{-2}) at harvest of sesame as influenced by methods of sowing and weed management practices.

of sedges (12.45 m^{-2}) with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.5.3 Broad leaved weeds

Lowest broad leaved weeds count (6.79 m^{-2}) was with broadcasting higher seed rate (M_3). Line seeding (M_1) was the next best treatment (7.21 m^{-2}). Significantly highest density of broad leaved weeds (7.64 m^{-2}) was with broadcasting recommended seed rate (M_2) which was significantly higher than the rest of the sowing methods.

Significantly lowest broad leaved weeds (3.26 m^{-2}) was registered with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (6.51 m^{-2}). Butachlor (W_1) was the next best weed management practice with lower broad leaved weeds count (7.49 m^{-2}). Unweeded check (W_4) recorded significantly higher number of broad leaved weeds (9.89 m^{-2}).

4.2.5.4 Total weeds

Among methods of sowing lowest density of total weeds count (12.67 m^{-2}) was with broadcasting higher seed rate (M_3). Line sowing (M_1) recorded significantly less number of total weed count (13.15 m^{-2}) compared with broadcasting recommended seed rate (M_2) (13.66 m^{-2}).

Significantly lowest total weed count (8.87 m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (11.32 m^{-2}). Butachlor (W_1) (14.06 m^{-2}) application was the next best weed management practice in suppressing the weed count. Significantly highest density of total weed count (17.77 m^{-2}) was with unweeded check (W_4), which was significantly higher than rest of the weed management practices.

4.2.6 Weed dry weight at 20 DAS

Weed dry weight varied significantly due to methods of sowing and weed management practices at 20 DAS. Interaction of these two weed management practices was not significant. Hand weeding was not imposed by the time of sampling at 20 DAS (Table 4.6 and Fig. 4.5).

Table 4.6. Weed dry weight (g m^{-2}) at 20 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	2.17 (4.50)	4.69 (21.85)	1.91 (3.45)	5.44 (29.80)
M_2 : Broadcasting	2.44 (5.58)	5.19 (26.83)	2.02 (3.95)	6.02 (37.20)
M_3 : Broadcasting with 1.5 times seed rate	2.05 (3.91)	4.21 (17.75)	1.72 (2.57)	4.91 (24.24)
SEm±	0.021	0.111	0.020	0.091
CD (P = 0.05)	0.07	0.43	0.09	0.38
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	2.12 (4.00)	4.55 (20.33)	1.72 (2.47)	5.22 (26.81)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	1.71 (2.60)	4.00 (16.34)	1.26 (1.11)	4.44 (20.05)
W_3 : Hand weeding at 20 and 40 DAS	2.49 (5.77)	5.06 (25.55)	2.27 (4.83)	6.01 (36.15)
W_4 : Unweeded check (control)	2.58 (6.22)	5.17 (26.88)	2.29 (4.88)	6.16 (37.98)
SEm±	0.072	0.141	0.081	0.111
CD (P = 0.05)	0.22	0.44	0.24	0.35
Interaction				
M at W				
SEm±	0.076	0.240	0.121	0.210
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	0.022	0.252	0.141	0.201
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

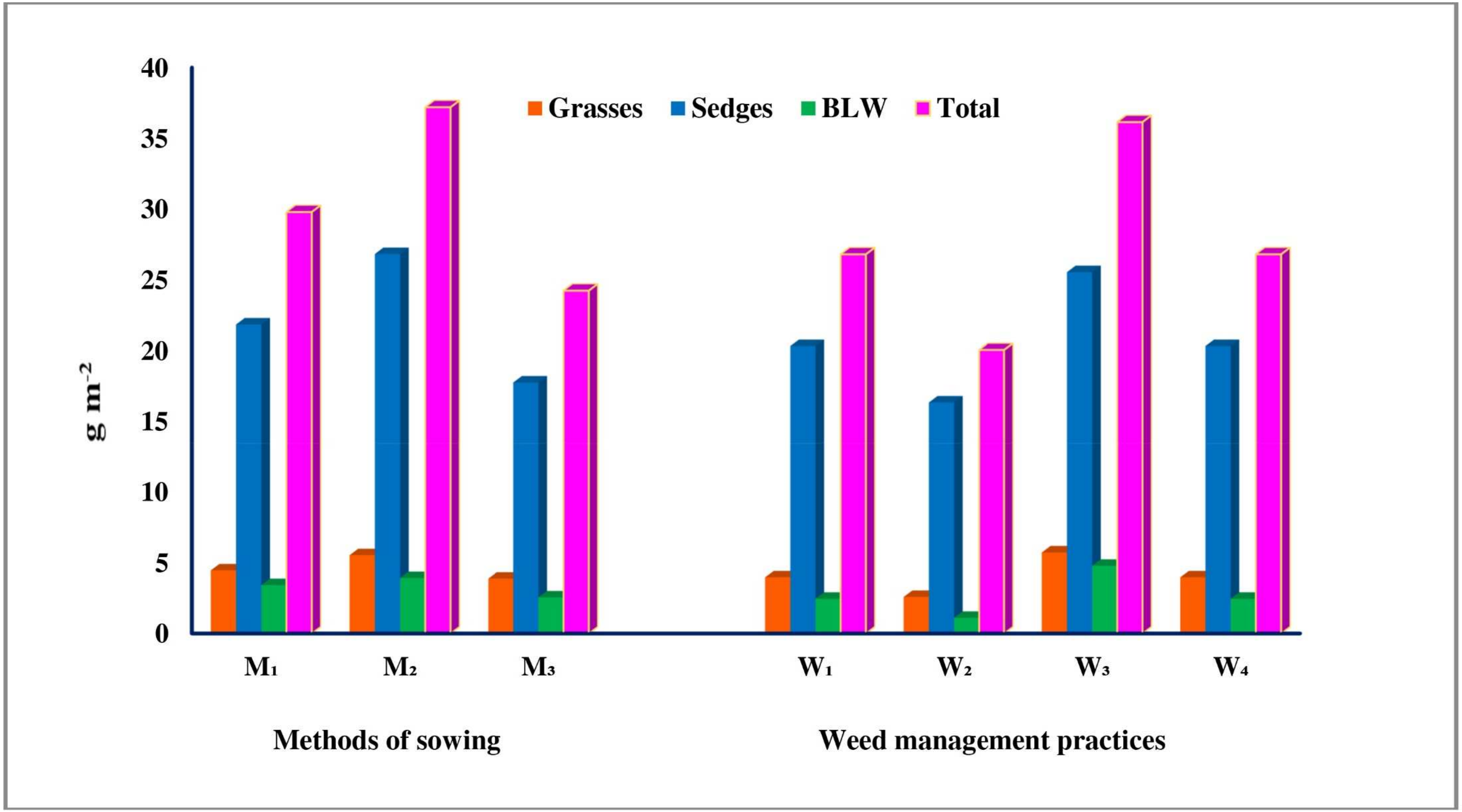


Fig. 4.5. Weed dry weight (g m^{-2}) at 20 DAS of sesame as influenced by methods of sowing and weed management practices.

4.2.6.1 Grasses

Among the methods of sowing, significantly lowest dry weight of grasses(2.05 g m^{-2}) was recorded with broadcasting higher seed rate (M_3). Line sowing (M_1) was the next best treatment which recorded weed dry weight of 2.17 g m^{-2}. Broadcasting (M_2) recorded significantly higher dry weight of grassy weeds (2.44 g m^{-2}).

Application of oxyflourfen (W_2) resulted in significantly lower weed dry weight (1.71 g m^{-2}). The next best treatment was butachlor (W_1) (2.12 g m^{-2}). Unweeded check (W_4) recorded significantly highest (2.58 g m^{-2}) dry weight of grasses which in turn was comparable with hand weeding (W_3) (2.49 g m^{-2}).

4.2.6.2 Sedges

Significantly lowest dry weight of sedges (4.21 g m^{-2}) was with broadcasting higher seed rate (M_3). Line sowing (M_1) was the next best treatment (4.69 g m^{-2}). Broadcasting using recommended (5.19 g m^{-2}) seed rate (M_2) recorded significantly highest dry weight of grasses.

Among the weed management practices, significantly lowest dry weight of sedges (4.00 g m^{-2}) was with pre emergence application of oxyfluorfen (W_2). Pre emergence application of butachlor (W_1) was the next effective treatment for controlling sedges growth (4.55 g m^{-2}). Unweeded check (W_4) (5.17 g m^{-2}) recorded higher dry weight of sedges (5.06 g m^{-2}) which was at par with hand weeding (W_3) (5.06 g m^{-2}).

4.2.6.3 Broad leaved weeds

Among the methods of sowing, dry weight of broad leaved weeds was significantly less (1.72 g m^{-2}) due to broadcasting higher seed rate (M_3). Line sowing (M_1) (1.91 g m^{-2}) and broadcasting (M_2) (2.02 g m^{-2}) recorded significantly higher dry weight.

Each of the four weed management practices significantly differed in dryweight of broad leaved weeds. Dry weight of broad leaved weeds increase in theorder of oxyflourfen (W_2) (1.26 g m^{-2}), butachlor (W_1) (1.72 g m^{-2}), hand weeding (W_3) (2.27 g m^{-2}) and unweeded check (W_4) (2.29 g m^{-2}).

4.2.6.4 Total weeds

Significantly lowest dry weight of total weeds (4.91 g m^{-2}) was with broadcasting using higher seed rate (M_3). Differences in total dry weight due to line seeding (M_1) (5.44 g m^{-2}) and broadcasting the recommended seed rate (M_2)(6.02 g m^{-2}) was also significant.

Total dry weight of weeds differed significantly due to weed management practices. Lowest dry weight (4.44 g m^{-2}) was due to pre emergence application of oxyflourfen (W_2) which was significantly higher than that due to the other three weed management practices. Application of butachlor (W_1) resulted in significantly lower weed dry weight (5.22 g m^{-2}) compared with hand weeding (W_1) (6.01 g m^{-2}) and unweeded check (W_4) (6.16 g m^{-2}).

4.2.7 Weed Dry Weight at 40 DAS

Dry weight of grasses, sedges, broad leaved weeds and total dry weight of weeds differed significantly due to methods of seeding and weed management practices. Interaction of these two management practices did not different significantly (Table 4.7 and Fig. 4.6).

4.2.7.1 Grasses

Among the methods of sowing, significantly lesser dry weight of grasses (2.63 g m^{-2}) was due to broadcasting higher seed rate (M_3) which was significantly lower than with the other two practices. Line seeding (M_1) with recommended seed rate resulted in significantly lower grass dry weight (3.03 g m^{-2}) relative to broadcasting using recommended seed rate (M_2) (3.45 g m^{-2}).

Table 4.7. Weed dry weight (g m^{-2}) at 40 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	3.03 (8.83)	5.52 (29.66)	5.12 (25.66)	8.09 (64.15)
M_2 : Broadcasting	3.45 (11.08)	5.92 (34.50)	5.33 (27.98)	8.64 (73.56)
M_3 : Broadcasting with 1.5 times seed rate	2.63 (6.91)	5.04 (24.91)	4.01 (24.11)	7.51 (55.93)
SEm±	0.050	0.081	0.040	0.061
CD (P = 0.05)	0.23	0.32	0.16	0.25
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	3.18 (9.68)	5.98 (35.44)	5.67 (29.98)	8.65 (75.1)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	2.82 (7.66)	4.86 (23.44)	4.18 (26.16)	7.57 (57.26)
W_3 : Hand weeding at 20 and 40 DAS	2.42 (5.66)	3.18 (9.77)	2.58 (4.34)	4.44 (19.77)
W_4 : Unweeded check (control)	3.69 (13.33)	7.06 (50.11)	6.96 (43.1)	10.33 (106.54)
SEm±	0.091	0.142	0.342	0.111
CD (P = 0.05)	0.28	0.42	1.02	0.34
Interaction				
M at W				
SEm±	0.112	0.232	0.160	0.192
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	0.121	0.242	0.181	0.181
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

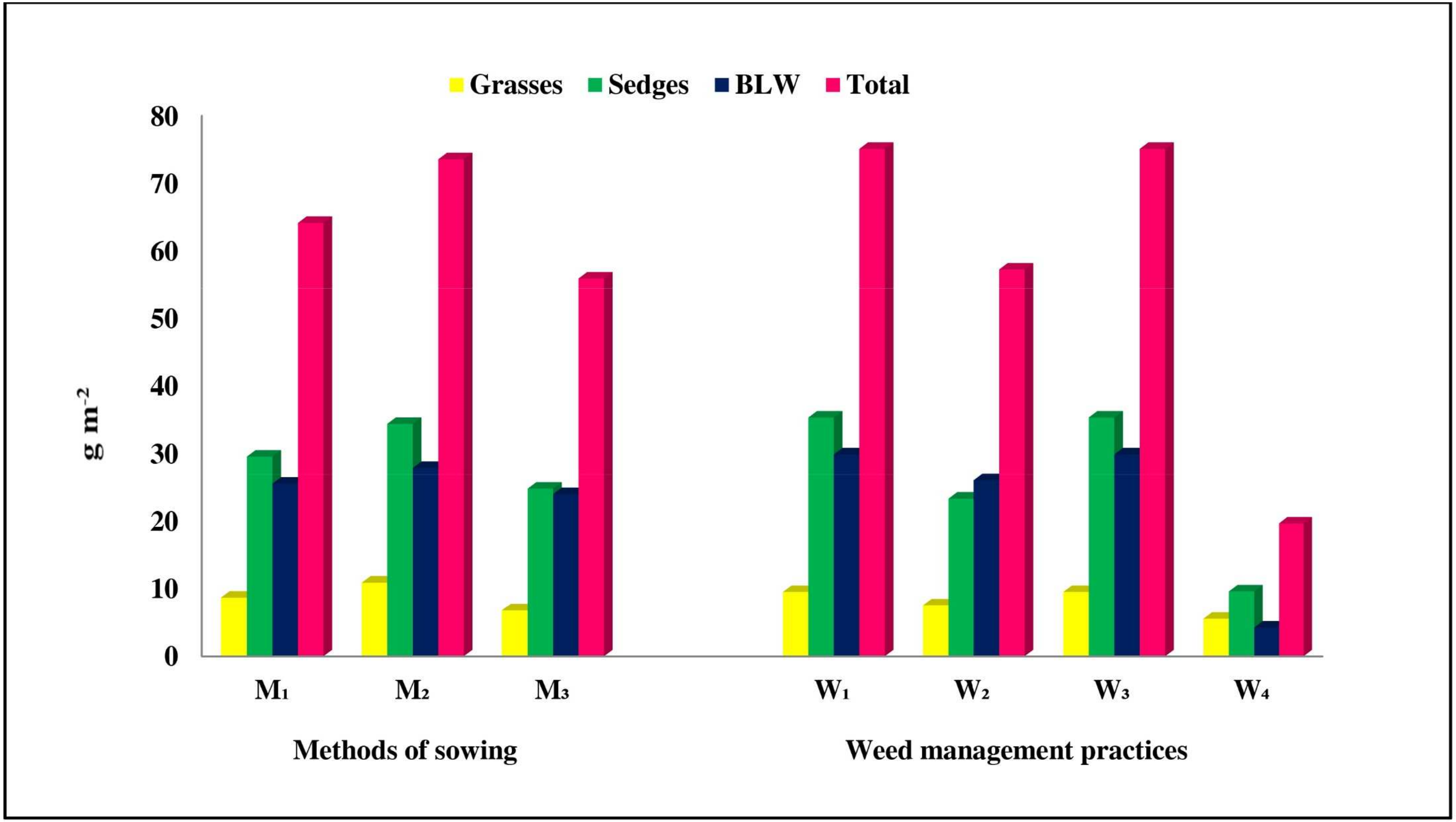


Fig. 4.6. Weed dry weight (g m^{-2}) at 40 DAS of sesame as influenced by methods of sowing and weed management practices.

