Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan

उत्तरी – पश्चिमी राजस्थान में तिल (*सिसेमम इण्डिकम* एल.) की किस्मों का विभिन्न बुवाई तिथियों के अन्तर्गत मूल्याकंन

Shri Rakesh

Thesis

Master of Science in Agriculture

(Agronomy)

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Department of Agronomy

College of Agriculture, Bikaner
Swami Keshwanand Rajasthan Agricultural University
Bikaner (Raj.)

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Thesis

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for the degree of

Master of Science in Agriculture
(Agronomy)

By

Shri Rakesh

2018

Swami Keshwanand Rajasthan Agricultural University, Bikaner

College of Agriculture, Bikaner

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This is to certify that **Shri Rakesh** had successfully completed the comprehensive examination held on------------as required under the regulation for the degree of **Master of Science** in **Agriculture (Agronomy).**

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Date......................

This is to certify that the thesis entitled "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan"** submitted for the degree of **Master of Science in Agriculture** in the subject of **Agronomy** embodies bonafide research work carried out by **Mr. Shri Rakesh** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on _____________

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This is to certify that the thesis entitled "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan" submitted** by **Mr. Shri Rakesh** to the Rajasthan Agricultural University, Bikaner in partial fulfillment of the requirements for the degree of Master **of Science in Agriculture** in the subject of **Agronomy,** after recommendation by the external examiner, was defended by the candidate before the following members of the advisory committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory. We therefore, recommend that the thesis be approved.

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This is to certify that **Mr. Shri Rakesh** of the Department of Agronomy, College of Agriculture, Bikaner (Rajasthan) has made all corrections/modifications in the thesis entitled "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan".** Which were suggested by the external examiner and the advisory committee in the oral examination held on _________. The final copies of the thesis duly bound corrected were submitted on __________ and forwarded herewith for approval.

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Place: Bikaner ***(Shri Rakesh)***

Date:

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ACRONYMS

@	At the rate of
%	Per cent
^{0}E	Degree East
B:C ratio	Benefit cost ratio
C.D.	Critical difference
cm	Centimeter
CV	Coefficient of variation
d.f.	Degree of freedom
DAP	Diammonium phosphate
DAS	Days after sowing
dS m^{-1}	Deci- Simens per meter
E.C.	Electrical conductivity
etc.	(et. cetera) and other similar things)
et al.	(et al. al. alii or et al. al. alia) other people or things)
Fig.	Figure
g	Gram
ha	Hectare
Hrs	Hours
HI	Harvest index
i.e.	(id est) That is
K	Potassium
kg ha^{-1}	Kilogram per hectare
Km/hr	Kilometers per hour
M	Meter
Max.	Maximum
m^{-2}	Squire meter
mg	Milligram
Mg m^{-3}	Mega gram per cubic meter
Min	Minimum
mm day^{-1}	Millimeter per day
m ha	Million hectare
N	Nitrogen
^{0}N	Degree North
No.	Number
NS	Non-significant
q ha^{-1}	Quintal per hectare
R.H.	Relative humidity
Rep.	Replication
₹ ha^{-1}	Rupee per hectare
SEm$\pm$	Standard error of mean
S. No.	Serial Number
USDA	United States Department of Agriculture
Viz.,	(Videlicet) namely
^{0}C	Degree Celsius

1. INTRODUCTION

Oilseeds are the main source of fat and protein, particularly for vegetarians. In Indian economy, oilseeds occupy an important place and contribute to near about 6 per cent of gross national production and consumed about 7.0 per cent of the world as edible. It covers about 15 per cent of the gross cropped area. Sesame (*Sesamum indicum* L.) is one of the most important oilseed crop which is suitable for tropical and temperate regions. It is also known as *Til* or Gingelly, and referred as "Queen of oilseeds" because of its high nutritional value.

The seeds of sesame contains 40 to 63 per cent oil which is rich in antioxidants and has a significant amount of oleic and linoleic acids (Abate and Mekbib, 2015). Sesame seed is consumed as a source of calcium, potassium, tryptophan and methionine. It is also used in pharmaceutical as well as cosmetic industries (Pornparn *et al.* 2009). Protein content generally varies from 18-20 per cent.

Globally sesame is cultivated in more than 7 million hectare with an annual production 4 million tonnes and productivity 535 kg ha^{-1}. India is the largest producer and acreage holder (26 per cent) of sesame in the world. In India, it is cultivated in 20 lakh hectares with an annual production of 8.66 lakh tonnes and productivity 405 kg ha^{-1} (GOI, 2016). It is extensively cultivated in the states of Gujarat, West Bengal, Tamil Nadu, Maharashtra, Karnataka, Rajasthan and Madhya Pradesh. Gujarat alone accounts for 20 per cent of the national production.

In Rajasthan, the crop occupied 2.66 lakh hectares and produced 0.92 lakh tonnes with the productivity 347 kg ha^{-1} in 2016-17 (GOR 2017). Pali, Tonk, Sawai Madhopur, Jodhpur, Bhilwara, Karoli and Jalore are important sesame growing districts of Rajasthan.

It belongs to family Pedaliaceae. The crop is grown in wide range of environments extending from semi-arid tropics and sub-tropics to temperate regions. The variability in environments *viz.,* location effect, seasonal influence and their interactions highly influences the performance of genotypes in relation to yield potential.

Recent studies confirmed that varieties differ extensively in the physiological processes determining the yield. It has been also shown that the total yield $plant^{-1}$ and $unit^{-1}$ area is determined by the number of capsules and seed weight $plant^{-1}$. These physiological factors also influenced by environmental factors. Now days, attention also paid on global warming and due to global warming climatic changes are often seen in India. That's why growth, yield, oil per cent in sesame is greatly affected. To overcome this problem, there is necessity to study the response of different varieties of sesame and different sowing times.

The low yield of sesame is mainly due to cultivation of low yielding tradition varieties with lack of improved agronomical practices. The increased availability of improved varieties also increases productivity of sesame. The various varieties have differences in growth habits and yield traits.

Studies showed that sowing date affects the growth of sesame and that early planting result in significant increase in growth and yield (Rahman *et al.,* 2007). Among the various factors responsible for low yield $unit^{-1}$ area, planting geometry and sowing time are very important. Early and late sowing decreased the seed yield of sesame (Nath *et al*., 2000).

Sesame normally requires fairly high temperature. Temperature for optimum growth from seedling to flowering and fruiting is in the range of 27-33^{0}C. Temperatures of 35^{0}C or above at flowering stage may affect fertilization and seed setting. On the other hand, if temperature falls below 20^{0}C for longer time, germination and seedling growth are delayed and these processes are inhibited at temperature below 10^{0}C. Seed yield of sesame is significantly influenced by sowing date and cultivar and if planting is delayed from optimum time, yield decreases.

Sowing time of sesame play an important role on its average production for different agro-climatic region of Rajasthan because it is mostly grown under rain fed conditions. Thus, the rainfall pattern (onset and termination of rainfall and distribution of rainfall) influence the growth and yield of crop. The late onset of monsoon generally delays the sowing resulting in to poor yield. This necessitates finding of suitable sowing time with the consideration to the effect of temperature on plant. Degree days concept based on the idea that plants have a specific temperature requirement for the completion of particular physiological stage will definitely provide ample scope to find the suitability of sowing time.

The sowing time of the crop varies considerably from one part to another part of country, owing to differences in climate, soil, variety grown and also the type of cultivation i.e. whether the crop is raised as rainfed or as irrigated.

Research has, however, been both limited and unevenly distributed geographically. A little information on sowing date of sesame is available. There is great scope for increasing the yield of sesame crop. Substantially by resorting to optimum sowing date is an "Non-cash" input, it is essential to find out the suitable date for sowing to a particular variety of sesame under North western Rajasthan condition.

Keeping In view of the above facts, the present investigation entitled "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan"** was conducted during *kharif*, 2017 to achieve the following objectives.

OBJECTIVES

1. To study the effect of different sowing dates on growth, yield and quality of sesame varieties.
2. To find out the effect of different sowing dates and varieties on nutrient uptake by crop.
3. To work out the economics of different treatments of sesame.

2. REVIEW OF LITRATURE

The available review of literature concerning to the present investigation entitled “**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan”** has been presented in this chapter. The work done related to these aspects on sesame crop is limited and, hence similar work on other oilseed crops has also been included wherever felt necessary. A brief summary of research work pertinent literature on the effect of such work to supplement the literature on sesame.

2.1 Effect of sowing dates

2.1.1 Growth parameters

Muthusankaranarayanan *et al.* (2001) observed that plant height of sesame increased to 122.88 cm on February 16th sowing whereas, 3rd March sowing recorded the maximum height of 108.84 cm which was lower than pre-succeeding dates of sowing.

Nath *et al.* (2003) carried out a field trial at Bidhan Chandra Krishi Viswavidyalaya, West Bengal during summer seasons of 1999 and 2000 in typical alluvial (Entisol) and sandy loam soil. The results revealed that the leaf growth rate, leaf area index, dry matter production and crop growth rate of sesame were significantly higher when the crop was sown on 19th February and the lowest on 28th April.

Abdel Rahman *et al.* (2003) conducted a field trial at Egypt in 2001 and 2002 to investigate the effect of sowing dates (10th and 25th May and 10th June) on the performance of sesame (*Sesamum indicum* L.) plant. They reported that sesamum sown on 10th May showed the maximum height (178.99 cm), whereas the height of the first branch and number of branches plant^{-1} were the highest in plant sown on 25th May.

Shegro e*t al.* (2010) revealed that the flowering was generally delayed and maturity hastened due to delay in planting dates. The magnitude of delay in flowering and hastening of maturity depended on varieties. Variety TGX 133-2644 being the most are maturing variety as against the earliest variety Williams. Leaf area (LA) plant^{-1} and Leaf Area Index (LAI) were reduced significantly due to at planting and variety TGX 133-2644 showed maximum LA and LAI. The extent of reduction in LA and LAI due to planting dates depended upon varieties.

Mohammad *et al.* (2012) reported that the growth parameters were influenced due to sowing dates and highest plant height (60.3 cm), primary branch numbers plant^{-1} (4.46) were obtained at sowing on 20 April.

Ogbonna and Umarshaaba (2012) reported that the optimum time of sowing sesame in the derived savanna agro ecology of southeastern Nigeria and identified high-yielding sesame accessions for the zone, three sowing dates (July 22nd, August 22nd and September 22nd) were tested in 2009 while in 2010, the planting dates were June 22nd, July 22nd and August 22nd, based on the results, time of sowing had a significant effect on growth and yield of sesame like, Plant height, number of leaves, stem girth and number of branches plant^{-1} decreased with delay in time of sowing.

Prathima *et al.* (2012) conducted a field experiment at Regional Agricultural Research Station, Tirupati, Acharya N. G. Ranga Agricultural University, Hyderabad and reported that, the 22nd June date of sowing recorded maximum plant height at 15 and 30 DAS as compared to 12th July sowing.

Sivagamy and Rahman (2013) They reported that significantly higher plant height, branches plant^{-1}, were observed in tested variety of KS 95010 during early sowing on 26th February than delayed sowing during the first fortnight of March.

Ali and Jan (2014) reported that plant sown on 20th June had significantly improved plant height (197 cm), branch plant^{-1} (15) and capsule length (2.78 cm) as compare to other sowing dates due to prolonged photoperiod for vegetative growth.

Jiotode *et al*. (2015) conducted a field experiment on sesame cultivars under different dates of sowing during 2013-2014 at Agronomy farm, College of Agriculture, Nagpur. Growth contributing characters like, plant height and number of branches plant^{-1} were significantly higher at sowing date *i.e.* 27th MW at harvest.

Chongdar *et al.* (2015) carried out a field experiment on the effect of dates of sowing and improved cultivars on growth and yield of summer sesame in North Bengal and found that the highest (114.66 and 115.83 cm) plant height was recorded when sesame sown on 12th March (D4) and which was statistically at par with 2nd March (D3). Among the varying date of sowing, the highest dry matter accumulation, leaf area index and crop growth rate was recorded in 2nd day of March as compared to the other date of sowing.