Hand weeding recorded significantly lowest (2.42 g m^{-2}) dry weight of grasses compared with the other three treatments. Application of oxyflourfen (W_2) recorded significantly lower dry weight of grasses (2.82 g m^{-2}) compared with butachlor (W_1) (3.18 g m^{-2}) and weedy check (W_4) (3.69 g m^{-2}).

4.2.7.2 Sedges

Significantly lowest dry weight of sedges (5.04 g m^{-2}) was with broadcasting using higher seed rate (M_3) which was significantly lower than other methods of sowing. The next best method was line sowing (M_1) with recommended seed rate (5.52 g m^{-2}). Significantly higher dry weight was with broadcasting recommended seed rate (M_2) (5.92 g m^{-2}).

Among the weed management practices, hand weeding (W_3) was the best treatment (3.18 g m^{-2}) relative to the other methods. Oxyflourfen (W_2) (4.86 g m^{-2}) and butachlor (W_1) (5.98 g m^{-2}) which differed significantly resultedin significantly lower sedge weight relative to unweeded check (W_4) (7.06 g m^{-2}).

4.2.7.3 Broad leaved weeds

Among the methods of sowing significantly lowest dry weight of broad leaved weeds (4.01 g m^{-2}) was due to broadcast sowing with higher seed rate (M_3) relative to other treatments. Line sowing (M_1) (5.12 g m^{-2}) and broadcasting with recommended seed rate (M_2) (5.33 g m^{-2}) recorded higher dry weight of broad leaved weeds.

Among the weed management practices, dry weight of broad leaved weeds was significantly lesser (2.58 g m^{-2}) due to hand weeding (W_3). Differences in dry weight of broad leaved weeds due to oxyflourfen (W_2) (4.18 g m^{-2}) and butachlor (W_1) (5.67 g m^{-2}) was also significant. Unweeded check (W_4) recorded significantly highest (6.96 g m^{-2}) dry weight of broad leaved weeds.

4.2.7.4 Total weeds

Significantly lesser total dry weight of weeds (7.51 g m^{-2}) was observed with broadcasting higher seed rate (M_2). Next best treatment was line sowing (M_1) (8.09 g m^{-2}) which was significantly lesser than that due to broadcasting recommended seed rate (M_2) (8.64 g m^{-2}).

Among the weed management practices, significantly lesser total dry weight of weeds was due to hand weeding (W_3) (4.44 g m^{-2}). Oxyflourfen (7.57 g m^{-2}) (W_2) and butachlor (W_1) (8.65 g m^{-2}), which differed significantly were the next effective practices. Unweeded check (W_4) resulted in significantly highest total dry weight of weeds (10.33 g m^{-2}).

4.2.8 Weed Dry Weight at 60 DAS

Dry weight of grasses, sedges, broad leaved weeds and total dry weight insesame crop were significantly influenced by methods of sowing and weed management practices. Interaction of these two management practices had no significant influence (Table 4.8 and Fig. 4.7).

4.2.8.1 Grasses

Among methods of sowing, significantly lower dry weight of grasses (3.27 g m^{-2}**)** was with broadcasting higher seed rate (M_3). The next treatment with lower dry weight of grasses was line sowing (M_1) (3.59 g m^{-2}) followed by broadcasting recommended seed rate of sowing (M_2) (3.91 g m^{-2}), which recorded significantly higher dry weight of grasses.

Significantly lowest dry weight of grasses (3.10 g m^{-2}) was with hand weeding twice (W_3) followed by pre emergence application of oxyfluorfen (3.40 g m^{-2}) (W_2). Butachlor application (W_1) was the next best weed management practice (3.69 g m^{-2}) followed by weedy check (W_4) (4.16 g m^{-2}), which also differed significantly.

Table 4.8. Weed dry weight (g m^{-2}) at 60 DAS of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	3.59 (12.50)	5.89 (35.66)	5.39 (30.66)	8.74 (78.82)
M_2 : Broadcasting	3.91 (15.08)	6.23 (40.50)	5.64 (32.98)	9.24 (88.56)
M_3 : Broadcasting with 1.5 times seed rate	3.27 (10.50)	5.41 (30.58)	5.19 (29.03)	8.14 (70.11)
SEm±	0.040	0.062	0.031	0.051
CD (P = 0.05)	0.18	0.26	0.13	0.21
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	3.69 (13.22)	6.43 (41.0)	5.94 (34.98)	9.46 (89.21)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	3.40 (11.22)	5.45 (29.44)	5.60 (31.05)	8.47 (71.71)
W_3 : Hand weeding at 20 and 40 DAS	3.10 (9.33)	4.02 (15.77)	3.11 (9.34)	5.88 (34.44)
W_4 : Unweeded check (control)	4.16 (17.00)	7.48 (56.11)	6.97 (48.18)	11.02 (121.29)
SEm±	0.070	0.131	0.091	0.112
CD (P = 0.05)	0.23	0.39	0.28	0.32
Interaction				
M at W				
SEm±	0.120	0.252	0.152	0.171
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	0.131	0.212	0.161	0.191
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

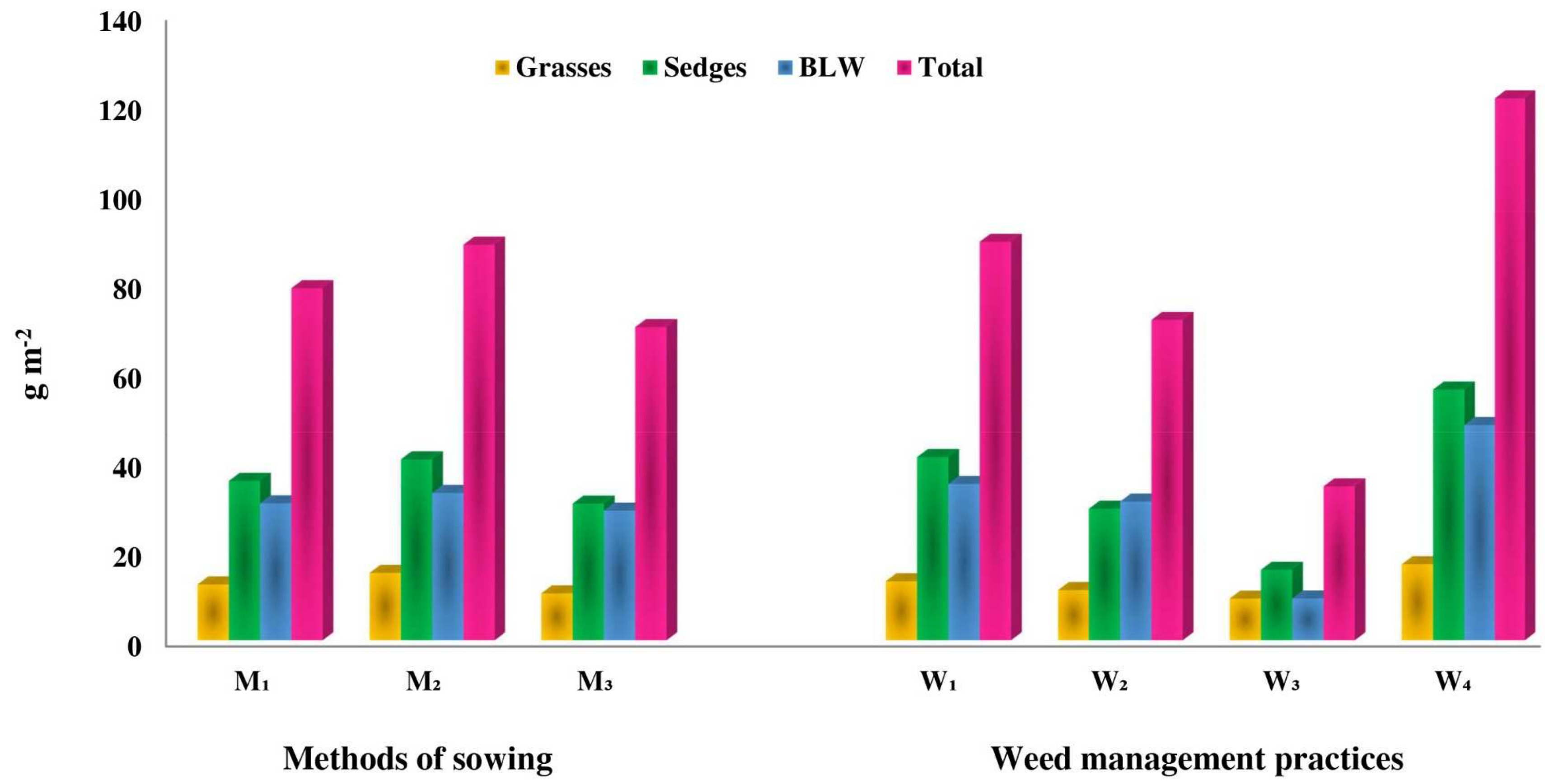


Fig. 4.7. Weed dry weight (g m^{-2}) at 60 DAS of sesame as influenced by methods of sowing and weed management practices.

4.2.8.2 Sedges

Lowest dry weight of sedges (5.41 g m^{-2}) was with broadcasting higher seed rate (M_3) followed by line seeding (M_1) (5.89 g m^{-2}), which differed significantly. Broadcasting recommended seed rate (M_2) (6.23 g m^{-2}) recorded significantly highest dry weight of sedges.

Among the weed management practices tested, dry weight of sedges was significantly lowest due to hand weeding (W_3) (4.02 g m^{-2}) followed by oxyflourfen (W_2) (5.45 g m^{-2}). Application of butachlor (W_1) resulted in significantly lesser dry weight of sedges (6.43 g m^{-2}) relative to that due to unweeded check (7.48 g m^{-2}).

4.2.8.3 Broad leaved weeds

Among the methods of sowing, lowest dry weight of broad leaved weeds (5.19 g m^{-2}) was with broadcasting higher seed rate (M_3) followed by that due line sowing (M_1) (5.39 g m^{-2}), both of which differ significantly. Sowing by broadcasting recommended seed rate (M_2) recorded significantly highest (5.64 g m^{-2}) dry weight of broad leaved weeds.

Lowest dry weight of broad leaved weeds (3.11 g m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (5.60 g m^{-2}), which differed significantly. Butachlor (W_1) was the next best weed management practice with (5.94 g m^{-2}). Highest density of broad leaved weeds (6.97 g m^{-2}) in unweeded check (W_4).

4.2.8.4 Total weeds

Lowest dry weight of total weeds (8.14 g m^{-2}) was with broadcasting usinghigher seed rate (M_3) which was significantly lower than the rest of the sowingmethods. The next treatment having significantly lower dry weight of total weeds (8.74 g m^{-2}) was line sowing (M_1). Highest dry weight of total weeds (9.24 g m^{-2}) was with broadcasting with recommended seed rate (M_2).

Among the weed management practices, lowest total weed dry weight (5.88g m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (8.47 m^{-2}). Butachlor (W_1) was the next best weed management practice in suppressing the total weed count (9.46 g m^{-2}). The highest density of total weed count (11.02 g m^{-2}) was with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.9 Weed Dry Weight at Harvest

Dry weight of grasses, sedges, broad leaved weeds and total weeds in sesame crop varied significantly due to weed management practices. Interaction of sowing methods and weed management practices did not vary significantly. (Table 4.9 and Fig. 4.8).

4.2.9.1 Grasses

Among methods of sowing, lesser dry weight of grasses (3.30 g m^{-2}) was with broadcasting using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment with lower dry weight of grasses (3.71 g m^{-2}) was line sowing (M_1). Highest dry weight of grasses (4.36 g m^{-2}) was with broadcasting recommended seed rate (M_2).

Lowest dry weight of grasses (3.18 g m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (3.54 g m^{-2}). Butachlor (W_1) was the next best weed management practice in suppressing the dry weight of grasses (3.99 g m^{-2}). Highest dry weight of grasses (4.45 g m^{-2}) was with unweeded check (W_4), which was significantly higher than the rest of weed management practices.

4.2.9.2 Sedges

Among methods of sowing, lowest dry weight of sedges (5.43 g m^{-2}) was with broadcasting using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment with lower dry weight of sedges (6.03 g m^{-2}) was line sowing (M_1). The highest dry weight of sedges (6.38

Table 4.9. Weed dry weight (g m^{-2}) at harvest of sesame as influenced by methods of sowing and weed management practices

Treatments	Grasses	Sedges	BLW	Total
Methods of sowing				
M_1 : Line sowing	3.71 (13.16)	6.03 (34.66)	5.69 (27.00)	8.69 (74.82)
M_2 : Broadcasting	4.36 (16.75)	6.38 (39.50)	5.48 (29.31)	9.29 (85.56)
M_3 : Broadcasting with 1.5 times seed rate	3.30 (10.91)	5.43 (29.58)	5.02 (25.28)	8.16 (65.77)
SEm$\pm$	0.060	0.071	0.050	0.044
CD (P = 0.05)	0.22	0.29	0.20	0.16
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	3.99 (13.88)	6.32 (40.00)	5.69 (31.32)	9.23 (85.22)
W_2 : Oxyflourfen 0.075 kg ha^{-1}	3.54 (11.88)	5.33 (28.44)	5.27 (27.27)	8.29 (67.59)
W_3 : Hand weeding at 20 and 40 DAS	3.18 (9.66)	3.94 (14.77)	2.48 (5.67)	5.58 (30.12)
W_4 : Unweeded check (control)	4.45 (17.66)	7.42 (55.11)	6.70 (44.52)	10.83 (117.30)
SEm$\pm$	0.122	0.121	0.111	0.123
CD (P = 0.05)	0.35	0.35	0.33	0.36
Interaction				
M at W				
SEm$\pm$	0.131	0.111	0.162	0.181
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm$\pm$	0.151	0.162	0.181	0.171
CD (P = 0.05)	NS	NS	NS	NS

Data were subjected to square root transformation $\left(\sqrt{x+0.5}\right)$. Figures in parenthesis are original values

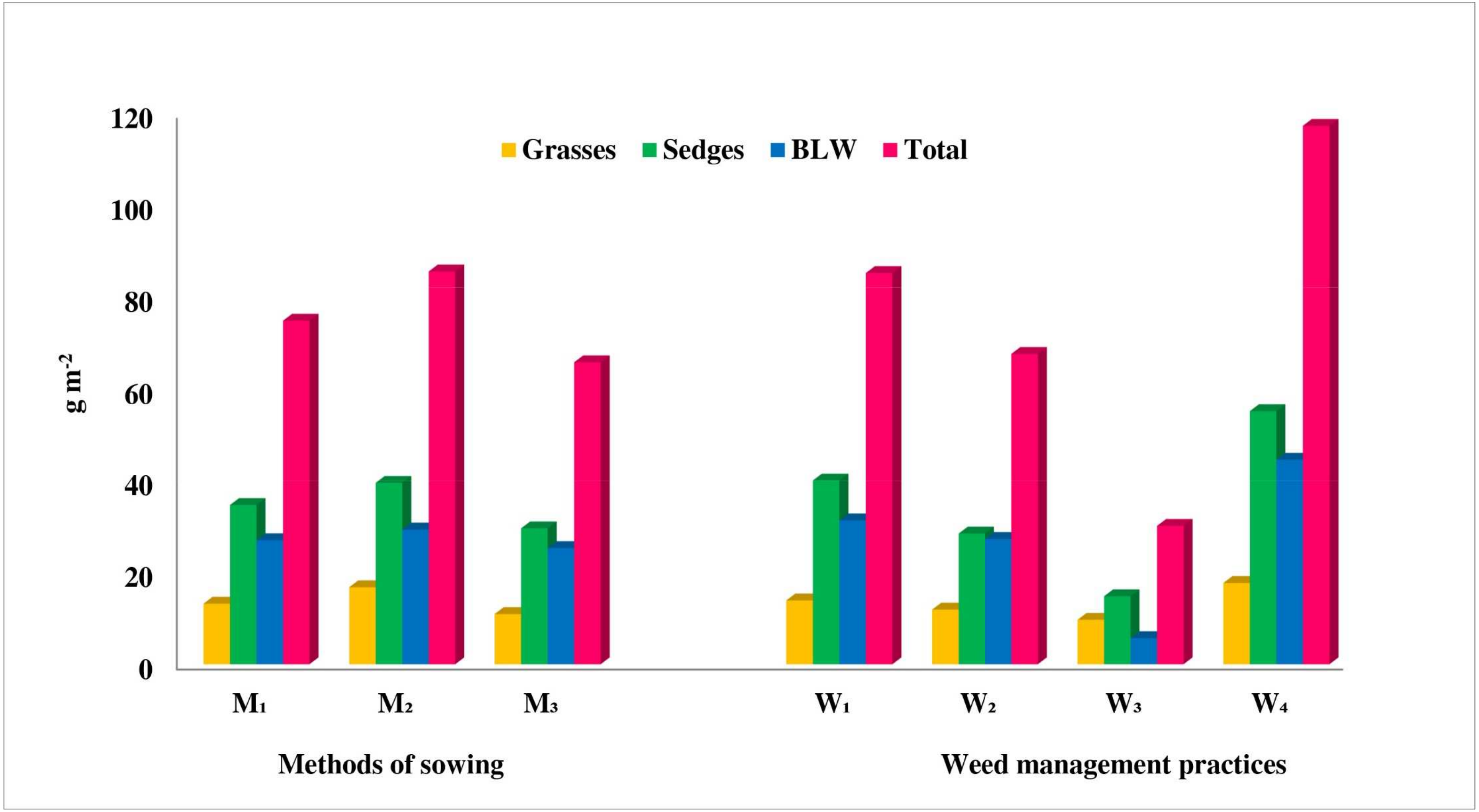


Fig. 4.8. Weed dry weight (g m^{-2}) at harvest of sesame as influenced by methods of sowing and weed management practices.

g m^{-2}) was with broadcasting using recommended seed rate (M_2) which was significantly higher than the rest of the sowing methods.

Among the weed management practices, lowest dry weight of sedges (3.94 g m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (W_2) (5.33 g m^{-2}). Butachlor (W_1) was the next best weed management practice in suppressing the sedge count (6.32 g m^{-2}). Highest dry weight of sedges (7.42 g m^{-2}) was with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.9.3 Broad leaved weeds

Among the methods of sowing, lowest dry weight of broad leaved weeds (5.02 g m^{-2}) was with broadcasting using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment having lower dry weight of broad leaved weeds (5.69 g m^{-2}) was line sowing (M_1). Highest dry weight of broad leaved weeds was with broadcasting using recommended seed rate (M_2) (5.48 g m^{-2}) which was significantly higher than the rest of the sowing methods.

Lowest dry weight of broad leaved weeds (2.48 g m^{-2}) was with hand weeding (W_3) followed by pre emergence application of oxyflourfen (5.27g m^{-2}) (W_2). Butachlor (W_1) was the next best weed management practice in suppressing the dry weight (5.69 g m^{-2}) of broad leaved weeds. Highest dry weight of broad leaved weeds (6.70 g m^{-2}) was with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

4.2.9.4 Total weeds

Lowest dry weight of total weeds (8.16 g m^{-2}) was with broadcasting using higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. The next treatment having lower dry weight of total weeds (8.69 g m^{-2}) was line sowing (M_1). Highest dry weight of total weeds (9.29 g m^{-2}) was with broadcasting using recommended seed rate (M_2), which was significantly higher than the rest of the weed management practices.

Total weed dry weight, at harvest was the lowest (5.58 g m^{-2}) with hand weeding (W_3) followed by pre emergence application of oxyfluorfen (8.29 g m^{-2}) (W_2). Butachlor (W_1) was the next best weed management practice in suppressing the total weed dry weight (9.23 g m^{-2}). The highest dry weight of total weed count (10.83 g m^{-2}) was registered with unweeded check (W_4), which was significantly higher than the rest of the weed management practices.

At all the stages of observations, lowest density and dry weight of grasses was with broadcasting using higher seed rate which was significantly lesser than the rest of the sowing methods.

High density of sesame plant population due to high seed rate smothered the weeds leading to lower density and dry weight of weeds as reported by Mahajan and Hirwe (2014).

Among the weed management practices, hand weeding twice at 20 and 40 DAS resulted in the lowest density and dry weight of weeds due to effective control of dominant weed flora by manual weeding. Superiority of hand weeding in suppressing the density and dry weight of weeds was extended upto harvest of the crop. Hand weeding twice at 20 and 40 DAS during critical period of competition completely eliminated the perennial sedge, *Cyperus rotundus* L. and other weeds more effectively. The results are in accordance with the findings of Onkar and Angadi (2018). Lower density and dry weight of weeds due to pre emergence application of oxyflourfen can be attributed to effective control of weed flora. Pre emergence application of butachlor controlled most of the annual grasses and broad leaved weeds by inhibiting the cell division and cell elongation, particularly in roots of the target plants at the time of germination itself. The highest density and dry weight of all the categories of weeds were with unweeded check due to heavy weed infestation right from the germination of the crop to harvest. These results are in conformity with those of Chaudhuri and Ghosh (2019).

4.2.10 Nutrient Uptake by Weeds

Nutrient uptake by weeds differed significantly due to methods of sowing and weed management practices. Interaction effect between these two factors was not statistically measurable (Table 4.10 and Fig. 4.9).

4.2.10.1 Nitrogen uptake

Among the methods of sowing, lowest uptake of nitrogen by weeds (24 kg ha^{-1}) was with broadcasting higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods followed by line sowing (M_1) (26.4 kg ha^{-1}). The highest uptake of nitrogen by weeds was recorded with broadcasting (M_2) (27.6 kg ha^{-1}).

Among the weed management practices, lowest uptake of nitrogen by weeds was (6.2 kg ha^{-1}) with hand weeding (W_3), which was significantly lesser than rest of the weed management practices. The next treatment having lower nitrogen uptake was pre emergence application of oxyflourfen (W_2) (28.3 kg ha^{-1}) followed by butachlor (W_1) (33.3 kg ha^{-1}) which recorded significantly lower uptake of nitrogen by weeds compared to the unweeded check (W_4) (37.4 kg ha^{-1}).

4.2.10.2 Phosphorus uptake

Among the methods of sowing, lowest uptake of phosphorus by weeds (5.2 kg ha^{-1}) was with broadcasting higher seed rate (M_3) which was significantly lesser than the rest of the sowing methods. Uptake of phosphorus by weeds significantly increased in the ascending order of line sowing (M_1) (7.2 kg ha^{-1}) and broadcasting (M_2) (9.6 kg ha^{-1}),

Among the weed management practices, the lowest uptake of phosphorus by weeds (5.2 kg ha^{-1}) was with hand weeding (W_3), which was significantly lesser than the rest of the weed management practices. Uptake of phosphorus by weeds significantly decreased in the descending order of unweeded check (W_4) (9.2 kg ha^{-1}), butachlor (W_1) (8.0 kg ha^{-1}), oxyflourfen (W_2) (7.1 kg ha^{-1}) and hand weeding (W_3) (5.2 kg ha^{-1}).

Table 4.10. Nutrient uptake (kg ha^{-1}) by weeds at harvest in sesame as influenced by methods of sowing and weed management practices

Treatments			Nitrogen	Phosphorus	Potassium
Methods of sowing					
M_1	:	Line sowing	26.4	7.2	18.5
M_2	:	Broadcasting	27.6	9.6	22.1
M_3	:	Broadcasting with 1.5 times seed rate	24.3	5.2	17.1
SEm$\pm$			0.24	0.22	0.32
CD (P = 0.05)			0.9	0.9	1.3
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	33.3	8.0	21.1
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	28.3	7.1	17.7
W_3	:	Hand weeding at 20 and 40 DAS	6.2	5.2	11.0
W_4	:	Unweeded check (control)	37.4	9.2	27.4
SEm$\pm$			0.81	0.31	0.59
CD (P = 0.05)			2.5	0.9	1.7
Interaction					
M at W					
SEm$\pm$			1.31	0.52	0.95
CD (P = 0.05)			NS	NS	NS
W at M					
SEm$\pm$			1.49	0.55	0.31
CD (P = 0.05)			NS	NS	NS

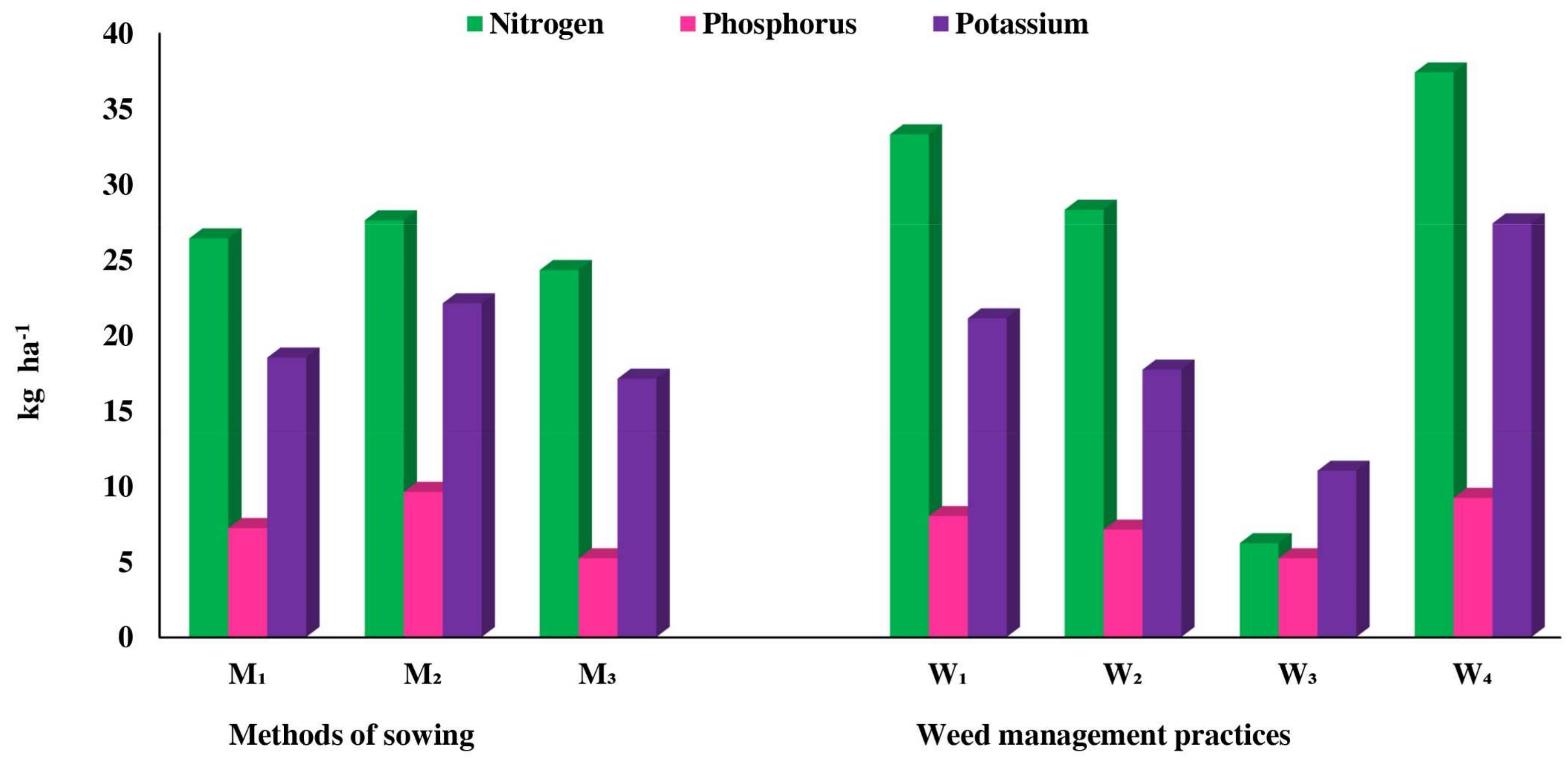


Fig. 4.9. **Nutrient uptake (kg ha^{-1}) by weeds at harvest in sesame as influenced by methods of sowing and weed management practices.**

4.2.10.3 Potassium uptake

Broadcasting with higher seed rate (M_3) recorded lowest uptake of potassium by weeds (17.1 kg ha^{-1}) which was significantly lesser than the rest of the sowing methods. The next treatment having lower uptake was line sowing (M_1) (18.5 kg ha^{-1}). Highest uptake of potassium by weeds was recorded with broadcasting (M_2) (22.1 kg ha^{-1}).