Meena *et al.* (2015) conducted a field experiment in loamy sand soil during *kharif* season of 2009 and 2010 to evaluate the temperature use efficiency and yield of groundnut varieties in response sowing dates and fertility levels. The treatments consisted of four sowing dates (20 April, 15 May, 9 June and 4 July) and two varieties of groundnut (HNG 10 and TG 37A) and he found that significantly higher crop growth rate (CGR) at 30-60 and 60-90 days after sowing (DAS) were observed in HNG 10 variety. Maximum heat unit efficiency (3.23 kg ha^{-1} degree- day^{-1}) was observed on 9 June sowing date Further delays in sowing from 9 June significantly reduce crop growth rate.

1.1.2 Yield attributes and yield

Number of capsules $plant^{-1}$ was significantly influenced by 19^{th} February sowing of sesame crop at Mohanpur of West Bengal (Rajibnath *et al.,* 2000 and Nath *et al.,* 2000).

Nath *et al.* (2000) conducted a field experiment during summer season on sesame (*Sesamum indicum* L.) to study the capsule production efficiency of the main stem and branches of sesame cultivars at different sowing dates in alluvial soil of the tropical humid region in West Bengal and they found that the highest capsule production by main stem and first, second and third primary branches in acorsentric order was observed for the crop sown on 19^{th} February. The number of capsules on main stem was reduced by 70.51 and 34.98 per cent when crop was sown on 21^{st} March and 28^{th} April, respectively.

Rajib Nath *et al.* (2000) adopted three sesame cultivars (Kanke-1, Rama and B-67) and were sown on 10^{th} and 19^{th} February, 1^{st}, 11^{th} and 21^{st} March and 7^{th}, 18^{th} and 28^{th} April, in West Bengal and reported that the maximum number of capsules $plant^{-1}$ was produced when crop was sown on 19^{th} February.

Bahale *et al.* (2001) conducted a field trial on sesame to determine the appropriate sowing time, suitable method of layout and management of excess water in vertisols to sustain or maximize the productivity of rainfed sesame in Northern Maharashtra, and they found that the optimum sowing date (OST) i.e. twenty six the meteorological week. The OST produced significantly higher grain yield than the rest of the delayed sowing time.

Muthusankaranarayanan *et al.* (2001) observed that number of capsules was more with 3rd March (84.79) sown crop whereas, February 16th crop recorded considerable capsule number (73.10).

Lee Sungwoo *et al.* (2001) conducted a field experiment to study the effect of delayed sowings on growth of sesame (*Sesamum indicum*) in Korea Republic. They reported that the sowing dates was delayed by 5, 15, 26, 36 and 46 days when compared to 15th May standard sowing date, the number of capsules plant^{-1} and the length of stem bearing capsule were greatly decreased, while plant height and stem diameter were not significantly affected by delayed sowing dates.

Muthusankaranarayanan (2001) reported the seed yield of sesame was higher when sown on March 3rd (613 kg ha^{-1}) followed by February 16th sowings (610 kg ha^{-1}). However, in later years of experimentation, February 16th sown crop recorded higher seed yield (849 kg ha^{-1}) at Vallanad of Tamil Nadu.

Patra (2001) conducted an experiment in Orissa, India with ten sesame cultivars (Vinayak, Usha, Kanak, OTM-10, OTM-11, Wma, Kalika, Krishna, B-67 and Balangir Local) and were sown on two different dates (25th June and 15th July). They found that the higher capsule plant^{-1} was obtained with the 25th June sowing compared to the 15th July sowing.

Badran (2002) conducted an experiment in Alexandria, Egypt during summer season 2000 and 2001 to study the effect of sowing date on the performance of sesame (cv. Giza-25, Giza-32) and groundnut (cv. Giza-5) in an intercropping system. The simultaneous planting of both crops on 15th April recorded 36.27 per cent higher relative yield (RY) as compared to the simultaneous planting of both the crops on 15th May.

Kim Dongkwan *et al.* (2002) carried out a study in Korea Republic to determine the differences in the growth, grain yield and seed quality of sesame plant in response to different sowing dates (9th May and 8th June). They found that the sesame plants which were sown on 9th May had more effective branch numbers and capsule numbers plant^{-1} than those sown on 8th June. Although sesame plants sown on 9th May had lower ripened grain percentage at the upper and middle part of the capsule setting and the seed yield was similar to those sown on 8th June.

Thanki *et al.* (2004) observed that the sesame crop sown on 17th February resulted in significantly the highest seed yield (1290 kg ha^{-1}), number of capsules and test weight as compared to the other dates of sowing (10th Feb and 24th Feb).

Ali *et al.* (2005) reported that the effect of sowing dates was highly significant and maximum seed yield was produced when crop was sown on 8th and 15th July due to more number of capsules plant^{-1} and more seeds capsule^{-1}, they concluded that sesame can be grown in second week of July under agro-climatic conditions of Faisalabad.

Churlwhan *et al.* (2006) assessed the HT-6 variety performance of line 96006 was evaluated at five planting dates commencing from 1st June to 30th July with 15th days interval during 2006 and 2007 and reported that line 96006 performed better when planted from 15th June to 15th July giving better yield in kgha^{-1}.

Abdel Rahman *et al.* (2007) reported that the sowing dates significantly affected` number of capsules plant^{-1}, 1000 seed weight and seed yield. The highest seed yield was recorded for early July sowing by Shuhak genotype.

Alam Sarkar *et al.* (2007) studied the effect of sowing date and time of harvesting on the yield and yield contributing characters of sesame (*Sesamum indicum* L.) and found that the capsules plant^{-1}, seeds capsule^{-1}, seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were obtained from the crop sown on 26 February. The highest seed yield (251.30kg ha^{-1}) was obtained in 26 February sown crop and there after reduced with delay in sowing.

Lazemi (2007) found that the number of capsules plant^{-1} was greatly influenced by planting date. A delay in planting will reduce the number of capsules.

Olowe (2007) stated that the sowing date significantly influenced number of days to 50 percent flowering and physiological maturity, and height at 50 per cent flowering and physiological maturity in both years, sesame sown in late July and late August attained 50 percent flowering earlier by 5–7 days compared with other sowing date treatments. However, sesame sown in mid July flowered by 5–11 days earlier than others sown at later dates with the late July sown sesame recording the largest value (65 DAP).

Ajalli *et al.* (2008) reported that the effect of three planting dates on yield and yield components of five sesame cultivars produced significant differences on capsule numbers, percentage biomass, and seed yield. The study also revealed that the first planting date of June 20 had higher yield than other planting dates.

Tahsin Sogut (2009) reported that the sowing time has a significant effect on seed yield a late sown led to a increase in seed yield. The main reason for higher productivity of crop sown in June may be favourable temperature condition during crop growth period.

Ahmed *et al.* (2010) reported that the highest number of pod plant^{-1} (39.85) and fertile pods plant^{-1} in soybean were observed with 16 December sowing while 7 November sowing showed the lowest number of pods. However, non-fertile pods plant^{-1} (7.17) was found with 27 January sowing and highest seeds/pod with 27 November sowing. The highest pods plant^{-1} (35.94), fertile pods plant^{-1} (32.87), seeds pod^{-1} (2.09), were found in the variety G-2 and the highest numbers of non-fertile pods plant^{-1} (4.47), was produced by BS-5. The interaction effect of sowing dates and varieties were also significant and hence 16 December sowing coupled with G-2 variety gave the best performances regarding pod development and seed production.

Cruz *et al.* (2010) revealed that the sowing date influences plant development and yield of soybean cultivars. The delay in the sowing period promotes to reduce the cycle of soybean cultivars, mainly in the reproductive phase.

Zhang *et al.* (2010) revealed that sowing after June 5th did not shorten the growing period for early maturity cultivar of soybean. The later the sowing date, the longer the duration from R 6 to mature seed harvest. Seed dry matter accumulation period was extended for one or two more weeks by late sowing. The marketable yield ranged from 4069 to 8660 kg ha^{-1}, and the response to sowing date differed among cultivars. Marketable yield decline, day^{-1} of sowing delay was 34.4-54.9 kg ha^{-1}day^{-1} for three cultivar, while an unexpected rank reversal occurred for brown seed cultivar. Yield decline associated with delayed sowing was primarily related to reduction in standard pod number, while increased fresh seed weight might compensate the yield loss at R6 stage. The insensitivity of yield response to sowing date from early maturity cultivar Dongdou 24 provides farmers flexibility to gain higher economic return.

Nafe *et al.* (2010) conducted an experiment to evaluate the effect of the day length and genotypes on yield and yield component for two seasons, eighteen genotypes (Local 2 exotic) of sesame crop were planted in January, May and September sowing date. The result revealed that May sowing date was favoured for yield and yield components, while January and September sowing date were resulted in reduction in yield.

Mohan Kumar *et al*. (2011) studied the effect of date of sowing dates on niger yield at Dharwad on black soil. Among the different sowing dates, sowing at June I fortnight recorded higher seed yield (600.09 kg ha^{-1}) in niger as compared to July, September, October, January and February sowings. The maximum seed yield was due to higher number of capitula $plant^{-1}$ (40.12) and 1000 seed weight (3.42g).

Bala *et al.* (2011) conducted a field trails during the 2004 and 2005 cropping seasons at Samaru, Nigeria and reported that, delaying of groundnut sowing till mid July caused a 27.3 per cent decline in number of pods $plant^{-1}$. When sowing was delayed until end of June or mid July; pod, seed and haulm yields declined 44.9, 45.2 and 23.5 per cent, respectively in relation to sowing in mid of June.

Turhan *et al*. (2011) noted that the seed yield of rapeseed-mustard significantly decreased, sowing time was delayed in Turkey. The lowest average seed yield (1027.40 kg ha^{-1}) was obtained from the later sowing time (10 November), whereas the highest average seed yield (2437.50 kg ha^{-1}) was obtained from the earliest sowing time (10 October).

Tahir *et al.* (2012) found that the yield attributing parameters were significantly affected by different sowing dates with different row spacing, the maximum number of capsule plant^{-1}, biological and seed yield, harvest index and oil yield were recorded in plots where sesame was sown at 15th June with row spacing of 15 cm. Sowing dates (15th June, 25th June, 05th July and 15th July) were placed in main plots and row spacing (15, 30 and 45 cm) were assigned to the sub-plots, HT-6 variety of sesame sown on 15th June with 15 cm row spacing seems to be best to get higher yield .

Mohammad *et al.* (2012) studied to determine the effect of planting date and irrigation stress on two spring varieties of flaxseed. The Highest capsule numbers plant^{-1} (65.9), seed numbers capsule^{-1} (5.78), seed yield (1763 kgha^{-1}), biological yield (5935 kgha^{-1}), harvest index (29.9) were obtained in first sowing date and under full irrigation by later sowing dates and limited irrigation stress especially at flowering and grain filling stages, this characters were reduced.

Rahimi *et al.* (2011) found that the highest plant height, capsule plant^{-1} and kernel weight in flex obtained by Mar. 5 and the lowest value were belonged to May 4 and April 18. At later planting date these three traits severely decreased. March 5 and 100 kg N ha^{-1} was the best combination to produce the highest straw yield and harvest index. Among the different planting dates, March 5 produced the highest grain yield at either N level. Grain yield after March 5 was reduced by 8 to 130 per cent.

An experiment was conducted at IARI, New Delhi by Kumar *et al*. (2013) and stated that seed yield plant^{-1} of various *Brassica* genotypes decreased significantly under (1st November) and (15thNovember) in all the genotypes compared to (15thOctober) sowing.

Sungjemkala *et al*. (2013) carried out a field experiment at Nagaland University, Medziphema during rainy season to study the effect of sowing dates on the growth and yield of sesame. From the results, they recorded maximum yield attributing characters and seed yield by sowing on 15th May among the five sowing dates having 15 days interval *i.e.* 15th, 30th May, 15th, 30th June and 15th July.

Venkatachalapathi and Rao (2014) conducted a field experiment at Agricultural Research Station, Anantapur under AICRP on Agro meteorology during kharif seasons of 2009 and 2010 on red sandy loam soil to study the performance of groundnut varieties at different dates of sowing and irrigation regimes. The crop sown during July 1st FN gave significantly higher pod yield (1667 kg ha^{-1}) compared to July 2nd FN (1411 kg ha^{-1}) and August 1st FN (1100 kg ha^{-1}) sown crop.

Meena *et al.* (2014) conducted a field experiment during *kharif* seasons of 2009 and 2010 on groundnut (*Arachis hypogaea* L.) under western dry zone of India at Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and reported that, the number of pods plant^{-1}, number of kernel, pod yield (q ha^{-1}), kernel yield (q ha^{-1}), harvest index (per cent) and B: C ratio recorded significantly higher in 4th July sowing date as compared to 9th June sowing date.

Rajendra Kumar and Ramesh (2014) conducted a field experiment during 2009-2010, 2010- 2011 and 2011-2012 to establish optimum sowing time of Sesame and to enhance the productivity of sesame in the north-coastal zone and found that the crop sown in the 4th week of April significantly yielded (430 kgha^{-1}) followed by May 2nd week sown crop (297 kgha^{-1}). During *Rabi* crop sown during December 1st week recorded significantly highest yield of 570 Kgha^{-1} followed by December 3rd week sowing (487 Kgha^{-1}). Sowing in the month of November or January significant reduction in the yields was noticed. The normal sowing time for sesame is May 2nd week to May 31st in *kharif* and December 15th to January 15th in *Rabi* in the NC zone.

Shekh *et al.* (2014) Found that sowing in 2nd week of February enhanced yield attributes viz., branches plant^{-1}, capsules plant^{-1} and test weight as well as ultimately gave higher seed yield (1.237 tha^{-1}) and stalk yield (2.132 tha^{-1}), early (3rd week of January) and late (4th week of February) sowing.

Akhter *et al*. (2015) reported that delayed planting of brown *sarson* resulted in a significant decline in the yield attributing components *i.e*. number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight, seed yield and stover yield.

Lakhran *et al.* (2015) conducted a field experiment to evaluate the effect of sowing time and nutrient management on quality and yield potential of sesame during summer season of 2014. The research results indicated that sowing at 20th February recorded higher yield attributes, seed and stalk yields, harvest index and quality parameters over the sowing at 10th February and 01st March. However, yield attributes except test weight, seed and stalk yields recorded at sowing 01st March was at par with sowing at 20th February whereas, sowing time had no significant effect on harvest index.

Hakeem *et al.* (2017) conducted a field experiment to study the impact of sowing interval on the yield and yield contributing traits of sesame (*Sesamum indicum* L.), under the tropical circumstance, during 2016 and results was found that the maximum yield and yields contributing parameters was observed in S_3 = 3rd sowing (15 April 2016) and sesame genotype SV_1 (TS-5), followed by SV_2 (TH-6), while minimum yield was noted in S_3 = 3rd sowing (15 April 2016) and SV_3 (4002) sesame genotypes.

Singh and Singh (2017) conducted a field experiments were to assess the influence of different varieties and dates of sowing on growth and yield of mustard (*Brassica juncea* L). Highest yield was produced by mustard cv. Pusa Bold among the two varieties tested whereas first date of sowing i.e. 21st October was adjudged as the best time for mustard seeding since substantial decrease in grain yield was observed with delayed sowing.

Khajuria *et al.* (2017) conducted a field experiment at research farm of SKUAST–Jammu and results revealed that the highest seed yield 1710 kg ha^{-1} was recorded with 25th October sown crop and significant reduction to the extent of 15.02 and 31.63 per cent was recorded when sowing was delayed to 5th November and 15th November, respectively.

Kumar *et al.* (2017) conducted a field trial on effect of sowing time on growth, phenology and yield attribute of summer groundnut (*Arachis hypogaea* L.) at Allahabad during crop season 2013. Sixteen treatment combinations with four dates of sowing (1st March, 11th March, 21st March and 31st March) and four varieties (HNG-69, R-2 (Girnar-2), HNG-10 and M-13) The yield attributes and yield in terms of characters like number of pods $plant^{-1}$, grain yield and haulm yield were significantly influenced by the dates of sowing. The highest pod yield and haulm yield were obtained from the first date of sowing (1st March) and followed by second date of sowing (11th March).

2.1.3 Nutrient content, uptake and quality

Kafitiri and Deckers (2001) reported that the environmental condition under which sesame is grown influences the yield, oil and protein content of the seeds, due to the immense importance of sesame as an oil seed crop.

Lewis *et al.* (2003) reported that the sesame seed dried (decorticated) contain an average of 45-61 percent, 21 percent fat, 16 percent protein, and 11.6 percent dietary fibre and agronomic practices involved in crop production have influence on the quality and quantity of the product.

Kumar *et al*. (2004) reported that oil content (per cent) was not significantly affected by sowing time whereas; oil yield in 21^{st} October was significantly superior to 7^{th} October sowing.

Ali *et al.* (2005) conducted a field experiment at University of Agriculture, Faisalabad during 2003 to study the effect of sowing dates on sesame crop and they found that significantly the highest oil content of the sesame seeds were obtained when the crop was sown on 8th and 15^{th} July.

Kalita *et al.* (2005) observed that crops sown on 10 November recorded significantly higher total N, P and K uptake in both the year. The crop sown on 10 November had better reproductive growth and significantly higher seed yield than that sown on 21 November.

Singh *et* al. (2006) conducted a field experiment at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh and reported that oil content and total nutrient uptake to be highest upon treatment with 30 October sowing date, 30 kg ha^{-1} sowing rate and 20 kg S ha^{-1}.

Sharma *et al*. (2006) noticed that there was no significant influence of sowing dates on protein content but oil content and oil yield were higher in 22^{nd} and 29^{th} October sowing of mustard crop.

Sardana and Kondhola (2007) conducted a field experiment at Punjab Agricultural University (PAU), Ludhiana and reported that, the oil content in groundnut was influenced due to later sowing dates, *viz.,* 10th and 20th June (51.1–51.2 per cent), was significantly lower than 30th May sowing (52.5 per cent), which in turn registered significantly lower oil content than 10th and 20th May sowings (53.7–53.8 per cent).

According to Sardana *et al*. (2008) oil yield and oil content of 25th September and 5th October sown crops were significantly higher than 15th, 25th October and 4th November sown crops.

Patel *et al.* (2010) conducted an experiment at S. D. Agricultural University, Sardar Krushinagar, Gujarat during summer season and the results revealed that maximum growth and yield attributing characters, seed yield, oil content and oil yield of summer sesame were recorded with 15th February sowing, which remained at par with 01st March sowing but both were significantly superior to late sowing (15th March).

Adak *et al*. (2011) suggested that the oil content in mustard was significantly higher with 15th October sowing (34.8 per cent) as compared to 30th October (32.3per cent) sowing. Mondal *et al*. (2011**)** reported that oil content was significantly higher with 20th October (43.9 per cent), 1st November (43.8 per cent) as compared to 10th November (42.5per cent), 20th November (41.7 per cent) and 30th November (41.7 per cent) sowings.

Mohammad *et al.* (2012) studied to determine the effect of planting date and irrigation stress on two spring varieties of flaxseed. The highest oil percentage (41), oil yield (718 kg ha^{-1}), linolenic percentage (48.4) and linoleic percentage (18.36) were obtained in first sowing date and under full irrigation by later sowing dates and limited irrigation stress especially at flowering and grain filling stages, this characters were reduced.

Tobe *et al*. (2013) reported that 30 March sown spring canola had significantly higher percentage of oil as compared to 14 April, 19 April and 14 May sown crops.

Mshelia *et al.* (2014) stated that the effect of sowing date and intra-raw spacing on the oil, protein, crude fibre and ash content of sesame seeds, the experiment consisted of sowing dates (17^{th}, 31^{th} July, 14^{th} ,28^{th} August and 11^{th} September) as main plot treatment and six intra-row spacing, giving plant population densities as subplot treatments making a total of thirty treatment combinations and results showed that oil and crude protein content were favoured by sowing between July 31^{st} and August 28^{th} while crude fibber and ash were more when sowing was delayed till September 11^{th}, however both were not influenced by population densities and interaction had no significant effect on oil, protein, fibre and ash content of the seeds of sesame.

Hamza *et al.* (2015) conducted a field experiment on sesame at Wadi El-Natroon, El-Beheira Governorate, Egypt during summer seasons of 2013 and 2014 and reported that the highest values of seed and oil yields were recorded from planting Shandauil-3 on 9 April.

2.1.4 Economics

Ramchandra, P.B. (2011) carried out a field experiment to determine the response of Sesame (*Sesamum indicum* L.) cultivars under varying sowing times during summer season and found that the Maximum gross returns (50258 ₹ ha-1) and Net returns (25418.01 ₹

ha^{-1}) was obtained with the sowing at 6th meteorological week and found to be superior over 4th and 8$^{th.}$

Lakhran *et al.* (2015) conducted a field experiment at Anand, Gujarat on effect of sowing dates and nutrient management on growth, yield and quality of summer sesame (*Sesamum indicum* L.) under middle Gujarat conditions and reported that highest net return of 37218 ₹ ha^{-1} was incurred with 20th February followed by 01st March with 36391 ₹ ha^{-1}.

Chonder et al. (2015) find the effect of sowing dates and cultivars on yield and economic attributes of summer sesame (*Sesamum i*ndicum L.) with five different dates of sowing (10th February, 2^{0th} February, 2nd March, 1^{2th} March and 22nd March) with three cultivars of sesame (Rama, Savitri and Tillotama) and found that sowing of crop during on 2nd March gave significantly higher gross returns, net return and return per INR investment.

2.2 Effect of varieties

2.2.1 Growth parameters

Experiments conducted by Patra and Mishra (2000) indicated that Kanak variety produced more number of primary branches (4.3) followed by B-67 variety (3.8) of sesame during post rainy season.

Patra (2001) conducted an experiment with ten sesame cultivars (Vinayak, Usha, Kanak, OTM-10, OTM-11, Wma, Kalika, Krishna, B-67 and Balangir Local) and were sown on two different dates (25th June and 15th July). They found that the cultivar B – 67 was the tallest, while OTM-10 and OTM-11 were the shortest among cultivars.

Experiment conducted at Vridhachalam, Tamil Nadu on sandy loam soils, TMV 4 variety recorded the maximum plant height than TMV 3 (Kathiresan and Gnanamoorthy, 2001 and Kathiresan, 2002).

Deshmuk *et al.* (2005) reported that plant population and maturity period were similar for all the varieties but they differ significantly in their growth parameters, variety TKG-21 had tallest plants (132 cm).

Shah and Rahman *(*2009) observed that significantly higher plant height in genotype RM-159-2 (180.8 cm) as compared to genotype RM-152-2 (180.7 cm) cm), Pak-Cheen (177.1 cm) and RM-182 (176.0 cm).

Lallu *et al.* (2010) at Kanpur (U.P) observed that among different mustard genotypes, plant height of genotype RGN-152 was significantly higher (184.7 cm) as compared to other genotypes in normal sowing and in late sown condition *cv*. RGN- 145 exhibited significantly higher (118.5 cm) plant height.

Kandil *et al*. (2010) at Mansoura, Egypt reported significant variations in plant height of different varieties i.e. Sakha 2, Sakha 3, Sakha 4 and Giza 8. Sakha 3 variety achived maximum plant height followed by Sakha 4, Sakha 2 and Giza 8 varieties, due to differences in the genetical structure of the varieties.

Ahmed *et al.* (2010) observed that the plant height and branches plant^{-1} were significantly affected by varieties. The higher plant (67.70 cm) and branches plant^{-1} (2.19) were found in the variety G-2 and the lowest (40.04 cm), more branches (1.40) were found in variety BS-5, and lowest nodes plant^{-1} (10.85) was found in PB-1. In those aspects, the interaction effect of sowing date and variety on plant height was non-significantly but on nodes plant^{-1} and branches plant^{-1} were significantly.

Ramchandra, P.B. (2011) carried out a field experiment to determine the response of Sesame (*Sesamum indicum* L.) cultivars under varying sowing times during summer season and found that the maximum plant height (94.33 cm), number of leaves plant^{-1}, leaf area (8.61dm^2), number of branches plant^{-1} (3.620) and dry matter production plant^{-1} (11.14 g plant^{-1}) were observed at 75 days after sowing with variety AKT-101 over rest of the varieties.

Afroz *et al*. (2011) observed that *cv*. BARI Sarisha-6 exhibited significantly higher plant height (96.7 cm) as compared to *cv*. BARI Sarisha-9 (84.9 cm) and *cv*. BARI Sarisha-9 exhibited significantly higher number of branches (3.30 plant^{-1}) as compared to *cv*. BARI Sarisha-6 (1.59 plant^{-1}) Kumari *et al*. (2012) observed that hybrid DMH-1 recorded significantly higher plant height (212 cm) and higher primary and secondary branches (7.6, 18.5 plant^{-1}) over hybrid NRCHB-506 and *cv*. Kranti.