Among the weed management practices, the lowest uptake of potassium by weeds (11.0 kg ha^{-1}) was with hand weeding (W_3), which was significantly lesser than the rest of the weed management practices. Uptake of potassium by weeds significantly decreased in the descending order of unweeded check (W_4) (27.4 kg ha^{-1}), butachlor (W_1) (21.0 kg ha^{-1}), oxyflourfen (W_2) (17.7 kg ha^{-1}) and hand weeding (W_3) (11.0 kg ha^{-1}).

Among the methods of sowing, highest uptake of N, P and K by weedswas with broadcasting due to higher weed population. The results are in line with the findings of Umed *et al*. (2009).

Among the weed management practices, highest uptake of N, P and K by weeds was with unweeded check, which was significantly higher than the rest of the weed management practices due to severe weed competition from weeds. In all the crops, highest uptake of N, P and K by weeds was with unweedy check as conformed by several researchers.

4.3 GROWTH AND YIELD OF SESAME AS INFLUENCED BY METHODS OF SOWING AND WEED MANAGEMENT PRACTICES

4.3.1 Growth Parameters

4.3.1.1 Initial and final plant population

Initial and final sesame plant population differed significantly due to methods of sowing and weeds management practices. Interaction effect between these two treatments was not statistically measurable (Table 4.11).

Table 4.11. Initial and final plant population (No. m^{-2}) of sesame as influenced by methods of sowing and weed management practices

Treatments			Plant population	
			Initial	Final
Methods of sowing				
M_1	:	Line sowing	29.1	24.1
M_2	:	Broadcasting	36.0	31.2
M_3	:	Broadcasting with 1.5 times seed rate	48.1	45.2
SEm±			0.42	0.58
CD (P = 0.05)			1.6	2.2
Weed management practices				
W_1	:	Butachlor 1.0 kg ha^{-1}	41.0	40.3
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	17.1	14.1
W_3	:	Hand weeding at 20 and 40 DAS	45.2	43.0
W_4	:	Unweeded check (control)	46.1	38.1
SEm±			0.79	0.64
CD (P = 0.05)			2.3	1.9
Interaction				
M at W				
SEm±			1.62	1.12
CD (P = 0.05)			NS	NS
W at M				
SEm±			1.72	1.13
CD (P = 0.05)			NS	NS

Among the methods of sowing, higher initial (48) and final plant population (45) was with broadcasting using higher seed rate (M_3) which was significantly higher over rest of the treatments. Higher plant population was due to higher seed rate. Similar findings were have been by Islam *et al.* (2008).

Among the weed management practices, the highest initial plant population was with unweeded check (W_4) (46), which was on par with hand weeding (W_3) (45) at 15 DAS (Hand weeding was not imposed by that time). Next best treatment was pre emergence application of butachlor (W_1) (41). Lower initial plant population m^{-2} was with oxyfluorfen (W_2) (17).

Among the weed management practices, the highest final sesame plant population (43) was with hand weeding which was significantly higher than rest of the weed management practices. Pre emergence application of butachlor was the next best treatment with higher final plant population (40). Lower final plant population was with unweeded check (38). Among the pre emergence herbicides, lowest final plant population (14) was with oxyfluorfen, which was significantly lesser than rest of the weed management practices. Significantly lowest initial and final sesame plant population was with oxyflourfen due to its phytotoxic effect on sesame plants. These results are in conformity with those of Sankar and Subramanyam (2011) in sunflower.

4.3.1.2 Plant height

Sesame plant height differed significantly due to methods of sowing and weed management practices (Table 4.12 and Fig. 4.10).

At all the stages of observations, plant height followed similar trend, except at 20 DAS, when hand weeding was not imposed. Differences in plant height were significant at 40 and 60 DAS and at harvest. At all the stages of sampling, interaction of these two factors was not significant.

Methods of sowing could not significantly vary the plant height of sesame at 20 DAS.

Table 4.12. Plant height (cm) at different growth stages of sesame as influenced by methods of sowing and weed management practices

Treatments	20 DAS	40 DAS	60 DAS	At harvest
Methods of sowing				
M_1 : Line sowing	10.9	48.3	80.2	83.7
M_2 : Broadcasting	10.3	42.5	69.3	78.2
M_3 : Broadcasting with 1.5 times seed rate	11.2	48.5	68.5	77.4
SEm±	0.27	1.22	2.70	1.31
CD (P = 0.05)	NS	5.0	10.8	5.1
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	12.4	55.0	79.8	87.0
W_2 : Oxyflourfen 0.075 kg ha^{-1}	7.7	27.4	59.1	65.4
W_3 : Hand weeding at 20 and 40 DAS	10.4	57.0	81.3	87.3
W_4 : Unweeded check (control)	10.9	47.6	70.4	75.7
SEm±	0.27	1.60	2.91	3.33
CD (P = 0.05)	1.4	4.8	8.8	9.8
Interaction				
M at W				
SEm±	0.84	2.82	5.10	5.71
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	0.78	2.70	5.21	5.10
CD (P = 0.05)	NS	NS	NS	NS

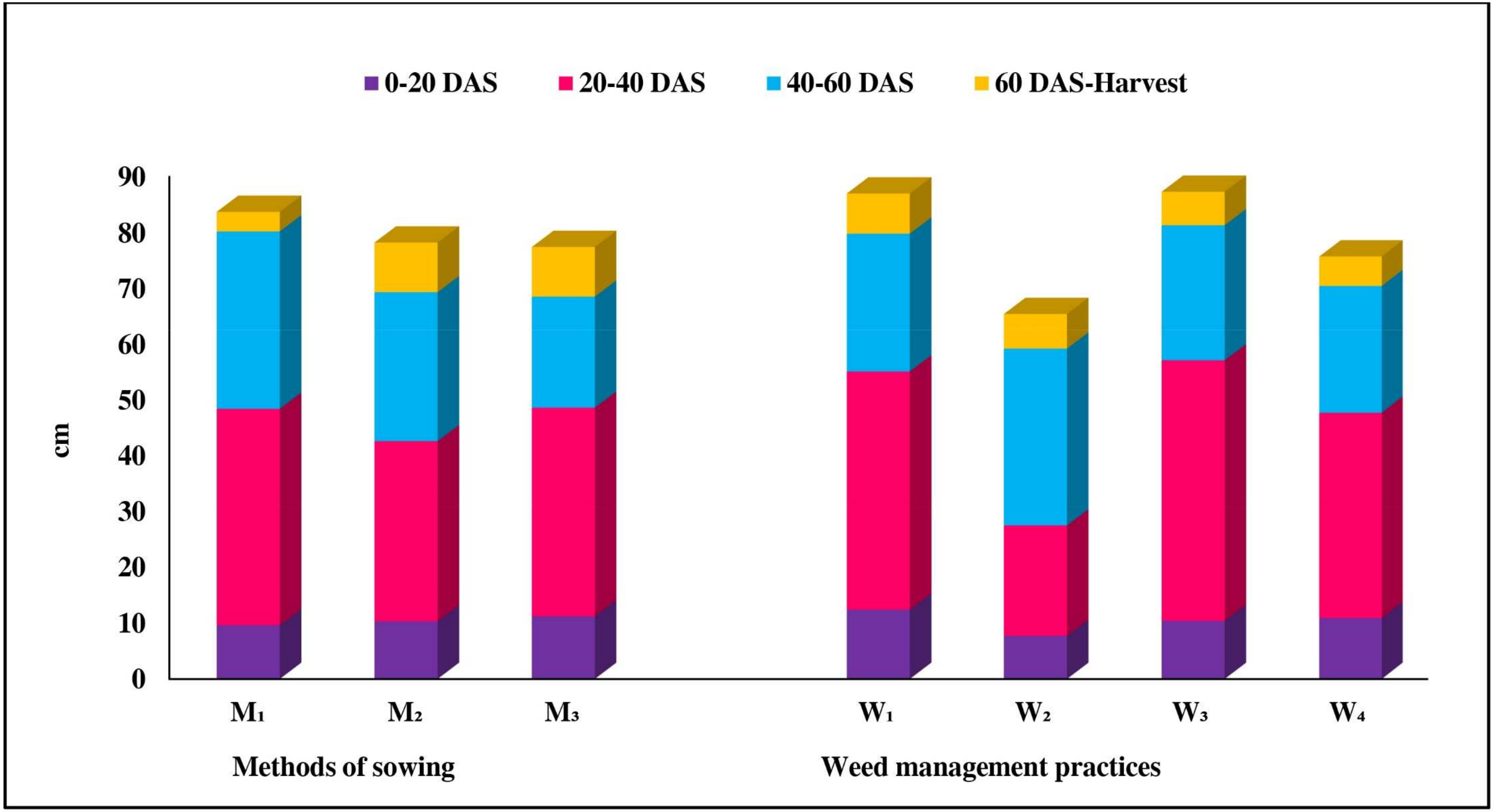


Fig. 4.10. Plant height (cm) at different growth stages of sesame as influenced by methods of sowing and weed management practices.

Significantly taller plants (12.4 cm) at 20 DAS were observed with pre emergence application of butachlor (W_1). Shorter plants (10.9 cm) were with unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding not imposed at the time of sampling). Among the pre emergence herbicides, shorter plants were due to application of oxyfluorfen (W_2).

At 40 DAS, higher plant height (48.5 cm) was due to broadcasting using higher seed rate (M_3) which was at par with line sowing (M_1) (48.3 cm). Broadcasting (M_2) resulted in shorter plant height (42.5 cm).

At other stages of observation (60 DAS and at harvest), higher plant height was with line sowing (M_1) which was significantly higher over rest of the treatments. Shortest plants were with broadcasting using higher seed rate (M_3) which was at par with broadcasting (M_2).

At 40, 60 DAS and at harvest, taller plants were due to hand weeding (W_3) which was comparable with that due to butachlor (W_1) application. Weedy check (W_4) recorded significantly taller plants relative to that due to the application of oxyfluorfen (W_2).

Among the methods of sowing, at all stages of observation, taller plants were with line sowing due to efficient use of nutrients, soil moisture, light interceptionsand space due to optimum plant population. Similar findings were observed by Rajpurohit *et al*. (2017).

Among the weed management practices highest plant height was with hand weeding due to complete removal of weeds, leading to reduced crop-weed competition during critical stages of crop growth. These results are in conformity with (Aruna *et al*., 2020). Shorter plants with unweeded check might be due to heavy weed infestation, leading to heavy competition for growth resources. Among the pre emergence herbicides, the shortest plants were with oxyfluorfen application. Phytotoxicity of oxyflourfen resulted in heavy mortality of sesame plants (Babu *et al*., 2016).

4.3.1.3 Leaf Area

Leaf area plant^{-1} progressively increased up to 60 DAS followed by gradual decline up to harvest (Table 4.13). At all the stages of observation, leaf area plant^{-1} followed similar trend, except at 20 DAS. Interaction of these two variables was not statistically measurable.

Methods of sowing could not significantly vary the leaf area of sesame at 20 DAS. Significantly higher leaf area (107 cm^2) at 20 DAS was with pre emergence application of butachlor (W_1). Difference due to unweeded check (W_4) (95 cm^2) and hand weeding (W_3) (91 cm^2) was not significant. Application of oxyflourfen (W_2) recorded significantly lesser leaf area (77 cm^2). (hand weeding was not imposed by that time of sampling).

At 40 and 60 DAS and at harvest, leaf area varied significantly in the decreasing order of line seeding (M_3), broadcasting higher seed rate (M_3) and broadcasting recommended seed rate (M_2).

At 40 and 60 DAS and at harvest, among the weed management practices, there was significant decrease in leaf area in the order of hand weeding (W_3), butachlor application (W_1), unweeded check (W_2) and oxyflourfen (W_3).

Significantly, higher leaf area was associated with line sowing due to relatively lesser competition from weeds for efficient use of growth factors by sesame crop. Similar findings have been reported by Rajpurohit *et al*. (2017).

Hand weeding and pre emergence application of butachlor were the best practices for higher leaf area of sesame. This might be due to weed free environment for sesame during the critical stages of crop growth for efficient useof growth resources for crop growth and development. Similar results have been reported by Audu *et al*. (2021). Heavy weed infestation in unweeded check resulted in severe competition for the growth resources leading to reduced leaf area of sesame. Similar results were reported by Fatima *et al*. (2020). Lower leaf area due to pre emergence application of oxyflourfen appears to be due to its phytotoxic effect on sesame leading to reduced plant population.

Table 4.13. Leaf area (cm^2 $plant^{-1}$) at different growth stages of sesame as influenced by methods of sowing and weed management practices

Treatments			20 DAS	40 DAS	60 DAS	At harvest
Methods of sowing						
M_1	:	Line sowing	88	364	1008	954
M_2	:	Broadcasting	97	312	858	804
M_3	:	Broadcasting with 1.5 times seed rate	93	340	945	891
SEm±			3.5	5.1	15.0	14.7
CD (P = 0.05)			NS	20	60	62
Weed management practices						
W_1	:	Butachlor 1.0 kg ha^{-1}	107	354	1055	1001
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	77	271	622	568
W_3	:	Hand weeding at 20 and 40 DAS	91	404	1253	1199
W_4	:	Unweeded check (control)	95	326	818	764
SEm±			3.6	8.7	45.0	15.1
CD (P = 0.05)			10	26	135	45
Interaction						
M at W						
SEm±			6.3	15.2	78.9	76.1
CD (P = 0.05)			NS	NS	NS	NS
W at M						
SEm±			6.5	14.1	70.1	71.1
CD (P = 0.05)			NS	NS	NS	NS

4.3.1.4 Number of branches plant^{-1}

Number of branches plant^{-1} at 40 and 60 DAS and at harvest differed significantly due to methods of sowing and weed management practices. Interaction between these two factors was not statistically measurable (Table 4.14).

Number of branches plant^{-1} decreased significantly in the order of line sowing (M_1), broad casting (M_2) and broadcasting higher seed rate (M_3).

In line sowing and broadcasting, plant population was within optimum limits for the sesame. Higher seed rate had high plant population leading to competition for growth resources relative to line sowing and broadcasting. Results are in conformity with that of Islam *et al*. (2008).

Hand weeding (W_3) recorded the highest number of branches at all the three stages of observation. Differences in number of branches plant^{-1} decreased significantly in the order of hand weeding (W_3), butachlor application (W_1), unweeded check (W_4) and oxyflourfen application (W_2).

Weed free environment due to hand weeding was congenial for efficient use of growth resources. Application of butachlor also resulted in more number of branches plant^{-1} relative to oxyflourfen and unweeded check, since it could suppress the weed growth from sowing. Phytotoxic effect of oxyflourfen adversely affected plant population of sesame leading to less number of branches plant^{-1}.

4.3.1.5 Dry matter production

Dry matter production of summer sesame at 20 DAS, 40 DAS and 60 DAS and at harvest varied significantly due to methods of sowing and weed management practices. Interaction of methods of sowing and weed management practices was not significant (Table 4.15 and Fig. 4.11).