Patel (2013) conducted a field experiment at Tikamgarh (M.P.) and revealed that *cv*. Pusa Bold produced significantly higher plant height at all growth stages as compared to *cvs*. Varuna and Pusa Agrani.

Chongdar *et al.* (2015) carried out a field experiment on the effect of dates of sowing and improved cultivars on growth and yield of summer sesame in North Bengal with three cultivars of sesame (Rama, Savitri and Tillotama). Among them, the variety Rama recorded higher plant height, dry matter accumulation, leaf area index and crop growth rate as compared to Savitri and Tillotoma.

Ibrahim *et al.* (2016) conducted field trials to evaluate the optimum sowing date and suitable sesame variety in Borno State, Nigeria and reported that the growth components of sesame varieties differed with different planting dates within a given environment. Ex-sudan variety is taller than Kenana-4 and Gwoza.

2.2.2 Yield attributes and yield

Patra and Mishra (2000) noted more number of capsules plant^{-1} and average seed yield in Kalika (44) and (918 kg ha^{-1}) followed by Kanak (41.5) and (873 kg ha^{-1}) respectively, in dry season on sandy loam soils of West Bengal.

Patra (2001) reported that the performance of 10 varieties (Vinayak, Usha, Kanak, OTM-10, OTM-II, Uma, Kalika, Krishna, B-67 and Balangir Local) of sesame (*Sesamum indicum* L.) under two dates of sowing (25th June and 15th July). Varieties varied significantly with respect to growth and yield attributes *viz*., plant height, branches plant$^{-1,}$ capsules plant^{-1}, and seed yield.

Kadam (2001) studied the performance of two summer cultivars L-38 and AKT-1. AKT-1 was found to be good in respect of growth parameters, yield contributing characters and utilization of applied fertilizer, oil content and yield as compared to L-38.

Sharar *et al.* (2002) find out that response of four sesame genotypes namely T-89, TS-3, 92001 and 90005 under same field conditions and reported that genotype TS-3 gave significantly higher seed yield than other genotypes due to higher number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000- seed weight and oil content.

Sarala *et al*. (2002) carried out a field experiment at Tirupati (Andhra Pradesh) on sandy loam soil under rainfed condition and observed that variety Madhavi (286 kg ha^{-1}) performed better than VRI-1 (198 kg ha^{-1}) and TMV-3 (253 kg ha^{-1}) in terms of yield.

Tripathi *et al.* (2007) at Tikamgarh reported that variety JTS-8 gave significantly higher seed yield and yield attributes followed by variety TKG 308.

Tembhurne and Dharai (2007) studied the performance of eight sesame genotypes (Selection 1, Selection 3, Selection 4, Dhavari 6, Selection 5, Dhavari (Ch), E 8-Ch and DS 1) under different climatic conditions. They observed that, the number of capsules, branches and seed yield plant^{-1} in Selection 5 were numerically higher which helped the cultivar to out yield other cultivars.

Afroz *et al*. (2011) conducted an experiment on mustard crop and observed that the higher number of siliquae (plant^{-1}) in *cv*. BARI Sarisha-9 (153.3) as compared to *cv*. BARI Sarisha-6 (138.8), 1000 seeds weight in *cv*. BARI Sarisha-9 (2.76 g) as compared to *cv*. BARI Sarisha-6 (2.68 g), higher seed yield was found in *cv*. BARI Sarisha-9 (1.54 t ha^{-1}) as compared to *cv*. BARI Sarisha-6 (1.41 t ha^{-1}), stover yield was found in *cv*. BARI Sarisha-9 (2.76 t ha^{-1}) as compared to *cv*. BARI Sarisha-6 (2.68 t ha^{-1}), higher HI was found in *cv*. BARI Sarisha-9 (31.3 per cent) as compared to *cv*. BARI Sarisha-6 (29.7 per cent) and higher number of effective seeds (siliqua^{-1}) were found in *cv*. BARI Sarisha-6 (20.6) as compared to *cv*. BARI Sarisha-9 (13.5).

Tan *et al.* (2011) observed a significant difference in seed yield, flowering date, physiological maturity and 1000 seed weight among the sesame varieties. In the yellow seeded variety had the highest seed yield (247 kg ha^{-1}) and the lowest seed yield (170 kgha^{-1}) was obtained from the varieties TUR-S-90.

Ramchandra, P.B. (2011) carried out a field experiment to determine the response of sesame (*Sesamum indicum* L.) cultivars under varying sowing times during summer season. He found the highest number of capsules plant,$^{-1}$ maximum seed yield (4.69 g plant^{-1}) number of seeds (1392.31 plant^{-1}), seed yield (10.10 q ha^{-1}) and straw yield (21.84 q ha^{-1}) were obtained from variety AKT-101 and was superior over Phule Til-1. The mean 1000 seed weight Phule Til-1 variety was (3.49 g) which was higher than AKT-101 variety (3.32 g).

Kumari *et al.* (2012) observed that hybrid DMH-1 recorded significantly higher number of siliquae (342 plant^{-1}), higher number of seeds (13.8 siliqua^{-1}), higher 1000-seeds weight (4.11 g), higher seed yield (1.88 t ha^{-1}) which was superior to hybrid NRCHB-506, Kranti and hybrid NRCHB-506.

Muhammad *et al.* (2012) reported that the TS-5 is a high yield, bold and white seeded variety of sesame having branched stem. Its maximum yield potential was achieved in zonal varietal trial at Faisalabad. Average yield 855 and 842 kg ha^{-1} as compared with check TS-3 (609 and 719 kg ha^{-1}) in national uniform sesame yield trials

Venkatachalapathi and Rao (2014) conducted a field experiment at Agricultural Research Station, Anantapur under AICRP on Agrometeorology during kharif seasons of 2009 and 2010 on red sandy loam soil to study the performance of groundnut varieties at different dates of sowing and irrigation regimes.Variety K-6 realized significantly higher pod yield (1486 kgha^{-1}) over K-134 (1308 kgha^{-1}) and K-1271 (1250 kgha^{-1}) and reported that interaction effects indicated that the maximum pod yield was gained with K-6 variety under both irrigated and rainfed conditions and in all dates of sowing.

Ali and Jan (2014) reported that the performance of sesame cultivars (*Sesamum indicum* L.) was evaluated using various sowing dates and nitrogen levels at New Peshawar, Pakistan during summer 2012. The cultivar local black had more capsules plant^{-1} (71), seed capsule^{-1} (61), seed yield (696 kg ha^{-1}), stover yield (4297 kg ha^{-1}) and harvest index (14 per cent) as compared to cultivar local white.

Chongdar *et al.* (2015) carried out an field experiment on the effect of dates of sowing and improved cultivars on growth and yield of summer sesame in North Bengal, Three cultivars of sesame (Rama, Savitri and Tillotama) were tested and found that Rama gave higher seed yield.

Jiotode *et al.* (2015) conducted a field experiment on sesame cultivars under different dates of sowing during 2013-2014 at Agronomy farm, College of Agriculture, Nagpur. Yield contributing characters such as total number of capsules plant^{-1}, seed yield plant^{-1}, straw yield plant^{-1}, seed yield q ha^{-1}, straw yield q ha^{-1} and biological yield q ha^{-1}, were significantly higher in cultivar AKT-64 as compared to Western-11.

Hamza and Salam (2015) conducted two field experiments in Cairo University, Egypt during summer seasons of 2013 and 2014. The treatments were planting dates of 20th March, 9th April, 29th April and 19th May and three cultivars (Giza-32, Shandauil-3 and Sohag-1). Results showed that the Shandauil-3 cv. surpassed significantly the other two cultivars in number of fruiting nodes plant^{-1}, number of capsules plant^{-1}, capsule length, number of seeds capsule^{-1}, 1000-seed weight, seed weight plant^{-1}, seed yields ha^{-1}, as well as, harvest index in both seasons.

Ibrahim *et al.* (2016) conducted field trials to evaluate the optimum sowing date and suitable sesame variety in Borno State, Nigeria. Exsudan variety recorded highest number of capsules plant^{-1}, seeds capsule^{-1}, thousand seed weight and seed yield (kg ha^{-1}) as compared to Kenana-4 and Gwoza varieties.

Salem and Emad (2016) carried out two field experiments in the Desert Research Center, Agriculture Experimental Station at El-Kharga Oasis, New Valley Governorate, Egypt during 2010 and 2011 growing seasons, to study the response of three Egyptian cultivars of sesame (Shandaweel-3, Toshka-1 and Giza-32) to four sowing dates (15th March, 1st April, 15th April and 1st May) under four levels of sulphur (0, 100, 200 and 300 kg S fed^{-1}). Shandaweel-3 cultivar gave the highest values of number and weight of capsules plant^{-1}, seeds weight plant^{-1}, 1000 seeds weight and seed, biological yield as comopare to Toshka-1 and Giza-32.

Meena *et al.* (2017) conducted a field experiments to assess the influence of different varieties and dates of sowing on growth and yield of mustard (*Brassica juncea* L). The experiment conducted as four varieties viz. Laxmi, Pusa Jaikisan (Bio-902), Pusa Bold and Pusa Agrani and four dates of sowings viz., 15th September, 25th September, 05th October and 15th October. Highest yield was produced by mustard cv. Pusa Bold among there four varieties.

Khajuria *et al.* (2017) conducted a field experiment at research farm of SKUAST–Jammu. The treatments consisted of three dates of sowing (25th October, 5th November and 15th November), two varieties (RL-1359 and NRCDR-2) and three spacing (30 cm x 10 cm, 30 cm x 20 cm and 30 cm x 30 cm. Results show that the yield attributes of varieties such as number of silliquae plant^{-1}, and 1000-seed weight were significantly higher with NRCDR-2 than RL-1359. However, seeds siliqua^{-1} of both the varieties was at par. Variety NRCDR-2 also recorded significantly higher seed yield 1510 kg ha^{-1} which was about 9.57 per cent more in comparison to RL-1359 (1378 kg ha^{-1}).

Kumar *et al.* (2017) conducted a field trial on effect of sowing time on growth, phonology and yield attribute of summer groundnut (*Arachis hypogaea* L.) at Agrometeorological Station Farm, School of Forestry and Environment, SHIATS-Deemed-To-Be-University, Allahabad during crop season 2013. The variety HNG-69 gave the highest yield due to more number of pods, number of grains per pod and 100 seed weight, followed by HNG- 10 variety.

2.2.3 Nutrient content, uptake and quality

Patra and Mishra (2000) carried out a field trial at Chip Lima, Orissa on sandy loam and reported that oil content was the highest in Vinayak followed by Kalika, Uma and Usha. However, the oil yield was the highest in Kalika (422 kg ha-1).

Kumar and Badiyala (2001) conducted a field experiment during *rabi* the season of 1993-94 in Palampur, Himachal Pradesh, India, to study the effect of nitrogen on dry matter accumulation, yield, content and nutrient uptake of N, P and K on 3 linseed cultivars. Results indicated that linseed cultivars, Surbhi was superior to Nagarkot and Janaki with respect to oil content and nutrient uptake.

Raja *et al.* (2007) reported that out of three cultivars (TMV-4, TMV-6 and KS- 95010), KS95010 recorded highest seed yield and seed oil content, while TMV-4 recorded highest seed protein under sulphur nutrition.

Kumar *et al.* (2008) reported that the oil content in *Brassica* spp. were found significantly greater in *B. napus cv.* Hyola-401 (39.8 per cent) as compared to *B. napus cv.* GSL-1 (39.1 per cent), *B. campestris cv.*NDYS-2 (38.6 per cent), *B. juncea cv.* Urvarshi (38.1 per cent), *B. carinata cv.* Kiran (37.8 per cent) and *B. juncea cv.* Kranti (37.7 per cent).

Korhale (2010) conducted an experiment on varietal performance of sesame with cultivars Phule Til-1 and AKT-101 under summer condition. He observed that AKT-101 shows better oil content over Phule Til-1.

Adak *et al*. (2011) observed that oil content was significantly higher in mustard genotype BIO169-96 (38.3 per cent) over the genotype Pusa Jaikisan (35.0 per cent). Tobe *et al*. (2013) revealed that *cv*. RDF003 exhibited the highest percentage of oil (39.9 per cent) as compared to *cvs*. RDF003 and Sarigol whereas latter two varieties had no significant difference with each other.