Methods of sowing could not significantly influence dry matter production of sesame at 20 DAS. Butachlor (W_1) recorded significantly higher

Table 4.14. **Number of branches plant^{-1} at different growth stages of sesame as influenced by methods of sowing and weed management practices**

Treatments			40 DAS	60 DAS	At harvest
Methods of sowing					
M_1	:	Line sowing	5.08	5.55	7.83
M_2	:	Broadcasting	4.08	4.58	6.07
M_3	:	Broadcasting with 1.5 times seed rate	3.41	3.66	5.16
SEm±			0.091	0.160	0.210
CD (P = 0.05)			0.37	0.64	0.82
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	4.55	5.11	6.88
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	2.88	3.12	4.58
W_3	:	Hand weeding at 20 and 40 DAS	5.55	6.11	8.06
W_4	:	Unweeded check (control)	3.77	4.13	5.88
SEm±			0.251	0.240	0.271
CD (P = 0.05)			0.76	0.73	0.81
Interaction					
M at W					
SEm±			0.441	0.430	0.472
CD (P = 0.05)			NS	NS	NS
W at M					
SEm±			0.392	0.410	0.461
CD (P = 0.05)			NS	NS	NS

Table 4.15. Dry matter production (kg ha^{-1}) at different growth stages of sesame as influenced by methods of sowing and weed management practices

Treatments	20 DAS	40 DAS	60 DAS	At harvest
Methods of sowing				
M_1 : Line sowing	232	1195	2144	2279
M_2 : Broadcasting	213	1167	1913	2124
M_3 : Broadcasting with 1.5 times seed rate	236	1265	2322	2465
SEm±	6.3	6.9	45.1	21.1
CD (P = 0.05)	NS	27	177	82
Weed management practices				
W_1 : Butachlor 1.0 kg ha^{-1}	295	1584	2705	2811
W_2 : Oxyflourfen 0.075 kg ha^{-1}	120	529	672	781
W_3 : Hand weeding at 20 and 40 DAS	241	1776	2893	2967
W_4 : Unweeded check (control)	251	947	2236	2598
SEm±	6.9	41.2	61.7	33.6
CD (P = 0.05)	20	122	183	99
Interaction				
M at W				
SEm±	12.0	71.4	106.9	58.2
CD (P = 0.05)	NS	NS	NS	NS
W at M				
SEm±	12.2	62.2	103.0	54.6
CD (P = 0.05)	NS	NS	NS	NS

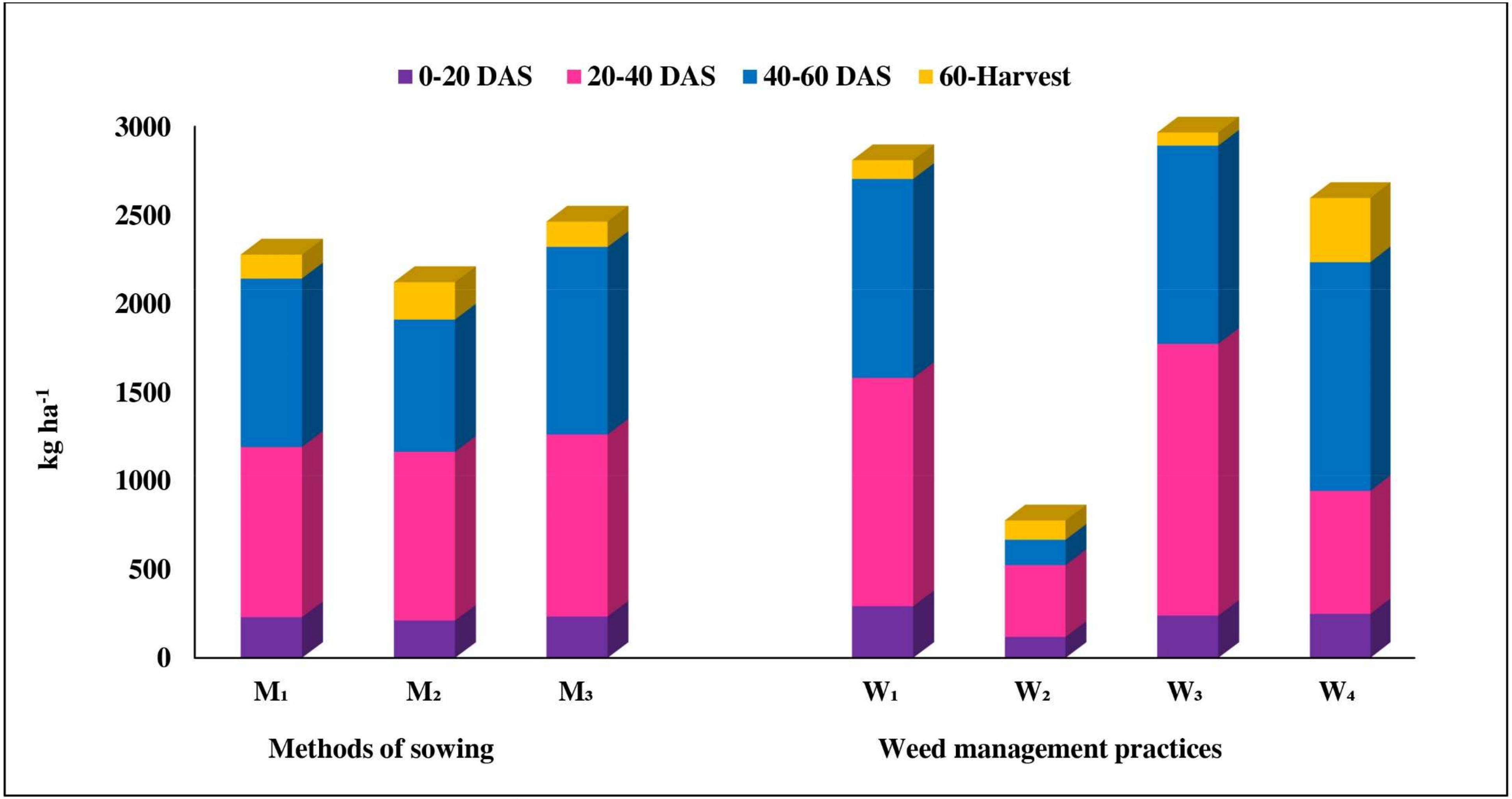


Fig. 4.11. Dry matter production (kg ha^{-1}) at different growth stages of sesame as influenced by methods of sowing and weed management practices.

dry matter production (295 kg ha^{-1}) of sesame at 20 DAS. Difference between unweeded check (W_4) (251 kg ha^{-1}) and hand weeding (W_3) (241 kg ha^{-1}) was not significant. Application of oxyflourfen (W_2) produced lower dry matter production (120 kg ha^{-1}).

At 40 and 60 DAS and at harvest, methods of seeding had significant influence on dry matter production of sesame. Significantly the highest dry matter production was with broadcasting at higher seed rate (M_3) followed by line sowing (M_1) and broadcasting with recommended seed rate (M_2). Each of the method of sowing differed significantly from the other in the order of broadcasting using higher seed rate, line sowing and broadcasting with recommended seed rate. Highest dry matter production at 40 and 60 DAS and at harvest with hand weeding could be attributed to its capacity to suppress the weeds leading to efficient use of resources and higher dry matter production of sesame, as reported by Islam *et al*. (2014), Mruthul *et al*. (2015) and Patnaik *et al*. (2020).

4.3.1.6 Phytotoxic effect of herbicides on sesame crop

Phytotoxicity of herbicides on sesame crop was observed at 10 days after pre emergence herbicide application (Table 4.16)

Among the pre emergence herbicides, butachlor (W_1) did not show any phytotoxic effect on sesame seedlings. Similar results have been reported by (Sahoo *et al.,* 2017). Pre emergence application of oxyfluorfen showed phytotoxicity rating of 8.0. (crop almost destroyed). Similar results were reported by Lins *et al.* (2020).

4.3.2 Yield Attributes and Yield

Major yield attributes (number of capsules plant^{-1}, seeds capsule^{-1} and test weight) differed significantly due to seeding methods and weed management practices. Interaction of these two management practices could not influence the yield attributes significantly (Table 4.17 and Fig. 4.12).

Table 4.16. Phytotoxicity scoring on sesame crop due to pre emergence herbicides application (0-10 Scale)

Treatments	Phytotoxicity scoring
W_1 : Butachlor 1.0 kg ha^{-1}	0.0
W_2 : Oxyflourfen 0.075 kg ha^{-1}	8.0

Table 4.17. Number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$ and test weight (g) of sesame as influenced by methods of sowing and weed management practices

Treatments			Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	Test weight
Methods of sowing					
M_1	:	Line sowing	32.6	52.3	2.78
M_2	:	Broadcasting	26.2	47.0	2.77
M_3	:	Broadcasting with 1.5 times seed rate	19.4	43.2	2.78
SEm$\pm$			1.01	0.60	0.030
CD (P = 0.05)			4.2	2.5	NS
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	30.1	50.1	2.81
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	13.3	39.7	2.70
W_3	:	Hand weeding at 20 and 40 DAS	35.2	54.2	2.82
W_4	:	Unweeded check (control)	25.2	45.8	2.75
SEm$\pm$			1.40	0.91	0.021
CD (P = 0.05)			4.3	2.8	NS
Interaction					
M at W					
SEm$\pm$			2.50	1.61	0.041
CD (P = 0.05)			NS	NS	NS
W at M					
SEm$\pm$			2.41	1.50	0.052
CD (P = 0.05)			NS	NS	NS

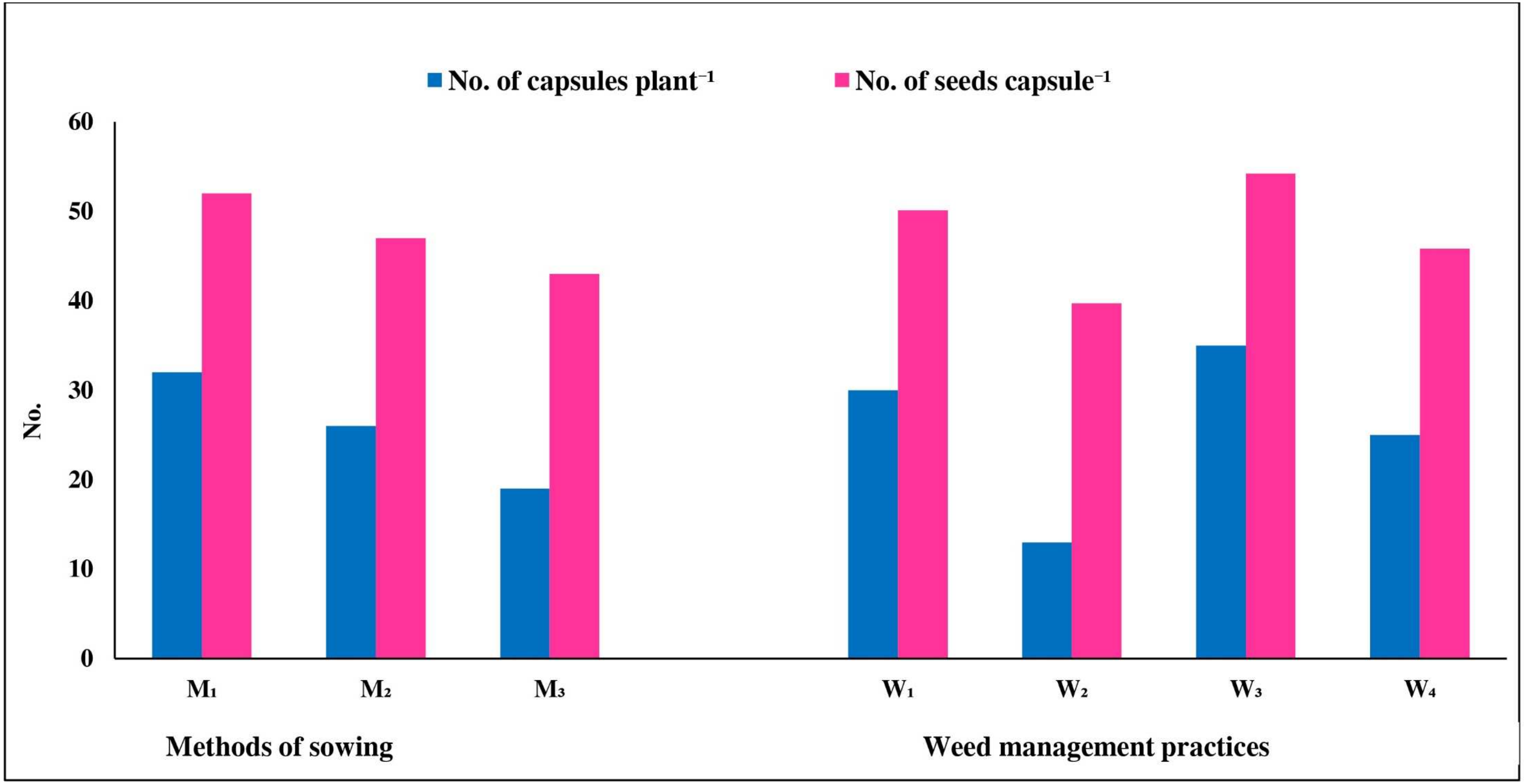


Fig. 4.12. Number of capsules plant^{-1} and number of seeds capsule^{-1} of sesame as influenced by methods of sowing and weed managementpractices.

4.3.2.1 Number of capsules plant^{-1}

Significantly higher number of capsules (32.6) plant^{-1} was with line sowing (M_1), relative to the other methods of sowing. Difference between broadcasting (26.2) (M_2) and higher seed rate (19.4) (M_3) was also significant. More number of capsules plant^{-1} with line sowing might be due to low degree of inter - plant competition for moisture, nutrients, solar energy *etc*., for vegetative growth leading to better partitioning of photosynthates from source to sink. Similar findings were observed by Singh *et al*. (2018).

Among the weed management practices, hand weeding (W_3) resulted in significantly the highest number of capsules plant^{-1} (35.2) followed by the other three methods which also differed significantly in the descending order of hand weeding (W_3) (35.2), butachlor application (W_1) (30.1), unweeded check (W_4) (25.2) and oxyflourfen (W_2) (13.3). Decrease in plant population due to phytotoxicity of oxyflourfen reduced the sesame plant population leading to lowest number of capsules plant^{-1}.

4.3.2.2 Number of seeds capsule^{-1}

Number of seeds capsule^{-1} at harvest differed significantly due to methods of sowing and weed management practices. Interaction between these two factors was not statistically traceable.

Significantly higher number of seeds capsule^{-1} (52.3) was with line sowing (M_1) which was significantly higher than broadcasting (M_2) (47.0). Broadcasting using higher seed rate (M_3) recorded least capsules plant^{-1} (43.2). More number of seeds capsule^{-1} with line sowing, presumably due to cumulative improvement in various growth parameters like number of branches plant^{-1} and dry matter production contributed to higher seeds capsule^{-1}. Similar findings have been reported by Ndor and Nasir (2019). Number of seeds capsule^{-1} was lower in broadcasting using higher seed rate due to decrease in seeds capsule^{-1} with increasing plant density.