Salunke *et* al. (2012) conducted an experiment with four levels of sulphur i.e. 0, 10, 15 and 20 kg ha-1 with RDF (60:30:0) and three genotypes of linseed i.e. NL-97, NL-260 and Padmini in the year 2011-12 in *rabi* season and reported that genotypes NL-260 showed the higher content of N (2.72 per cent), P (0.6515 per cent), K (1.3046 per cent) and S (0.3532 per cent) in seed and N (0.8458 per cent), P (0.1881 per cent), K (0.3387 per cent) and S (0.1898 per cent) in straw followed by NL-97 and Padmini. In case of nutrient uptake genotypes NL-260 recorded highest nutrients uptake (35.57 N kg ha^{-1}, 8.49 P kg ha^{-1}, 16.98 K kg ha^{-1} and 4.57 S kg ha^{-1} in seed and 17.67 N kg ha^{-1}, 3.89 P kg ha^{-1}, 7.03 K kg ha^{-1} and 3.96 S kg ha^{-1} in straw respectively) followed by Padmini and NL-97 and in case total nutrient uptake genotypes NL-260 also recorded highest total nutrient uptake (53.72 N kg ha^{-1}, 12.38 P kg ha^{-1}, 19.18 K kg ha^{-1} and 8.54 S kg ha^{-1}) of linseed. From the above results it is stated that sulphur @ 20 kg ha^{-1} gave higher content and uptake of NPK and S while genotype NL-260 performed better and recorded higher content and uptake of NPK and S.

Hamza and Salam (2015) conducted two field experiments in the Desert Experimental Station, Cairo University in Wadi El-Natroon, El-Beheira Governorate, Egypt during summer seasons of 2013 and 2014. Giza - 3gave the highest seed oil per cent in both seasons as compared to Shandauil-3 and sahog-1.

Salem and Emad M.M. (2016) carried out two field experiments in the Desert Research Center, Agriculture Experimental Station at El-Kharga Oasis, New Valley Governorate, Egypt during 2010 and 2011 growing seasons, to study the response of three Egyptian cultivars of sesame (Shandaweel-3, Toshka-1 and Giza-32) with four sowing dates (15th March, 1st April, 15th April and 1st May) under four levels of sulphur (0, 100, 200 and 300 kg S fed^{-1}). Results showed that the Shandaweel-3 cultivar gave the highest values of sesame oil yield as compared to other remaining cultivars.

2.2.4 Economics

Ramchandra, P.B. (2011) carried out a field experiment to determine the response of Sesame (*Sesamum indicum* L.) cultivars under varying sowing times during summer season and found that the gross monetary returns were the highest (52659 ₹ha^{-1}) and returns were maximum (27819 ₹ha^{-1}) significantly more with sesame variety AKT- 101 as compared Phule Til-1, JLT-7 and Padma.

Meena, J.K. (2015) conducted a field experiment on response of sesame [*Sesamum indicum* (L.)] varieties to varying levels of sulphur and its sources and reported that variety RT-346 recorded significantly higher net returns (₹ 25728 ha^{-1}.) as compared to RT-127 (₹ 22631 ha^{-1}) wherein the maximum net returns and B : C ratios were obtained.

Chonder *et al.* (2015) find out the effect of sowing dates and cultivars on yield and economic attributes of summer sesame (*Sesamum indicum* L.) with five different dates of sowing (10th

February, 2^{0th} February, 2nd March, 1^{2th} March and 22nd March) with three cultivars of sesame (Rama, Savitri and Tillotama) and found that Irrespective of cultivars, Rama (V_1) gave significantly higher economic return as compared to Savitri and Tillotama during 2013 and 2014, respectively.

3. MATERIALS AND METHODS

The field experiment entitled "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan"** was carried out during *kharif*, 2017. The details of experimental techniques, materials used and methods adopted for treatment evaluation during the course of investigation are described in this chapter.

3.1 Experimental site and location

The field experiment was conducted at Agronomy Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Raj.). Bikaner is situated at 28° 01'N latitude and 73° 22'E longitude at an altitude of 234.70 meters above mean sea level. According to "Agro-ecological region map" brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro-ecological region No. 2 (MgE1) under arid ecosystem (Hot Arid Eco-region with desert and Saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate. As per NARP, Bikaner falls in Agro climatic zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). According to National Planning Commission, Bikaner falls under Agro-climatic zone XIV (Western Dry Region) of India.

3.2 Climate and weather conditions

Bikaner has arid climate with average annual rainfall of about 250 mm. More than 80 per cent of rainfall is received during *kharif* season (July-September) by the South West monsoon. During summer, the maximum temperature may go as high as 48° C while in the winters it may fall as low as 0° C. The periodical mean weekly weather parameters recorded for the period of the experimentation presented in Table 3.1 and depicted in Fig. 3.1. The maximum temperature ranged between 34.0^{o}c and 47.1^o c during the crop growing season in the 35th and 28th standard meteorological weeks, respectively (Table 3.1). Likewise, the values of minimum temperature i.e., 15.4^{o}c and 28.1^{o}c was recorded in the 44th and 27th standard meteorological weeks, respectively. Crop received 168.3 mm of rainfall with 09 rainy days in the growing season. Pan evaporation ranged from 4.6 to 10.3 mm day^{-1} during the crop growing period. The average relative humidity during experiment fluctuated in the range of 16.7 to 85.9 per cent. The bright sun shine hours during experiment fluctuated in the range of 6.3 to 10.3 hours.

3.3 Soil of experimental field

In order to know the physical and chemical properties of soil, the soil samples from 0-30 cm depth were drawn randomly from different spots of the experimental field and a representative composite sample was prepared. This composite sample was analyzed to determine the physico-chemical properties of the soil. The data of the analysis along with methods used are presented in table 3.2.

The analytical results revealed that the soil of the experimental field was loamy sand in texture and slightly alkaline in reaction (pH 8.5), poor in organic carbon (0.11 per cent), low in available nitrogen (118 kg ha^{-1}) but medium in available phosphorus (15.1 kg ha^{-1}), potassium (173.7 kg ha^{-1}).

Table 3.1 Mean weekly meteorological data of Bikaner for the year 2017 (*Kharif season)*

Standard Week	Duration		Temperature (°C)		R.H. (%)		Total Rainfall (mm.)*	No. of Rainy days*	Wind Velocity (km./hr.)	Evaporation (mm/day)	BSSH
			Max.	Min.	Max.	Min.					
26	25.06.2017	01.07.2017	**37.6**	27.3	78.4	49.0	44.2	2.0	5.9	7.1	8.6
27	02.07.2017	08.07.2017	38.6	28.1	71.6	42.6	0.0	0.0	10.8	10.3	10.1
28	09.07.2017	15.07.2017	47.1	28.1	73.7	43.4	0.0	0.0	10.7	9.1	9.3
29	16.07.2017	22.07.2017	38.6	27.0	82.6	48.4	11.7	2.0	4.6	6.9	7.4
30	23.07.2017	29.07.2017	38.5	27.7	83.1	49.6	15.8	1.0	6.4	8.6	9.4
31	30.07.2017	05.08.2017	36.0	26.3	84.3	53.9	0.0	0.0	11.6	6.3	5.8
32	06.08.2017	12.08.2017	37.5	27.8	70.9	45.1	4.4	1.0	11.2	7.9	6.3
33	13.08.2017	19.08.2017	38.6	26.6	72.1	36.1	0.0	0.0	12.0	8.9	10.0
34	20.08.2017	26.08.2017	38.6	26.4	73.0	52.0	59.8	2.0	6.6	9.7	8.5
35	27.08.2017	02.09.2017	34.0	25.5	85.9	60.7	26.4	1.0	6.6	4.6	5.7
36	03.09.2017	09.09.2017	36.5	25.4	78.1	46.3	2.0	0.0	7.4	6.3	8.2
37	10.09.2017	16.09.2017	37.6	24.8	77.7	42.3	4.0	0.0	4.6	6.4	9.0
38	17.09.2017	23.09.2017	40.1	22.3	65.9	23.6	0.0	0.0	3.4	6.6	8.3
39	24.09.2017	30.09.2017	39.3	23.5	61.4	24.4	0.0	0.0	6.5	8.0	9.7
40	01.10.2017	07.10.2017	39.4	21.0	53.4	20.4	0.0	0.0	4.8	7.1	9.9
41	08.10.2017	14.10.2017	39.8	19.9	51.6	16.7	0.0	0.0	3.7	6.3	9.6
42	15.10.2017	21.10.2017	40.2	16.8	44.7	23.4	0.0	0.0	3.3	6.9	10.3
43	22.10.2017	28.10.2017	36.8	16.9	47.1	21.9	0.0	0.0	3.4	5.1	9.8
44	29.10.2017	04.11.2017	35.6	15.4	51.0	20.9	0.0	0.0	3.3	5.4	9.5

* A day having 2.5 mm or more rainfall is considered as a rainy day

Data taken from Agro-meteorological Observatory, ARS, Beechwal, Swami Keshwanand Rajasthan Agricultural University, Bikaner.

Table 3.2: Physico-chemical characteristics of the experimental soil (0-30 cm depth)

Soil properties	Value (0-30 cm)	Methods of analysis with reference
A. Mechanical Composition		
Sand (%)	82.70	International Pipette Method
Silt (%)	10.60	(Piper, 1950)
Clay (%)	6.70	
Texture	loamy Sand	USDA Hand book-60 (Richards, 1954)
B. Physical properties		
Bulk density (Mg m^{-3})	1.53	Undisturbed core sampler method (Blake and Hartge, 1986)
Particle density (Mg m^{-3})	2.68	Method No.33, USDA Hand book No. 60 (Richard,1954)
Porosity (%)	42.91	USDA Hand book-60 (Richards, 1954)
C. Chemical properties		
Organic carbon (%)	0.11	Walkley and Black"s rapid titration method (Walkley and Black, 1947)
Available N (kg ha^{-1})	118	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	15.1	Olsen's method (Olsen *et al.,* 1954)
Available K_2O (kg ha^{-1})	173.7	Flame photometric method (Metson, 1956)
EC (dsm^{-1}) (1:2 soil water suspension at 25^0C)	0.16	Method No. 4 USDA Handbook No.60 (Richards, 1954)
Soil pH (1:2 soil water suspension at 25^0C)	8.5	Method No. 21 (b), USDA Handbook No. 60 (Richards, 1954)