Among the weed management practices, the highest number of seeds capsule^{-1} was with hand weeding (W_3). The next best weed management practice in producing higher number of seeds capsule^{-1} was the pre emergence application of butachlor (W_1). Increase in number of seeds capsule^{-1} in these treatments were 15.4 % and 8.5%, respectively compared to unweeded check. The highest number of seeds capsule^{-1} with these weed management practice were largely due to increased dry matter production and efficient translocation of photosynthates from source to sink as a result of efficient utilization of growth resources because of weed free environment during the critical stage of the crop. These results are in conformity with those of Audu *et al*. (2021). Lower number of seeds capsule^{-1} was with unweeded check. This might have been due to poor dry matter production of crop leading to poor partitioning of photosynthates to developing seeds. Among the pre emergence herbicides, lower number of capsules plant^{-1}was with oxyfluorfen which was significantly lesser than rest of the weed management practices. Lower number of capsules plant^{-1} was due to phytotoxic effect of oxyflourfen leading to mortality in sesame plant population.

4.3.2.3 Test weight

Scrutiny of data revealed that the test weight of sesame did not vary significantly with methods of sowing and weed management practices. Interaction between these two management practices was also not significant. Sesame test weight appears to be, largely, amenable to its genetic makeup rather than crop management practices.

4.3.2.4 Seed yield

Seed yield of sesame differed significantly with methods of sowing and weed management practices. Interaction of these two factors was not statistically measurable (Table 4.18 and Fig. 4.13).

Highest seed yield (660 kg ha^{-1}) was with broadcasting higher seed rate (M_3) which was significantly higher than the line sowing (M_1) (601 kg ha^{-1}). Broadcasting at recommended seed rate (M_2) resulted in significantly lower sesame seed yield (510 kg ha^{-1}). Yield advantage due to broadcasting at higher

Table 4.18. Seed and stalk yield (kg ha^{-1}) and harvest index (%) of sesame as influenced by methods of sowing and weed management practices

Treatments			Seed yield	Stalk yield	Harvest index (%)
Methods of sowing					
M_1	:	Line sowing	601	1163	34.04
M_2	:	Broadcasting	510	1082	32.02
M_3	:	Broadcasting with 1.5 times seed rate	660	1254	34.45
SEm±			8.5	19.5	0.59
CD (P = 0.05)			34	77	NS
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	789	1711	31.53
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	157	351	30.15
W_3	:	Hand weeding at 20 and 40 DAS	862	1801	32.36
W_4	:	Unweeded check (control)	554	1221	31.17
SEm±			24.0	28.1	0.51
CD (P = 0.05)			71	83	NS
Interaction					
M at W					
SEm±			41.6	48.5	0.66
CD (P = 0.05)			NS	NS	NS
W at M					
SEm±			37.1	46.3	0.63
CD (P = 0.05)			NS	NS	NS

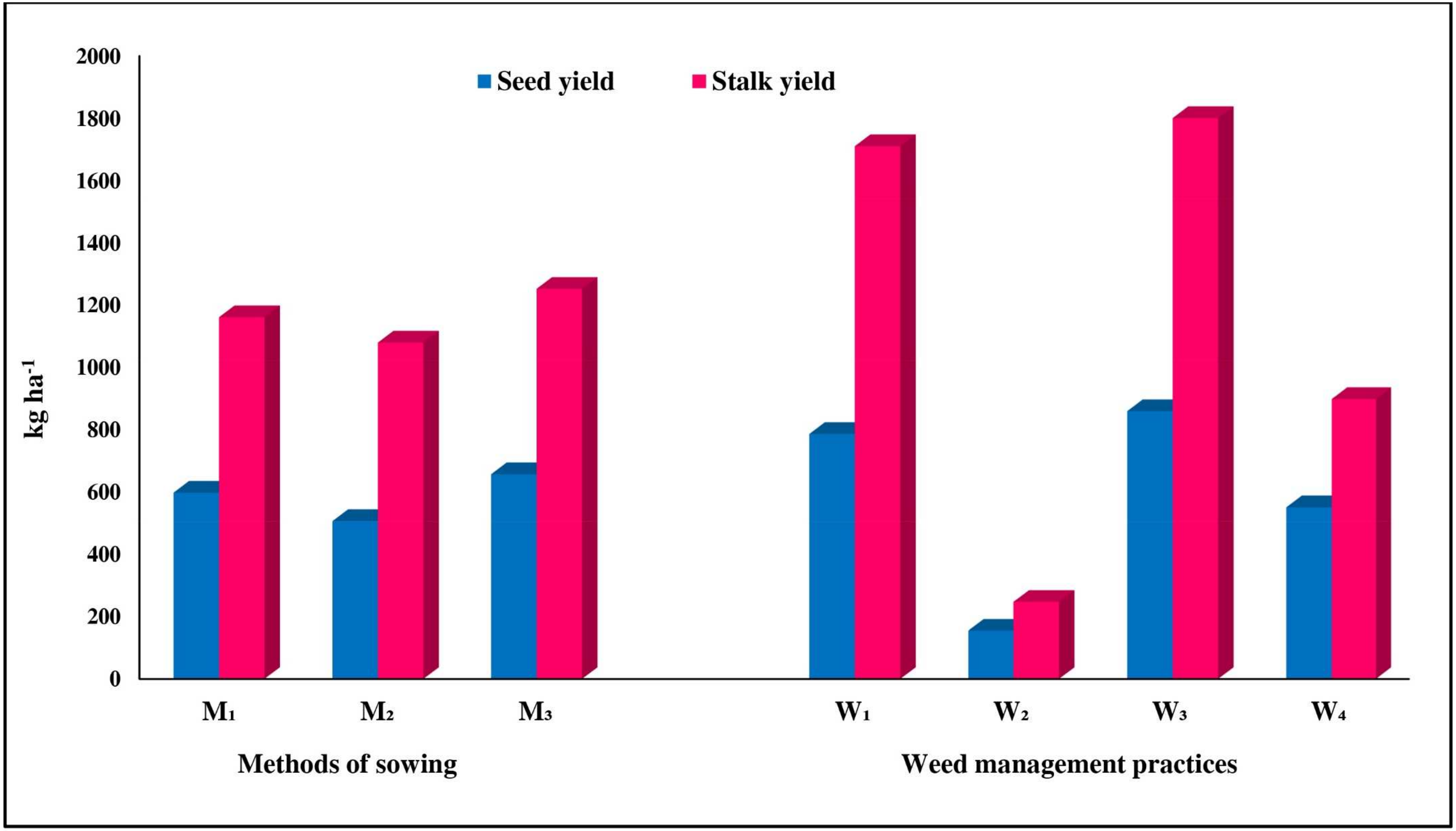


Fig. 4.13. Seed and stalk yield (kg ha^{-1}) of sesame as influenced by methods of sowing and weed management practices.

seed rate over the broadcasting recommended seed rate was 23 %. Higher seed yield with increase in seed rate appears to be due to higher sesame plant population which smothered weed growth leading to efficient use of growth resources. Increase in seed yield with, relatively higher seed rate has been reported by Islam *et al.* (2014) and Daniya *et al.* (2015). The lowest seed yield of sesame in broadcast sowing might be due to relatively lesser sesame plant density for efficient use of available growth resources (Caliskan *et al*., 2004).

Among the weed management practices, highest seed yield of sesame (862 kg ha^{-1}) was observed with hand weeding (W_3), which was significantly superior over rest of the weed management practices. Pre emergence application of butachlor (W_1) was the next best treatment with the seed yield of (789 kg ha^{-1}). Seed yield of sesame increased by 36 and 30 % respectively with hand weeding and pre emergence application of butachlor relative to unweeded check. Higher number of capsules $plant^{-1}$ and more number of seeds $capsule^{-1}$, as a result of reduced competition for growth resources by weeds, improved the yield attributes of sesame crop leading to higher seed yield.

These results are in agreement with thoseof Sangeetha and Chinnamuthu (2019) and Audu *et al*. (2021). Lower seed yield of sesame with unweeded check (W_4) might be due to heavy weed competition for growth resources, leading to poor partitioning of photosynthates from source to sink. Seed yield of sesame due to unweeded check reduced sesame seed yield by 64 and 70 %, respectively compared to hand weeding and pre emergence application of butachlor. Pre emergence application of oxyfluorfen (W_2) recorded significantly lesser seed yield (157 kg ha^{-1}) relative to rest of the weed management practices (Lins *et al*., 2020) and Babu *et al*., 2016).

4.3.2.5 Stalk yield

Stalk yield of summer sesame varied significantly due to methods of sowing and weed management practices. Interaction of these two management practices was not significant (Table 4.18 and Fig. 4.13).

Among the methods of sowing, significantly the highest stalk yield (1254 kg ha^{-1}) was with broadcasting at higher seed rate (M_3), relative to that due to line sowing (M_1) (1163 kg ha^{-1}). Stalk yield (1082 kg ha^{-1}) was significantly lower with broadcasting using recommended seed rate (M_2). The percentage gain in stalk yield due to broadcasting at higher seed rate over broadcasting at recommended seed rate was13.8%. Relatively higher plant population might have contributed to the increased stalk yield (Islam *et al*., 2008).

Among the weed management practices, highest stalk yield (1801 kg ha^{-1}) of sesame was with hand weeding (W_3), which was significantly higher than rest of the weed management practices. Higher dry matter production of sesame due to weed free environment throughout crop period contributed to high stalk yield with hand weeding. These results are in conformity with those of Aruna *et al.* (2020). Next best weed management practice for high stalk yield (1711 kg ha^{-1}) was pre emergence application of butachlor (W_1) followed by unweeded check (W_4) (901 kg ha^{-1}). Pre emergence application of oxyflourfen (W_2) resulted in the lowest stalk yield (251 kg ha^{-1}) which was significantly lesser than other weed management practices. Phytotoxic effect of oxyflourfen on sesame crop reduced plant population leading to heavy weed infestation and reduced the stalk yield of sesame.

4.3.2.6 Harvest index

Data pertaining to harvest index of summer sesame are presented in the table 4.18. The perusal of data revealed that methods of sowing and weed management practices did not alter both these parameters to a statistically significant level. The interaction effect between these two factors was also not detectable to a statistically measurable magnitude.

4.3.2.7 Weed index

Weed index of sesame varied significantly due to methods of sowing and weed management practices. Interaction of these two factors was not statistically measurable (Table 4.19).

Table 4.19. Weed index (%) of sesame as influenced by methods of sowing and weed management practices

Treatments			Weed index
Methods of Sowing			
M_1	:	Line sowing	30.24
M_2	:	Broadcasting	40.85
M_3	:	Broadcasting with 1.5 times seed rate	23.49
Weed management practices			
W_1	:	Butachlor 1.0 kg ha^{-1}	8.52
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	81.80
W_3	:	Hand weeding at 20 and 40 DAS	0
W_4	:	Unweeded check (control)	35.71

Minimum weed index was with broadcasting at higher seed rate (M_3) (23.49) which provided competitive advantage to the crop over weeds, as crop plants can absorb limited resources at a faster rate leading to reduced yield loss due to presence of weeds. Similar results have been reported by Mohler, (1996). Broadcasting (M_2) resulted in higher weed index (40.85) which was significantly higher than rest of the weed management practices. Yield loss due to presence of weeds with broadcasting increased in terms of weed index.

Among the weed management practices, minimum weed index (8.52) was with pre emergence application of butachlor (W_1) because of lesser weed density and dry weight leading to minimize yield loss in the presence of weeds. Present investigation confirms the results of Imoloame *et al*. (2011). Yield loss due to weeds in pre emergence application of oxyfluorfen (W_2) increased in terms of weed index (W_2) (81.80).

4.4 NUTRIENT UPTAKE BY SESAME CROP AS INFLUENCED BY METHODS OF SOWING AND WEED MANAGEMENT PRACTICES

Nutrient uptake by sesame crop differed significantly due to methods of sowing and weeds management practices. Interaction between these two practices was not statistically measurable (Table 4.20 and Fig. 4.14)

4.4.1 Nitrogen Uptake

Significantly the highest uptake of nitrogen by crop was with broadcasting at higher seed rate (M_3) which was significantly higher then that due to other sowing methods. N uptake significantly decreased in the order of broadcasting at higher seed rate (M_3) (39.1 kg ha^{-1}), line sowing (M_1) (37.2 kg ha^{-1}) and broadcasting at recommended seed rate (M_2) (34.4 kg ha^{-1}).

Among the weed management practices, hand weeding (W_3) recorded significantly higher nitrogen uptake by sesame crop relative to rest of the weed management practices. Nitrogen uptake significantly decreased in the order of hand weeding (W_3) (45.3 kg ha^{-1}), butachlor (W_1) (41.1 kg ha^{-1}), unweeded check (W_4) (33.3 kg ha^{-1}) and oxyflourfen (W_2) (29.2 kg ha^{-1}).

4.4.2 Phosphorus Uptake

Phosphorus uptake by crop varied significantly due to methods of sowing and weeds management practices.

With regard to methods of sowing, highest uptake of phosphorus by crop was with broadcasting at higher seed rate (M_3) (33.4 kg ha^{-1}) which was significantly higher than rest of the sowing methods. The next practices in the order of decreasing uptake were line sowing (M_1) (30.4 kg ha^{-1}) and broadcasting (M_2) (29.2 kg ha^{-1}).