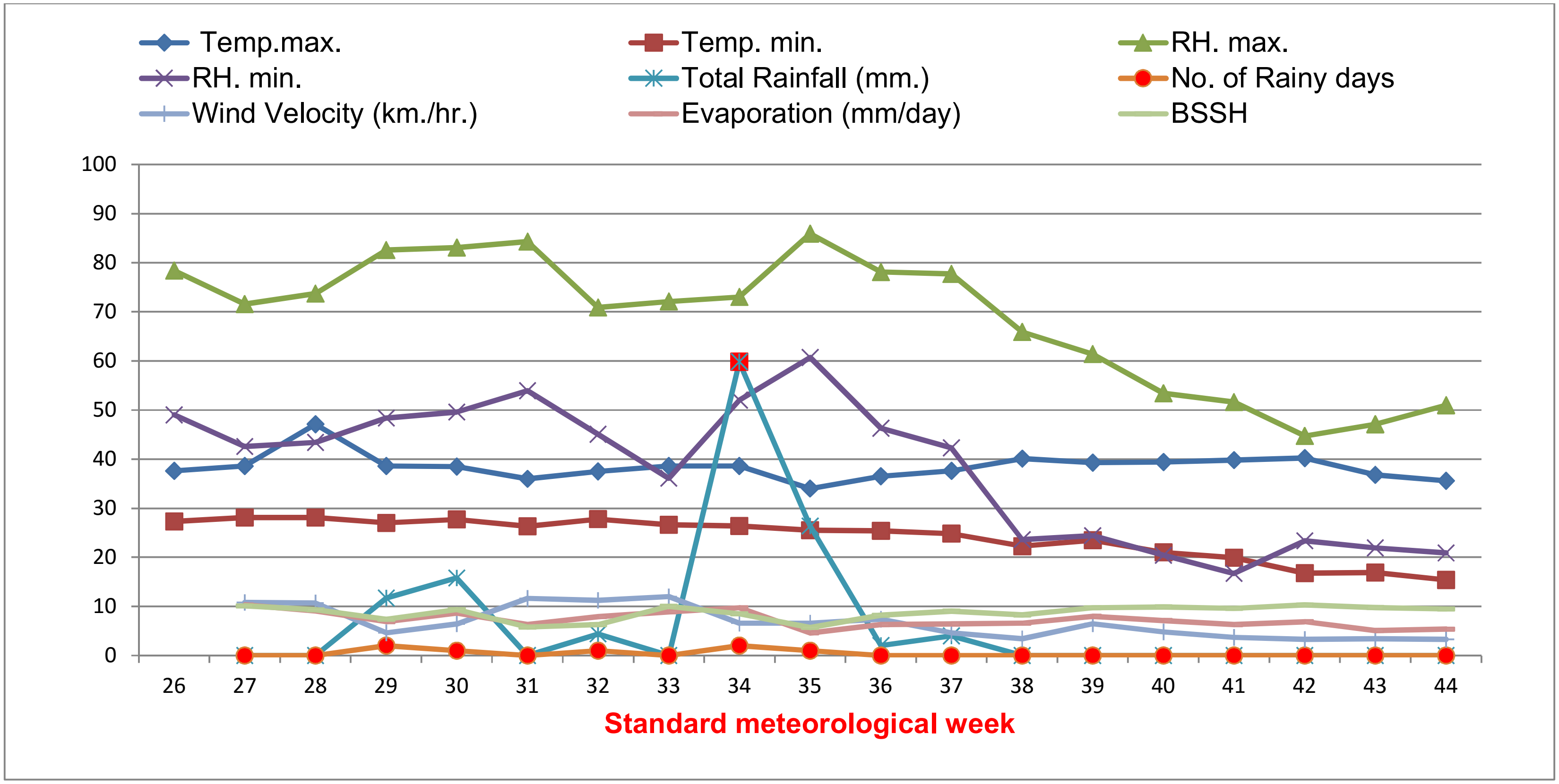


Fig. 3.1 Mean weekly meteorological data of Bikaner for the year 2017 (*Kharif*)

3.4 Cropping history of experimental field

Table 3.3: Cropping history of the experimental field

Crop year	Season	
	Kharif	*Rabi*
2015 – 16	Moth bean	Wheat
2016 – 17	Sesame	Wheat
2017 – 18	Sesame*	--

* Experimental crop.

3.5 Experimental details

3.5.1 Treatments details

The treatments along with their symbols are given in table 3.4 and other details are given below:

Table 3. 4: Treatments details with their symbols

	Treatments	Symbols
A.	**Date of sowing**	
1	10 July	D_1
2	20 July	D_2
3	30 July	D_3
4	09 August	D_4
B.	**Verities**	
1	RT - 125	V_1
2	RT - 46	V_2
3	RT - 127	V_3
4	RT - 346	V_4

3.5.2 Other details

The plan of experiment and other details are given as under:

1.	Season	-	*Kharif*, 2017
2.	Test crop	-	Sesame
3.	Design	-	Split plot design
	Main plots	-	Dates of sowing
	Sub plots	-	Varieties
4.	No. of treatments	-	16
5.	No. of Replications	-	3
6.	No. of Plots	-	48
7.	Gross plot size	-	3.0 m X 4.0m
8.	Net plot size	-	2.4 m X 3.0 m
9.	Varieties	-	As per treatments
10.	Crop geometry	-	30 cm x 10 cm
11.	Seed rate	-	3 kg ha^{-1}
12.	Fertilizers	-	40 kg N ha^{-1} and 32 kg P_2O_5 ha^{-1}

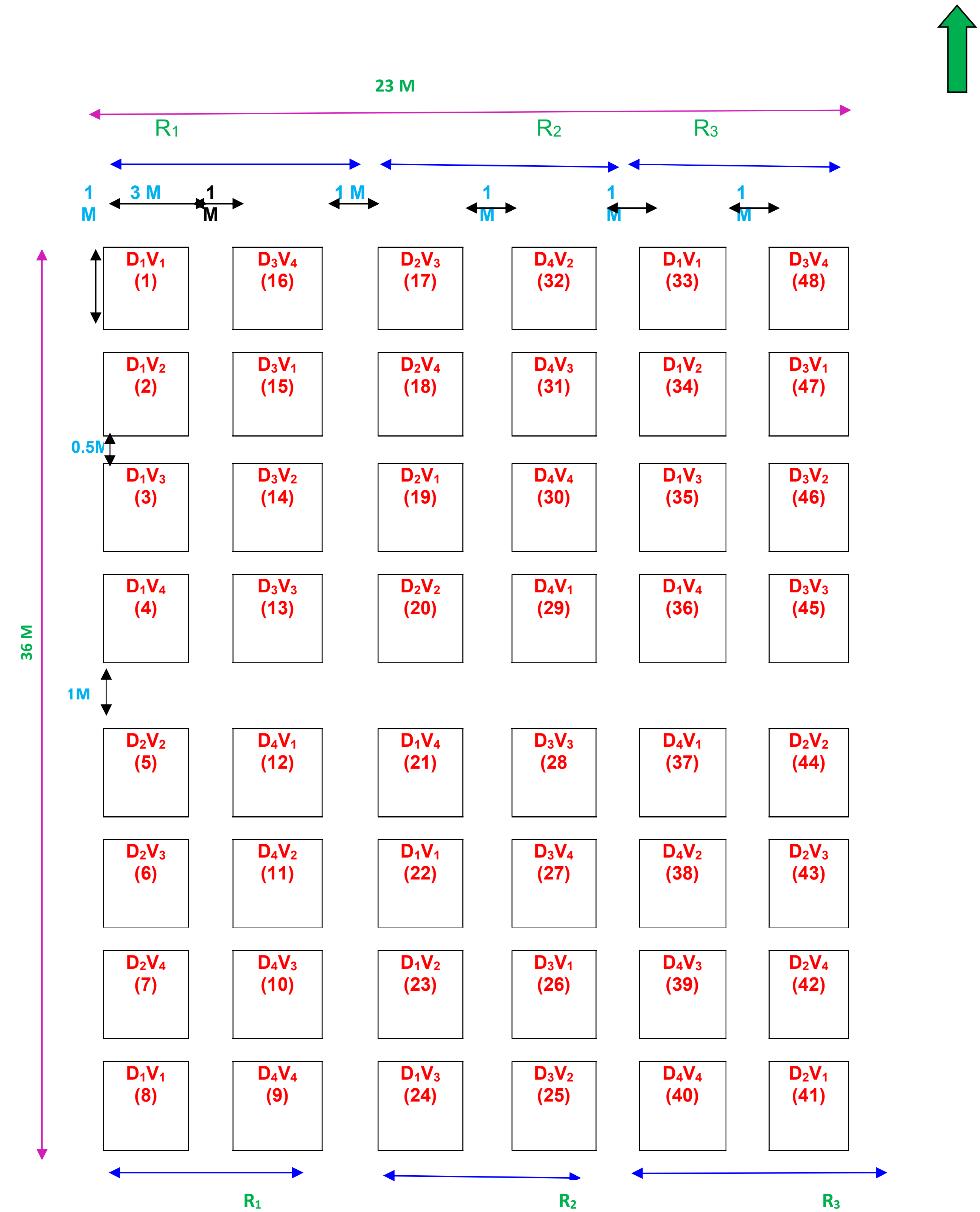
3.5.3 Experimental design and layout

The experiment was laid out in Split plot design and replicated thrice. The treatment combination of four dates of sowing and four varieties were randomly allotted to main plots and sub plots using random number tables of Fisher (1950).

3.6 Salient features of crop variety-

1. RT- 125

Plants are about 90 – 120cm tall. This variety having white seeds and all capsules are mature at same time. At maturity leaves, stem and whole plant are turns in yellowing. It is insect and disease resistant variety, having 3-5 branches, test weight 2.5 to 3.15g



Plot size	=	4 m x 3 m = 12 m^2	Design	=	Split plot design
Total number of treatments	=	16	Main plots	=	Date of sowing (4)
Replications	=	3	Sub plot	=	Varieties (4)
Total number of plots	=	48			

Fig. 3.2: Plan of Layout

(1000 seeds weight) and 48.8 percent oil content. It is mature within 75 – 85 days after sowing and it gives an average yield 9 – 12 q ha^{-1}.

2. RT- 46

This variety was developed at ARS, Mandore, Jodhpur in 1990. Plants are about 100-125 cm tall, attained 4- 6 branches and flowering occurs within 30 – 35 days. The crop is mature within 75 – 90 days after sowing. The average yield is 6 – 8 q ha^{-1}. Its seeds are white in colour, contain 49 per cent oil and having 1000 seeds weight is 2.55g.

3. RT-127

Variety was developed at ARS, Mandore, Jodhpur in 2001. It is a drought tolerant and have 90-135 cm in height. It is best suited for export. Mature in 75- 84 days and gives an average yield of 6-9 q ha^{-1}. Seeds having white colour, bold in size and shining it and contain 49.5 per cent oil.

4. RT-346

The variety was developed at ARS, Mandore, Jodhpur in 2009. Plants are about tall, capsules are sparsely hairy, compact, medium long and arranged alternatively on branches. Plant type is branched and dark green in colour with white coloured flowers. The variety mature within 82 - 86 days and gives an average yield 7-9 qha^{-1}.Its seeds contain 48 – 50 per cent oil.

3.7 Details of crop raising

The schedule of different pre and post sowing operations carried out in the experimental field is given in table 3.5 and other details of crop rising are described as under:

3.7.1 Field preparation and fertilizer application

The experimental field was prepared by tractor drawn disc plough followed by two cross harrowing and planking. Thereafter the field was laid out manually into plots according to the plan of layout (Fig. 3.2) with the provision of path. Fertilizers were given as basal application before sowing @ 30 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}.

3.7.2 Seed treatment

The seed was treated with bavistin @ 2g kg^{-1} seed just before sowing to ensure protection from soil borne diseases.

3.7.3 Seed and sowing

The sesame seeds were sown using 3.0 kg seed ha^{-1} at the depth of 3 cm on specified seed varieties and date of sowing as per treatments manually by *kera* method.

3.7.4 Thinning and gap filling

Thinning and gap filling of the crop was done manually at 15 days after sowing (DAS) to maintain optimum plant population.

3.7.5 Weeding, hoeing

Hand weeding was done manually 20 days after sowing with the help of hand hoe to keep the field weed free.

3.7.6 Irrigation

One pre - sowing irrigation (*palewa*) was applied before field preparation to ensure uniform and adequate moisture at sowing time. In addition to rainfall received during the crop season two irrigations were given through sprinkler system during dry spell to ensure optimum growth, development and yield of the crop.

3.7.7 Plant protection

Prophylactic plant protection measures were undertaken to protect the crop from insects and diseases. Before sowing, the seed was treated with bavistin @ 2 g kg^{-1} to protect from seed borne diseases. Dusting of methyl parathion 2 per cent @ 25 kg ha^{-1} was done on 21.08.2017 to protect the crop from damage of sucking insects.

3.7.8 Harvesting, threshing and winnowing

At maturity, after leaving the two border rows on each side along the length, a net area of 3.4 m x 2.4 m was harvested separately from each plot. The harvested produce of each plot was tied up in bundles, tagged and allowed to sun dry on threshing floor. After drying, the bundles were weighed for biological yield. Threshing and winnowing was done manually. After cleaning, the seed yield per plot was recorded and converted into kg ha^{-1}. The straw yield was computed by subtracting the seed yield from biological yield.