Among the weed management practices, hand weeding recorded significantly higher phosphorus uptake by sesame crop relative to rest of the weed management practices. Differences in P uptake were significant in the

Table 4.20. Nutrient uptake (kg ha^{-1}) by sesame at harvest as influenced by methods of sowing and weed management practices

Treatments			Nitrogen	Phosphorus	Potassium
Methods of sowing					
M_1	:	Line sowing	37.2	30.4	53.3
M_2	:	Broadcasting	34.4	29.2	49.1
M_3	:	Broadcasting with 1.5 times seed rate	39.1	33.4	56.0
SEm±			0.14	0.22	0.56
CD (P = 0.05)			0.5	0.9	2.2
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	41.1	33.1	56.1
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	29.2	23.3	45.2
W_3	:	Hand weeding at 20 and 40 DAS	45.3	37.2	59.0
W_4	:	Unweeded check (control)	33.3	30.0	49.1
SEm±			1.10	0.69	0.58
CD (P = 0.05)			3.2	2.0	1.7
Interaction					
M at W					
SEm±			1.91	1.20	1.01
CD (P = 0.05)			NS	NS	NS
W at M					
SEm±			1.66	1.02	1.04
CD (P = 0.05)			NS	NS	NS

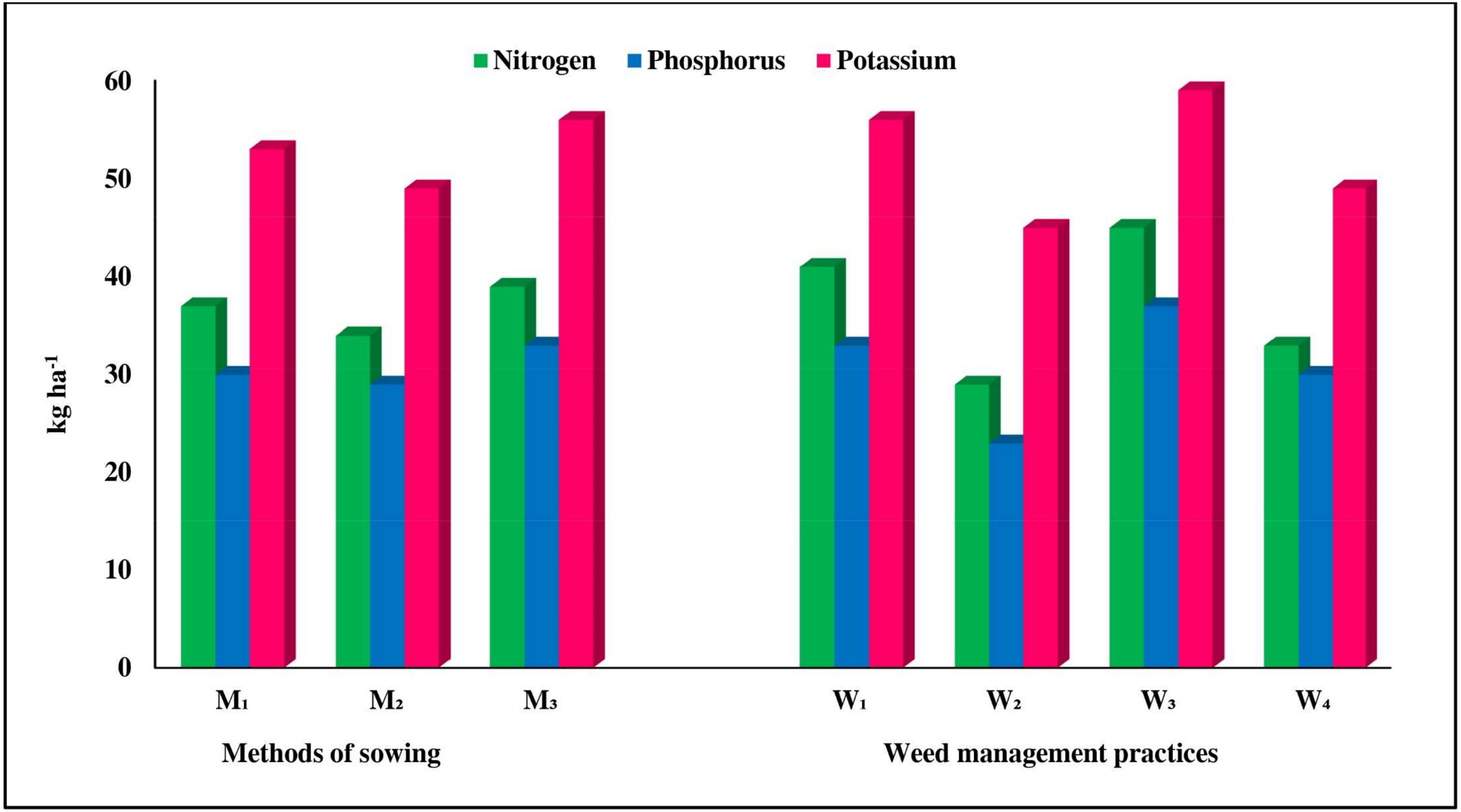


Fig. 4.14. Nutrient uptake (kg ha^{-1}) by sesame at harvest as influenced by methods of sowing and weed management practices.

order of hand weeding (W_3) (37.2 kg ha^{-1}), butachlor (W_1) (33.1 kg ha^{-1}), unweeded check (W_4) (30.0 kg ha^{-1}) and oxyflourfen (W_2) (23.3 kg ha^{-1}).

4.4.3 Potassium Uptake

Potassium uptake by crop differed significantly due to methods of sowing and weeds management practices.

With regard to methods of sowing, highest uptake of potassium by crop was with broadcasting at high seed rate (M_3) (56.0 kg ha^{-1}) which was significantly higher than rest of the sowing methods. The next practices in the order of decreasing uptake were line sowing (M_1) (53.3 kg ha^{-1}) and broadcasting (M_2) (43.1 kg ha^{-1}).

Among the weed management practices, hand weeding (W_3) recorded significantly higher potassium uptake by sesame crop relative to rest of the weed management practices. Differences in potassium uptake due to other three practices also significant in the order of hand weeding (W_3) (59.0 kg ha^{-1}), butachlor (W_1) (56.1 kg ha^{-1}), unweeded check (W_4) (49.1 kg ha^{-1}) and oxyflourefen (W_2) (45.2 kg ha^{-1}).

Among the methods of sowing the highest uptake of N, P and K by sesame were with broadcasting at higher seed rate due to lower weed infestation. Similar results have been reported by Rajpurohit *et al.* (2017).

Hand weeding recorded significantly higher N, P and K uptake by sesame crop relative other three weed management practices. This might be due to higher dry matter accumulation and higher nutrient content in sesame crop. The nutrient uptake by crop and associated weeds followed an inverse relationship as evident in the present investigations. Lower nutrient uptake of N, P and K by crop was with unweeded check due to low dry matter production and reduced nutrient uptake by the crop as a result of heavy weed competition. These results are in conformity with the results of Sahoo *et al*. (2017).

4.5 ECONOMICS

Economics in terms of gross and net returns and benefit-cost ratio of sesame crop significantly differed due to methods of sowing and weed management practices. While the interaction effect was not significantly traceable (Table 4.21 Fig. 4.15).

4.5.1 Gross Returns

There was significant difference in gross returns due to methods of seeding and weed management practices.

Among the methods of sowing, higher gross returns (₹ 49481 ha^{-1}) were with broadcasting at higher seed rate (M_3) which was significantly higher than the two other methods. This might be due to better weed control efficiency leading to high seed yields. Similar results have been reported by Zaho *et al*. (2017). The next practice with higher gross returns was line sowing (M_1) (₹ 45118 ha^{-1}). Broadcasting resulted in significantly lower returns (M_2) (₹ 38250 ha^{-1}).

Among the weed management practices, the highest gross returns were with hand weeding (W_3) (₹ 64675 ha^{-1}), which was significantly higher than rest of the weed management practices this might be due to increased seed yield. Pre emergence application of butachlor (W_1) was the next best weed management practices for realizing higher gross returns (₹ 59166 ha^{-1}).Similar results have been reported by Aruna *et al*. (2020). Lower gross returns (₹ 41550 ha^{-1}) were with unweeded check (W_4) due to reduced seed yield as a result of heavy weed competition. Oxyfluorfen (W_2) recorded lowest gross returns (₹11741 ha^{-1}) which was significantly lesser than rest of the three weed management practices.

4.5.2 Net Returns

Broadcsting with higher seed rate resulted in highest net returns. Differences between all the three practices significantly varied the net returns in the decreasing order of broadcasting at higher seed rate (M_3) (₹ 29392 ha^{-1}), line sowing (M_1) (₹ 25187 ha^{-1}) and broadcasting with recommended seed rate (M_2) (₹18273 ha^{-1}).

Table 4.21. Gross and net returns (₹ ha^{-1}) and B : C ratio of sesame as influenced by methods of sowing and weed management practices

Treatments			Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Methods of sowing					
M_1	:	Line sowing	45118	25187	2.23
M_2	:	Broadcasting	38250	18273	1.89
M_3	:	Broadcasting with 1.5 times seed rate	49481	29392	2.41
SEm$\pm$			640.1	644.0	0.021
CD (P = 0.05)			2513	2516	0.09
Weed management practices					
W_1	:	Butachlor 1.0 kg ha^{-1}	59166	40179	3.11
W_2	:	Oxyflourfen 0.075 kg ha^{-1}	11741	-7132	0.622
W_3	:	Hand weeding at 20 and 40 DAS	64675	40428	2.66
W_4	:	Unweeded check (control)	41550	23633	2.32
SEm$\pm$			1805.2	1807.3	0.080
CD (P = 0.05)			5364	5366	0.24
Interaction					
M at W					
SEm$\pm$			3127	3126	0.141
CD (P = 0.05)			NS	NS	NS
W at M					
SEm$\pm$			2782	2782	0.121
CD (P = 0.05)			NS	NS	NS

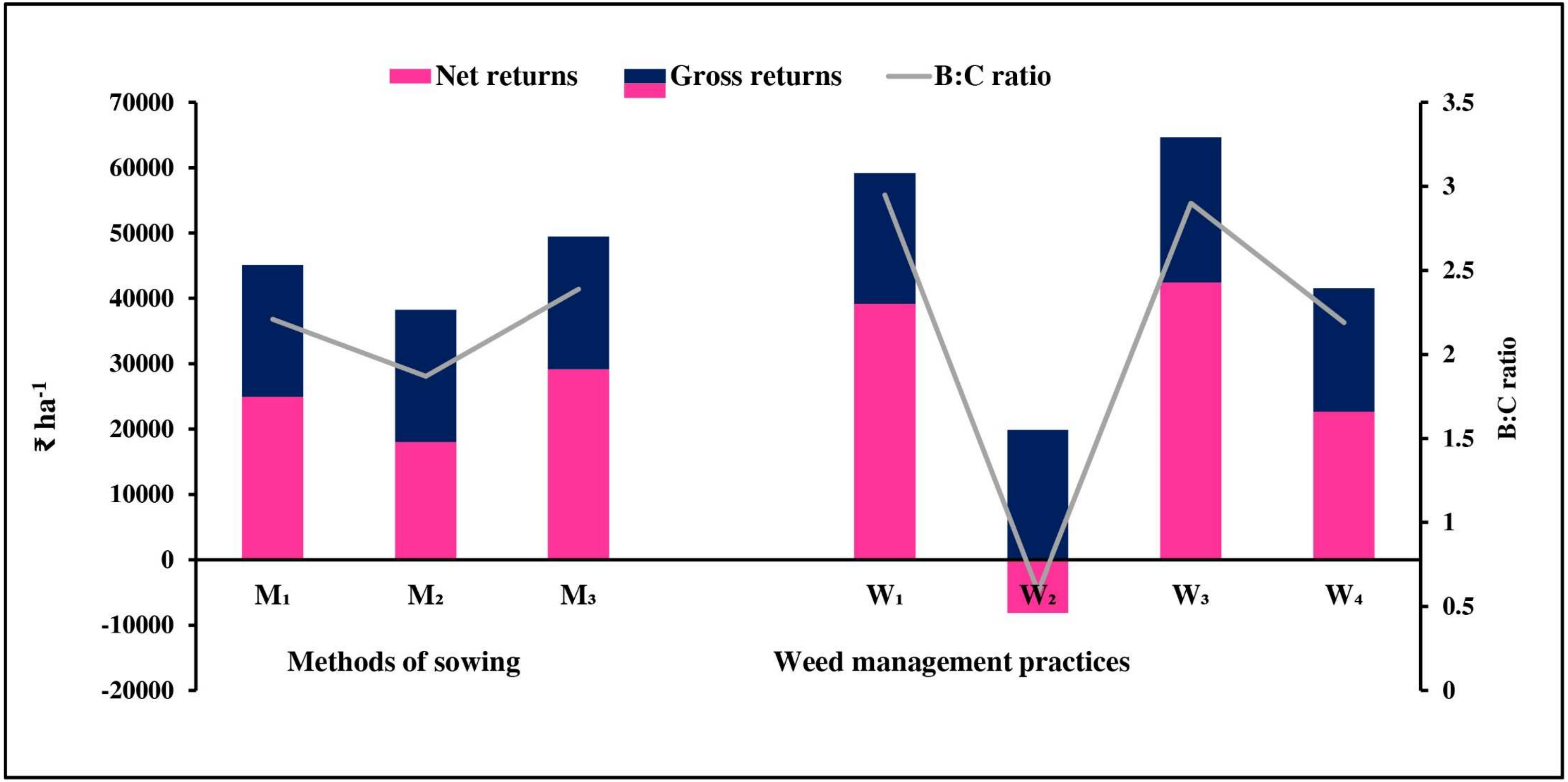


Fig. 4.15. Gross and net returns (₹ ha^{-1}) and B:C ratio of sesame as influenced by methods of sowing and weed management practices.

Hand weeding resulted in significantly the highest net returns (W_3) (₹ 40428 ha^{-1}) which was however comparable with butachlor application (W_1) (₹ 40179 ha^{-1}) and both were significantly higher over other treatments. Unweeded check (W_4) resulted in significantly lowest net returns (₹ 23633 ha^{-1}) relative to oxyflourfen (W_2) (₹ -7132 ha^{-1}). Higher yield due to hand weeding resulted in higher net returns. Monetary loss (₹ -7132 ha^{-1}) with oxyflourfen was due to very low yield of sesame because of its phytotoxicity on sesame crop.

4.5.3 Benefit-Cost ratio

Benefit-cost ratio differed significantly due to methods of seeding and weed management practices. Broadcasting at higher seed rate (M_3) resulted in significantly highest benefit-cost ratio (2.41) followed by line sowing (M_1) (2.23) and broadcasting (M_2) (1.89) in the descending order.

The benefit-cost ratio varied significantly due to butachlor application (W_1) (3.11) and hand weeding (W_3) (2.66). These two methods recorded significantly higher benefit-cost ratio over unweeded check (W_4) (2.32) and oxyflourfen (W_2) (0.62). Higher benefit-cost ratio with butachlor, might be due to higher gross and net returns resulting from higher yield. Due to higher cost of cultivation, hand weeding recorded lower benefit-cost ratio compared to butachlor application. Phytotoxicity of oxyflourfen on sesame crop resulted in lowest benefit-cost ratio.

Chapter – V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

A field experiment to evaluate the "Performance of pre emergence herbicides under different methods of sowing in summer sesame (*Sesamum indicum* L.)" was conducted during summer, 2022 on sandy loam soils of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh.

Treatments comprised of three methods of sowing *viz.*, line sowing (M_1), broadcasting (M_2) and broadcasting with 1.5 times higher seed rate (M_3) (Main plots) and four weed management practices *viz.*, pre emergence application of butachlor 1.0 kg ha^{-1} (W_1), pre emergence application of oxyfluorfen at 0.075 kg ha^{-1} (W_2) hand weeding at 20 and 40 DAS (W_3) and unweeded check (W_4) (Sub-plots) were tested in split-plot design, replicated thrice.