3.8 Schedule of pre and post sowing operations carried out in the experimental field

Table 3.5: Schedule of pre and post sowing operations carried out in the experimental field

Sr. no	Field operations	D_1	D_2	D_3	D_4
1.	Ploughing	08/07/2017	08/07/2017	08/07/2017	08/07/2017
2.	Harrowing	08/07/2017	08/07/2017	08/07/2017	08/07/2017
3.	Planking	08/07/2017	08/07/2017	08/07/2017	08/07/2017
4.	Layout	09/07/2017	09/07/2017	09/07/2017	09/07/2017
5.	Pre sowing irrigation	09/07/2017	19/07/2017	29/07/2017	08/08/2017
6.	Fertilizers drilling and Sowing	10/07/2017	20/07/2017	30/07/2017	09/08/2017
8.	Thinning	26/07/2017	05/08/2017	15/08/2017	25/08/2017
	Weeding and hoeing	28/07/2017	09/08/2017	19/08/2017	29/08/2017
10.	Irrigation				
	1st	05/08/2017	15/08/2017	25/08/2017	05/09/2017
	2nd	25/08/2017	07/09/2017	25/09/2017	05/10/2017
11.	Harvesting	1 October	09 October	18 October	26 October
12.	Threshing and winnowing	11/11/17	11/11/17	11/11/17	11/11/17

3.9 Observations for treatment evaluation

In order to evaluate the effect of different treatments on growth, yield and quality of crop, necessary observations were recorded periodically, the particulars of which are given as under:

3.9.1 Growth attributes

3.9.1.1 Plant stand

The number of plants plot^{-1} was counted at 20 DAS and at harvest, and expressed as plant stand ha^{-1}.

3.9.1.2 Plant height

Five plants were selected randomly from each plot, tagged permanently and used for measurement of plant height. Height of each tagged plant was measured periodically at 25 and at harvest from base of the plant to the tip of the main shoot by metre scale and average of five was computed as mean plant height.

3.9.1.3 Number of branches plant^{-1}

The five plants selected randomly and tagged permanently in each plot for record the number of branches plant^{-1} at harvest and their average was computed.

3.9.1.4 Dry matter accumulation

Dry matter production from randomly selected spots in out rows of plot was recorded at 25, 50, DAS and at harvest stages. For this, plants were uprooted randomly from 3 spots in out rows. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^0 C till a constant weight was achieved. The weight was recorded and expressed as average dry matter plant^{-1} (g).

3.9.1.5 Chlorophyll content

Chlorophyll content was worked out at flowering stage. Accordingly Hiscox and Israelstem (1979) demonstrated that the absorption spectrum (600-680nm) for chlorophyll extracted in DMSO was virtually identical to that for extracted in 90 per cent acetone. Chlorophyll was extracted in DMSO and transmittance was recorded with spectro-photometer at 645 and 663 nm. Arnon's equation (1949) was used to work out chlorophyll content as here under:

Chlorophyll "a" (mg g^{-1} fresh weight of leaves

$$= \frac{(12.7 \times A_{663}) - (2.69 \times A_{645})}{1000} \times \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

Chlorophyll "b" (mg g^{-1} fresh weight of leaves)

$$= \frac{(22.9 \times A_{645}) - (4.65 \times A_{663})}{1000} \times \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

Total chlorophyll content was worked out by adding chlorophyll "a" and chlorophyll "b" as under:

Total Chlorophyll (mg g^{-1} fresh weight of leaves) = Chlorophyll a + Chlorophyll b

3.9.1.6 Crop growth rate

Crop growth rate is defined as the rate of increase in dry weight per unit land area per unit time. The mean crop growth rate was calculated as suggested by Enyi (1962) and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{P(t_2 - t_1)}$$

Where, W_2 and W_1 are the dry matter production of the plant at time t_2 and t_1, respectively and P is the ground area occupied by the plant in m^2.

3.9.1.7 Relative growth rate

The relative growth rate expresses the dry weight increase in time interval in relation to initial weight. The mean RGR is calculated from dry weight measurement at time t_1 and t_2 suggested by Blackman (1919).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the dry matter production of the plant at time t_2 and t_1 respectively, and it is expressed in mg g^{-1} day^{-1}.

3.9.1.8 Days to 50 per cent flowering

Days to 50 percent flowering was recorded in the plot when 50 per cent plants in the treatment plots were flowered.

3.9.1.9 Days to maturity

Days to maturity was recorded in all the plots when crop was harvested.

3.9.1.10 Heat unit efficiency

The heat unit or growing degree days (GDD) concept was proposed to explain relationship between growth and development of plants and temperature. The growth and yield are primarily decided by thermal and photo thermal conditions experienced by the crop. The scientific way of assessing and quantify the effect of temperature and photo period on the plant growth is by applying heat unit/ GDD theory which advocates that plants have defined temperature requirement to pass through a certain growth stages. The biomass observation was taken of sesame and utilized to find out heat unit sufficiency ($kgha^{-1}degreeday^{-1}$) in the present investigation. Maximum and minimum temperature data of growing season were collected from Agro meteorological observatory, Agricultural research station, Bikaner. Accumulated heat unit up to certain growth stages were worked out by the method as described by Iwata, 1975 as under mathematically, it can expressed as:

$$\text{Accumulated heat units or GDD (degreeday}^{-1}) = \sum_{i=1}^{n}\left\{\frac{(T_{max.} + T_{min.})}{2} - T_b\right\}$$

Where, T_{max} is maximum temperature, T_{min} is minimum temperature of the day and Tb is the lowest temperature at which there is no growth which is also called base temperature, it is taken as 10 ^{0} C (9 - 12).

The accumulated heat units of biomass were used to calculate heat unit efficiency (HUE) of sesame. Mathematically, it can be expressed as:

$$\text{Heat unit efficiency } (Kgha^{-1}degreeday^{-1}) = \frac{\text{Biomass yield } (kg\ ha^{-1})}{\text{Accumulated heat units } (kgha^{1}degree\ day^{-1})}$$

3.9.2 Yield attributes and yield

3.9.2.1 Number of capsules per plant

The randomly selected plants used for recording the height and branches were also used for counting the number of capsules plant^{-1} at harvest and their average was worked out to record capsules plant^{-1}.

3.9.2.2 Number of seeds capsule^{-1}

At the time of threshing, 10 capsules were randomly selected from each plot and their total seeds were counted to record the average number of seeds capsule^{-1}.

3.9.2.3 Test weight

One thousand seeds were counted from the sample drawn randomly from the finally winnowed and cleaned produce of each plot and their weight was recorded as test weight (g).

3.9.2.4 Biological yield

The weight of the thoroughly sun dried harvested produce of each plot was recorded separately before threshing as biological yield and then converted into kg ha^{-1}.

3.9.2.5 Seed yield

After threshing, winnowing and cleaning, the produce of each plot was weighed separately in kg plot^{-1} and converted in terms of seed yield in kg ha^{-1}.

3.9.2.6 Straw yield

Straw yield ($kgha^{-1}$) was obtained by subtracting the seed yield from biological yield.

3.9.2.7 Harvest index (per cent)

The harvest index was worked out as per formula advocated by Singh and Stoskopf (1971).

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

3.10 Chemical studies

3.10.1 Nutrient content

Nitrogen: Representative samples of sesame seed and straw taken at harvest stage were oven dried, ground in Willey mill and analysed for their N content. Nitrogen was estimated by colorimetric method (Snell and Snell, 1949). Samples were digested with sulphuric acid and treated with hydrogen peroxide to remove black colour. Nesseler's reagent was used to develop colour. The results so obtained were expressed as per cent N content on dry weight basis.

Phosphorus: Phosphorus content in seed and straw were determined by "Vanadomolybdo phosphate" Yellow colour method. Digestion of samples was done by triacid mixture. Ammonium molybdate-ammonium vandate solution was used to develop colour and resultant intensity of colour was measured spectro photometer at 420 nm wavelength and expressed as per cent phosphorus content on dry weight basis (Jackson, 1973).

3.10.2 Nutrient uptake

The uptake of nitrogen and phosphorus after harvest in seed was estimated by using the following relationship:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in seed (per cent)} : \text{Seed yield (kg ha}^{-1}\text{)} + \text{Nutrient content in straw (per cent)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

3.11. Quality parameters

3.11.1. Crude protein content

Crude protein per cent in seed was calculated by multiplying nitrogen content percentage in seed by the factor of 6.25 (A.O.A.C., 1960).

Crude protein content was estimated by using following expression.

Crude protein content (per cent) = N content in seed (per cent) x 6.25

3.11.2. Oil content

Oil content in seed was determined by Soxhlet's Ether Extraction Method (A.O.A.C., 1960).

3.11.3. Oil yield

Oil yield was worked out by using the following formula:

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (per cent)} \times \text{Seed yield(kg ha}^{-1}\text{)}}{100}$$

3.12. Economics of treatments

3.12.1. Cost of cultivation

The total cost of investment incurred in different agro-inputs and agricultural operations to raise the crop under a particular treatment was worked out on the basis of existing market price of the input, powers and wages etc. These estimations were made by considering the cultivation of crop in one hectare area.

3.12.2 Gross returns (GR)

The GR is the value of the total produce of a particular treatment as per existing marker ate. It was computed treatment wise on per hectare area basis. It gives an indicative of the true gain over every rupee of investment under a particular treatment.

3.12.3 Net returns (NR)

The cost of cultivation for each treatment was subtracted from the gross returns worked out for the respective treatment to arrive at net returns for each treatment.

Net returns (` $ha^{-1}$) = Gross return (` ha^{-1}) - Cost of cultivation (` ha^{-1}).

3.13 Statistical analysis

3.13.1 Analysis of variance and test of significance

Experimental data recorded in various observations were statistically analysed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons were worked out where ever the variance ratio (F test) was found significant at 5% level of significant. To elucidate the nature and magnitude of treatments, summary tables along with S.Em. ± and CD (P=0.05) were prepared and presented the chapter “Experimental Results" and their analysis of variance are given in the “Appendices”.

3.13.2 Correlation and regression coefficient

To assess the relationship, correlation and regression coefficients between seed yield of sesame (Y) and the independent variables (X) such as crop dry matter accumulation, yield attributes and nutrient uptake were computed using the method given by Snedecor and Cochran (1968). The regression equations were also fitted and tested for significance.

4. EXPERIMENTAL RESULTS

A field experiment "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan"** was conducted at the Agronomy Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif* 2017. The experimental findings pertaining to growth parameters, yield attributes, yield and nutrient uptake by sesame as influenced by different varieties and sowing dates based upon field experiment is presented in this chapter. The data recorded for important characters have also been depicted graphically for elucidation of the important trends, where ever necessary.

4.1 Growth parameters

4.1.1 Plant stand

Data presented in Table 4.1 indicated that different dates of sowing and varieties did not affect the plant stand ha^{-1} significantly. Thus, plant stand almost uniform at all dates of sowing at 20 DAS and at harvest and in all varieties.

4.1.2 Plant height

Sowing dates

It is evident from the data (Table 4.2) and (Fig. 4.1) that plant height of sesame was influenced significantly by different sowing dates. Sowing of crop on 10 July gave maximum plant height (15.19 cm and 138.09 cm) at 25 DAS and harvest, respectively. It was significantly higher over sowing on 30 July and 09 August but remained at par with sowing on 20 July.

Table 4.1 Effect of sowing dates and varieties on plant stand of sesame (lac ha^{-1})

Treatments	At 20 DAS	At harvest
Sowing dates		
10 July	3.25	3.20
20 July	3.25	3.21
30 July	3.27	3.21
09 August	3.25	3.21
SEm±	0.07	0.04
CD (P=0.05)	NS	NS
Varieties		
RT - 125	3.26	3.21
RT – 46	3.26	3.20
RT - 127	3.26	3.22
RT - 346	3.24	3.20
SEm±	0.06	0.08
CD5%	NS	NS

DAS = Days after sowing, NS= Non Significant

Sowing of sesame on 10 July enhanced plant height to the tune of 2.56, 32.54 and 24.61 per cent at 25 DAS and 1.23, 61.96 and 107 per cent at harvest over sowing on 20 July, 30 July and 09 august, respectively.

Varieties

Table 4.2 and (Fig. 4.1) indicated that different varieties of sesame did not influence significantly to plant height at any growth stages. Therefore, plant height of sesame was almost similar to each other at all growth stages.

Table 4.2 Effect of sowing dates and varieties on plant height

Treatments	Plant height (cm)	
	At 25 DAS	At harvest
Sowing dates		
10 July	15.19	138.0
20 July	14.81	136.4
30 July	11.46	85.2
09 August	12.19	66.7
SEm±	0.12	0.8
CD (P=0.05)	0.43	3.0
Varieties		
RT – 125	13.52	106.1
RT – 46	13.14	105.6
RT – 127	13.37	105.7
RT – 346	13.61	108.8
SEm±	0.18	1.0
CD5%	NS	NS

DAS = Days after sowing, NS= Non Significant

4.1.3 Dry matter accumulation

Sowing dates:

A perusal of data (Table 4.3 and Fig. 4.2) indicated that different sowing dates of sesame significantly influenced the dry matter accumulation at all growth stages. Sowing on 10 July recorded significantly higher dry matter accumulation (0.41 g plant^{-1}, 3.73 g plant^{-1} and 14.57 g plant^{-1}) at 25 DAS, 50 DAS and harvest over 20 July, 30 July and 09 August but statistically at par with 20 July at 50 DAS.