Weed flora belonged to eight taxonomic families of which four species were grasses, two species sedges and twelve species broad leaved weeds. Predominant weeds in the experimental field were *Cyperus rotundus* (40.0 %), *Commelina benghalensis* (10.0 %), *Cleome viscosa* (8.0 %), *Boerhavia diffusa* (5.0 %), *Phyllanthus niruri* (5.0 %), *Dactyloctenium aegyptium* (5.0 %) and *Digitaria sanguinalis* (4.0 %). Summary and conclusions on the investigations are presented below.

5.1 WEED DYNAMICS IN SESAME CROP

Methods of sowing and weed management practices significantly influenced the weed dynamics during the crop period.

At all the stages of observations, among the methods of sowing, the lowest density and dry weight of weeds was with broadcasting using higher seed rate (M_3) which was significantly lesser than that due to line sowing (M_1). Broadcast sowing (M_2) resulted in significantly the highest weed density and dry weight of weeds relative to line sowing.

Among the weed management practices, at 20 DAS, lowest density and dry weight of weeds was due to pre emergence application of oxyfluorfen (W_2) and it was significantly lesser than that due to butachlor application (W_1). Significantly the highest density and dry weight of weeds was with unweeded check (W_4), which was comparable with that due to hand weeding (W_3) (Hand weeding was not imposed by that time). At all other stages of observations, significantly the lowest density and dry weight of weeds were with hand weeding followed by pre emergence application of oxyflourfen.

5.1.1 Weed index

Minimum weed index was with broadcasting at higher seed rate (M_3). The next best weed management practice with lower weed index was line sowing (M_1). Broadcasting (M_2) recorded significantly higher weed index than the rest of the weed management practices.

Among the weed management practices, minimum weed index was with pre emergence application of butachlor (W_1), followed by unweeded check (W_4). The yield loss due to presence of weeds in pre emergence application of oxyfluorfen (W_2) was increased in terms of weed index.

5.2 BIOMETRIC OBSERVATIONS ON SESAME CROP

Biometric observations (growth parameters) on summer sesame varied significantly due to methods of sowing and weed management practices.

Methods of sowing could not vary summer sesame **plant height** at 20 DAS to a statistically perceptible magnitude.

At 40 DAS, taller plants were noticed with line sowing (M_1) which was at par with broadcasting using higher seed rate (M_3). The lower plant height was recorded with broadcasting (M_2).

At all other stages of observation *viz*., 60 DAS and at harvest, higher plant height was noticed with line sowing (M_1) which was significantly superior to the rest of the treatments investigated. The lower plant height was recorded with broadcasting with higher seed rate (M_3) which was at par with broadcasting (M_2).

Significantly higher plant height at 20 DAS was recorded pre emergence application of butachlor (W_1). The lower plant height of sesame was obtained with unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding not imposed at the time of sampling). Lowest plant height was recorded with oxyfluorfen (W_2).

At all other stages of observation *viz.*, 40, 60 DAS and at harvest, the highest plant height was observed in hand weeding (W_3), which was at par with pre emergence application of butachlor (W_1). The lower plant height was recorded with unweeded check (W_4). Pre emergence application of oxyfluorfen (W_2) recorded lowest plant height.

Leaf area of sesame progressively increased up to 60 DAS followed by a decline towards harvest due to senescence of older leaves. Methods of sowing could not significantly vary the leaf area of sesame at 20 DAS. At 40,60 DAS and at harvest, higher leaf area was with line sowing (M_1) which was significantly higher over other treatments.

At 20 DAS, leaf area of sesame was higher due to pre emergence application of butachlor (W_1). Lower leaf area was with unweeded check (W_4), which was comparable with that of hand weeding (W_3) (Hand weeding not imposed at the time of sampling). At 40,60 DAS and at harvest, highest leaf area was with hand weeding (W_3), which was significantly higher than that with other practices. Lowest leaf area was with oxyfluorfen (W_2).

Methods of sowing could not significantly vary the **dry matter production** of sesame at 20 DAS. At 40, 60 DAS and at harvest, higher dry matter production was with broadcasting using higher seed rate (M_3), which was significantly higher over rest of the treatments.

Significantly higher dry matter production at 20 DAS was due to pre emergence application of butachlor (W_1). Lower dry matter production of sesame was in unweeded check (W_4), which was comparable with hand weeding (W_3) (Hand weeding not imposed at the time of sampling).

At 40, 60 DAS and at harvest, highest dry matter production was with hand weeding (W_3), which was significantly higher than rest of the weed management practices. Lowest dry matter production was with oxyfluorfen (W_2) which was significantly relative to other weed management practices.

5.3 YIELD ATTRIBUTES, YIELD AND ECONOMICS OF SESAME CROP

Highest number of **branches plant^{-1}, capsules plant^{-1} and number of seeds capsule^{-1}** were due to line sowing (M_1) which was significantly higher over broadcasting (M_2). Broadcasting with higher seed rate (M_3) resulted in lowest values. Among the weed management practices, these three attributes were significantly highest with hand weeding (W_3) followed by butachlor application (W_1). Lowest number of branches plant^{-1}, capsules plant^{-1} and number of seeds capsule^{-1} were with oxyfluorfen (W_2) which was significantly lesser than rest of the weed management practices.

Among the methods of sowing, higher **seed and stalk yields and gross returns** of sesame were due to broadcasting using higher seed rate (M_3) which was significantly higher over line sowing (M_1) and broadcasting (M_2). Among the weed management practices, highest seed and stalk yields and gross returns of sesame were with hand weeding (W_3). Pre emergence application of butachlor (W_1) was the next best weed management practice. Since, oxyfluorfen (W_2) was phototoxic to sesame crop, its use resulted in very low seed and stalk yields of sesame leading to heavy monetary loss.

5.4 NUTRIENT UPTAKE BY WEEDS AND SESAME CROP

Nutrient uptake by weeds and sesame crop followed the order of weed dry weight, sesame seed and stalk yields. Nutrient (N, P and K) uptake by weeds varied significantly due to methods of sowing and weeds management practices.

With regard to methods of sowing, highest uptake of N, P and K by **sesame crop** was due to broadcasting using higher seed rate (M_3) which was significantly higher than rest of the sowing methods. Uptake of nutrients was in the decreasing order of broadcasting higher seed rate (M_3), line sowing (M_1) and broadcasting (M_2).

Among the weed management practices tried, hand weeding recorded significantly higher N, P and K uptake by sesame. The next best weed management practice was the pre emergence application of butachlor (W_1). The lower N, P and K uptake of sesame crop was recorded with unweeded check (W_4). Oxyfluorfen (W_2) recorded lowest uptake which was significantly lesser than the rest of the weed management practices.

Among the methods of sowing, highest uptake of N, P and K by **weeds** was with broadcasting (M_2) followed by others in the decreasing order of line sowing (M_1), broadcasting using higher seed rate (M_3).

Among the weed management practices, highest uptake of N, P and K by **weeds** was with unweeded check (W_4) followed by others in the decreasing order of butachlor (W_1), hand weeding (W_3) and oxyfluorfen (W_2).

Among the methods of sowing, higher net returns and benefit-cost were with broadcasting using higher seed rate (M_3) which was significantly higher relative to rest of the treatments tested.

Higher net returns due to hand weeding (W_3), which did not significantly differed from that due to pre emergence application of butachlor (W_1). Highest benefit-cost ratio with pre emergence application of butachlor (W_1) which was significantly higher than the hand weeding (W_3). Among the two pre emergence herbicides, oxyfluorfen (W_2) recorded significantly lower net returns and benefit-cost ratio which were significantly lower, relative to other weed management practices.

Conclusions

Based on the foregoing discussion, the following conclusions could be drawn from the present investigation.

1. Among the three methods of sowing, broadcasting with 1.5 times seed rate (7.5 kg ha^{-1}) proved superior over other methods of sowing in recording lowest density and dry weight of weeds and higher growth parameters and seed yield.

2. Among the weed management practices tried, hand weeding twice at 20 and 40 DAS resulted in higher growth characters and seed yield of summer sesame.

3. Among the herbicides, higher growth and yield parameters and higher monetary returns were recorded with pre emergence application of butachlor 1.0 kg ha^{-1}.

4. The interaction effect between methods of sowing and weed management practices was not statistically measurable and failed to exert significant influence on any of the parameters studied in the present investigation.

Hence, the present study concluded that effective control of weeds and higher seed yield, gross and net returns were obtained with broadcasting with 1.5 times seed rate (7.5 kg ha^{-1}) along with hand weeding at 20 and 40 DAS. However, the highest benefit-cost ratio was realized with pre emergence application of butachlor 1.0 kg ha^{-1} in summer sesame.

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Appendices

APPENDIX-A

CALENDAR OF OPERATIONS

S.No.	Particulars of operation	Date
1	Land preparation	11-01-2022
2	Levelling	12-01-2022
3	Lay-out of the experimental field	17 -01-2022
4	Micro levelling of individual plots	18-01-2022
5	Sowing	19-01-2022
6	Irrigation	19-01-2022
7	Pre emergence application of herbicides as per the treatments	20-01-2022
8	Thinning	27-01-2022
9	Spraying of larvin	07-02-2022
10	Irrigation	08-02-2022
11	Hand weeding (20 DAS) in W_3	09-02-2022
12	Top dressing of nitrogen	09-02-2022
13	Irrigation	15-02-2022
14	Irrigation	24-02-2022
15	Second hand weeding (40 DAS) in W_3	27-02-2022
16	Spraying of wettable sulphur	16-03-2022
17	Irrigation	18-03-2022
18	Irrigation	01-04-2022
19	Harvesting	19-04-2022
20	Threshing and cleaning of the produce	25-04-2022

APPENDIX-B

COST OF CULTIVATION (₹ ha^{-1}) OF SUMMER SESAME EXCLUDING THE COST OF TREATMENTS

S. No.	Particulars	Cost
1	Land preparation	3537
2	Levelling	850
3	Sowing	2800
4	Thinning	1700
5	Fertilizers	2900
6	Plant protection	960
7	Irrigation	1400
8	Harvesting and threshing	3750
	Total	**17,897**

Cost of imposing main plot treatments

Methods of sowing	Total cost of seed
M_1 : Line sowing (4 kg ha^{-1})	720
M_2 : Broadcasting (5 kg ha^{-1})	900
M_3 : Broadcasting with 1.5 times seed rate (7.5 kg ha^{-1})	1350

Cost of imposing sub plot treatments

Weed management practices	Total cost
W_1 : Pre emergence application of butachlor 1.0 kg ha^{-1}	1100
W_2 : Pre emergence application of oxyfluorfen 0.075 kg ha^{-1}	987
W_3 : Hand weeding at 20 and 40 DAS	3360
W_4 : Unweeded check (control)	0

APPENDIX-C

COST OF INPUTS AND OUTPUT*

S.No.	Input / Output	Unit	Cost (₹ $unit^{-1}$)
1	Seed	kg	180
2	Urea	kg	6
3	Single super phosphate	kg	10
4	Muriate of potash	kg	19
5	Butachlor	ml^{-1}	0.41
6	Oxyflourfen	ml^{-1}	2.21
7	Larvin	kg	840
8	Wettable sulphur	kg	240
9	Labour cost for normal operations	day	280
10	Sesame seed	kg	75

*Costs are as per the prevailing rates at Agriculture Market Committee, Tirupati, Andhra Pradesh.

APPENDIX – D

TOTAL COST OF CULTIVATION OF SUMMER SESAME (₹ ha^{-1})

S. No.	Treatments	Cost of cultivation excluding treatments (₹ ha^{-1})	Cost of main plot treatments (₹ ha^{-1})	Cost of sub plot treatments (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})
1	M_1W_1	17897	720	1100	18717
2	M_1W_2	17897	900	987	18784
3	M_1W_3	17897	1350	5360	24607
4	M_1W_4	17897	720	0	17617
5	M_2W_1	17897	900	1100	18897
6	M_2W_2	17897	1350	987	19234
7	M_2W_3	17897	720	5360	23977
8	M_2W_4	17897	900	0	17797
9	M_3W_1	17897	1350	1100	19347
10	M_3W_2	17897	720	987	18604
11	M_3W_3	17897	900	5360	24157
12	M_3W_4	17897	1350	0	18247

Plates

Plate 1. Overall view of the experimental field of sesame crop at flowering stage.

Plate 2. Imposition of treatments (pre-emergence herbicides) in sub-plots of the experimental field.

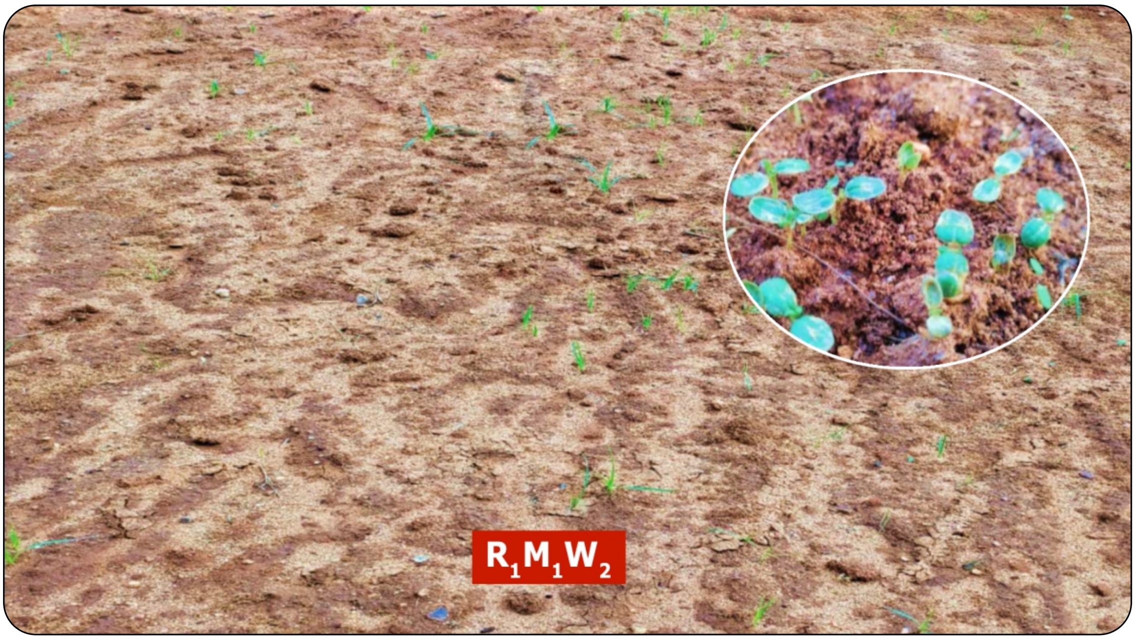

Plate 3. Poor seedling emergence and phytotoxicity symptoms of oxyfluorfen on sesame crop at 10 DAS.

Plate 4. Weed density in sesame crop in unweeded check plot at 30 DAS.

Plate 5. Weed density in sesame crop in butachlor applied plot at 30 DAS.

Plate 6. Weed density in sesame crop in hand weeded plot at 30 DAS.

Plate 7. Visit of student advisory committee to the sesame experimental field.