Table 4.3 Effect of sowing dates and varieties on dry matter accumulation of sesame

Treatments	Dry matter accumulation (g plant^{-1})		
	At 25 DAS	At 50 DAS	At harvest
Sowing dates			
10 July	0.41	3.73	14.57
20 July	0.38	3.69	11.55
30 July	0.27	2.64	5.89
09 August	0.25	1.82	3.59
SEm±	0.004	0.03	0.09
CD (P=0.05)	0.013	0.12	0.33
Varieties			
RT – 125	0.32	3.01	8.87
RT – 46	0.32	2.92	8.81
RT – 127	0.32	2.94	8.81
RT – 346	0.34	3.01	9.11
SEm±	0.01	0.06	0.11
CD5%	NS	NS	NS

DAS = Days after sowing, NS= Non Significant

Sowing of sesame on 10 July, increased dry matter accumulation by 7.89, 51.85 and 64 per cent at 25 DAS, 1.08, 41.28 and 104.94 per cent at 50 DAS and 226.14, 147.36 and 389.41 per cent at harvest over sowing on 20 July, 30 July and 09 August, respectively.

Varieties

A perusal of data (Table 4.3) and (Fig. 4.2) indicated that different varieties of sesame did not influence the dry matter accumulation significantly at any growth stage and almost similar to each other at all growth stages.

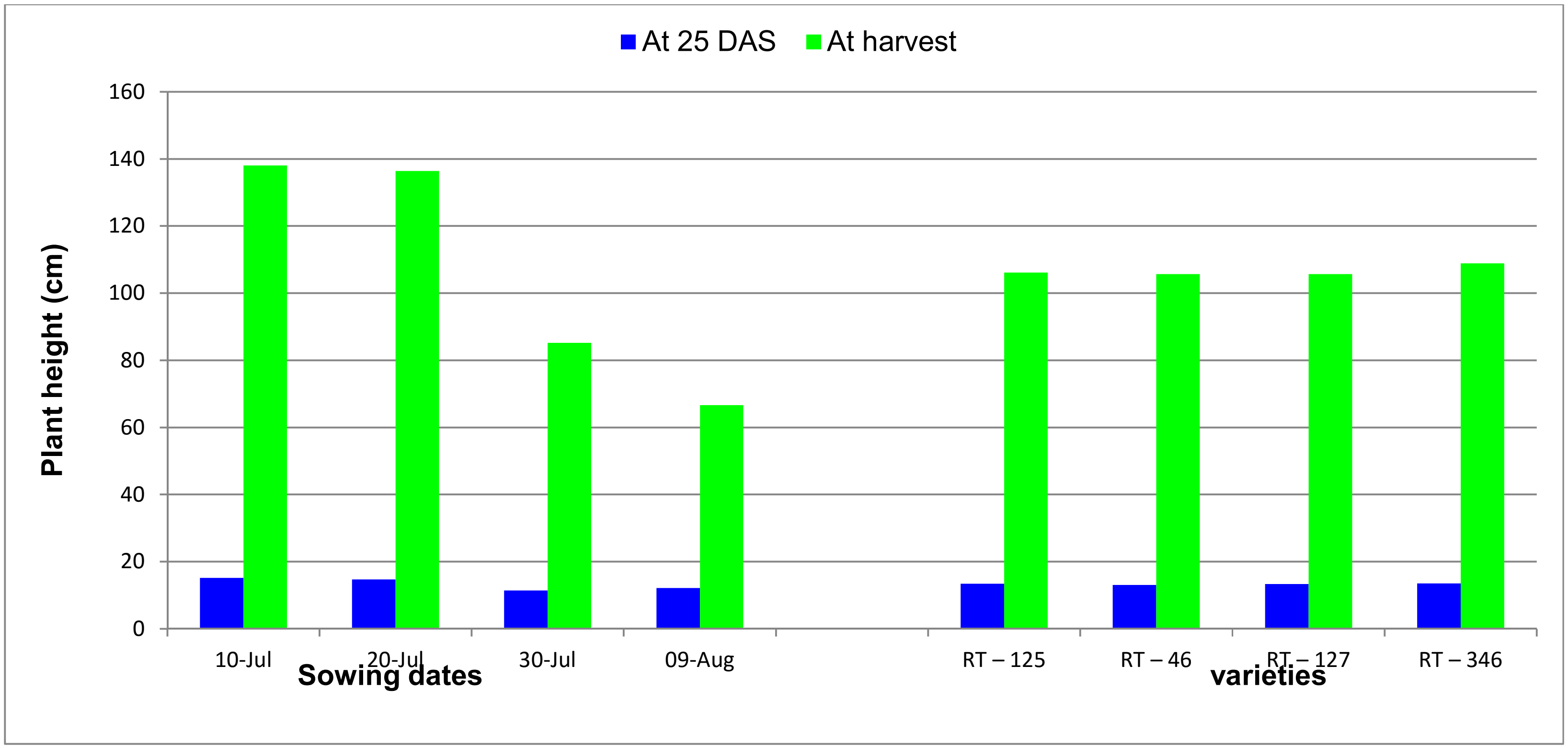


Fig. 4.1 Effect of sowing dates and varieties on plant height

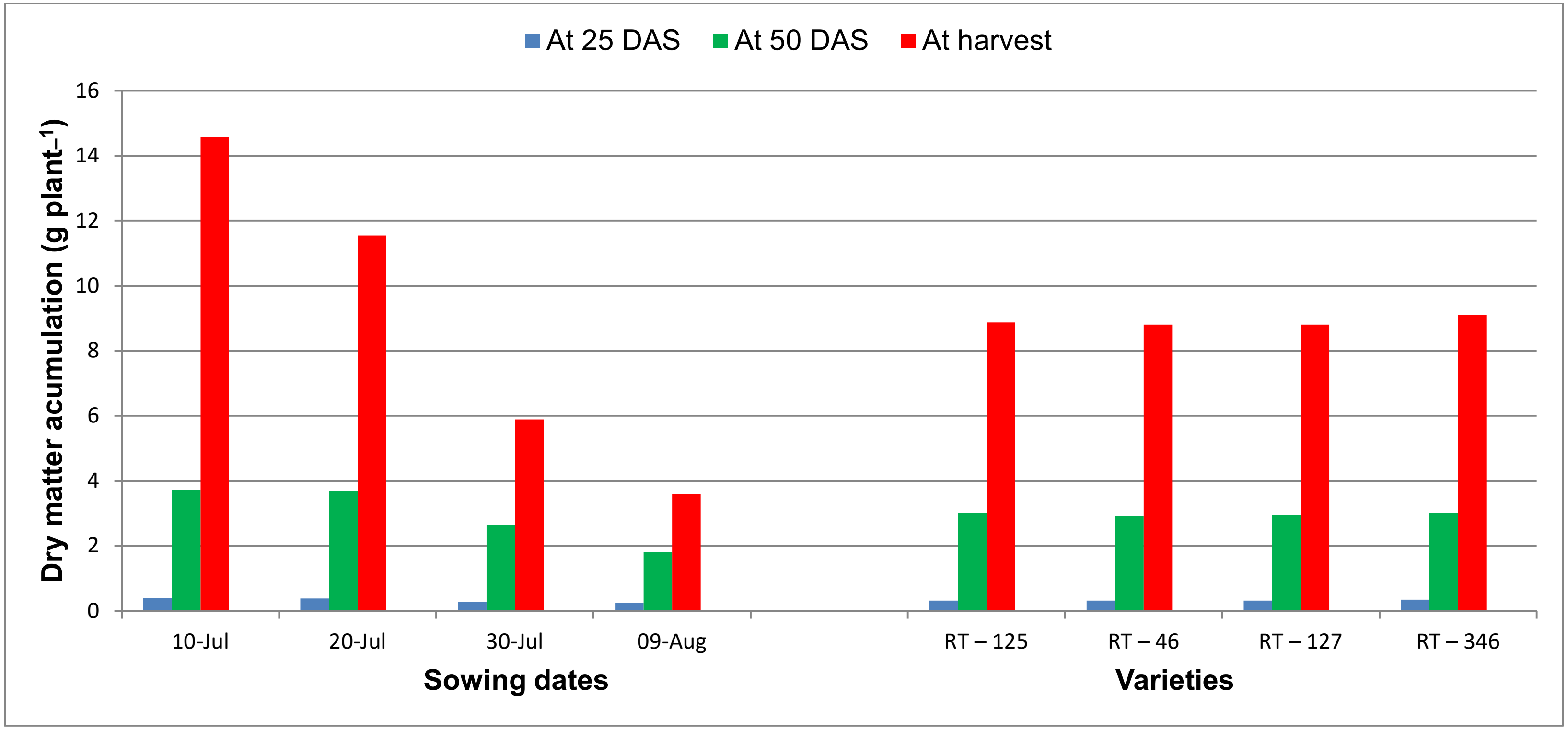


Fig. 4.2 Effect of sowing dates and varieties on dry matter accumulation of sesame

4.1.4 Crop growth rate (CGR)

Sowing dates

It is clear from the data presented in Table 4.4 and (Fig. 4.3) that different sowing dates affect the crop growth rate of sesame significantly. Sowing on 10 July recorded maximum crop growth rate (0.540 g m^{-2} day^{-1}, 4.438 g m^{-2} day^{-1} and 7.326 g m^{-2} day^{-1}) during 0 to 25 DAS, 25 to 50 DAS and 50 to harvest as compared to sowing on 20 July, 30 July and 09 August but statistically at pat with 20 July during 25 to 50 DAS .

Sowing of sesame on 10 July increased the crop growth rate by 11.57, 63.63 and 122.22 during 0 to 25 DAS .40, 39.34 and 105.17 per cent during 25 to 50 DAS, 36.17, 201.48 and 441.06 per cent during 50 to harvest over sowing on 20 July, 30 July and 09 August, respectively.

Varieties

Data (Table 4.4) and (Fig. 4.3) apparently show that crop growth rate of sesame was did not influenced significantly due to different varieties.

4.1.5 Relative growth rate

Sowing dates

It is clear from the data presented in (Table 4.4) and (Fig. 4.4) that different sowing dates significantly affected, relative growth rate of sesame. Sowing on 10 July recorded significantly higher relative growth rate (0.581 mg g^{-1} day^{-1}, 1.143 mg g^{-1} day^{-1}) during 25 to 50 DAS and 50 DAS to harvest as compared to 20 July, 30 July and 09 August, respectively.

Table 4.4 Effect of sowing dates and varieties on crop growth rate (CGR) and relative growth rate (RGR) of sesame

Treatments	CGR ($g\ m^{-2}\ day^{-1}$)			RGR ($mg\ g^{-1}\ day^{-1}$)	
	0-25 DAS	**25- 50 DAS**	**50 DAS – at harvest**	**25-50 DAS**	**50 DAS- at harvest**
Sowing dates					
10 July	0.540	4.438	7.326	0.581	1.143
20 July	0.484	4.420	5.380	0.577	1.034
30 July	0.330	3.185	2.430	0.442	0.727
09 August	0.243	2.163	1.354	0.276	0.537
SEm±	0.007	0.076	0.753	0.004	0.005
CD (P=0.05)	0.025	0.263	2.604	0.015	0.016
Varieties					
RT – 125	0.399	3.600	4.029	0.467	0.801
RT – 46	0.393	3.506	3.922	0.454	0.889
RT – 127	0.393	3.527	4.155	0.484	0.892
RT – 346	0.412	3.572	4.384	0.472	0.859
SEm±	0.009	0.076	0.140	0.008	0.005
CD5%	NS	NS	NS	0.023	0.015

DAS = Days after sowing, NS= Non Significant

Sowing of sesame on 10 July increased the relative growth rate by 0.69, 31.44 and 110.50 per cent between 25 to 50 DAS and 10.54, 57.22 and 112.84 per cent between 50 DAS to harvest, over sowing on 20 July, 30 July and 09 August, respectively.

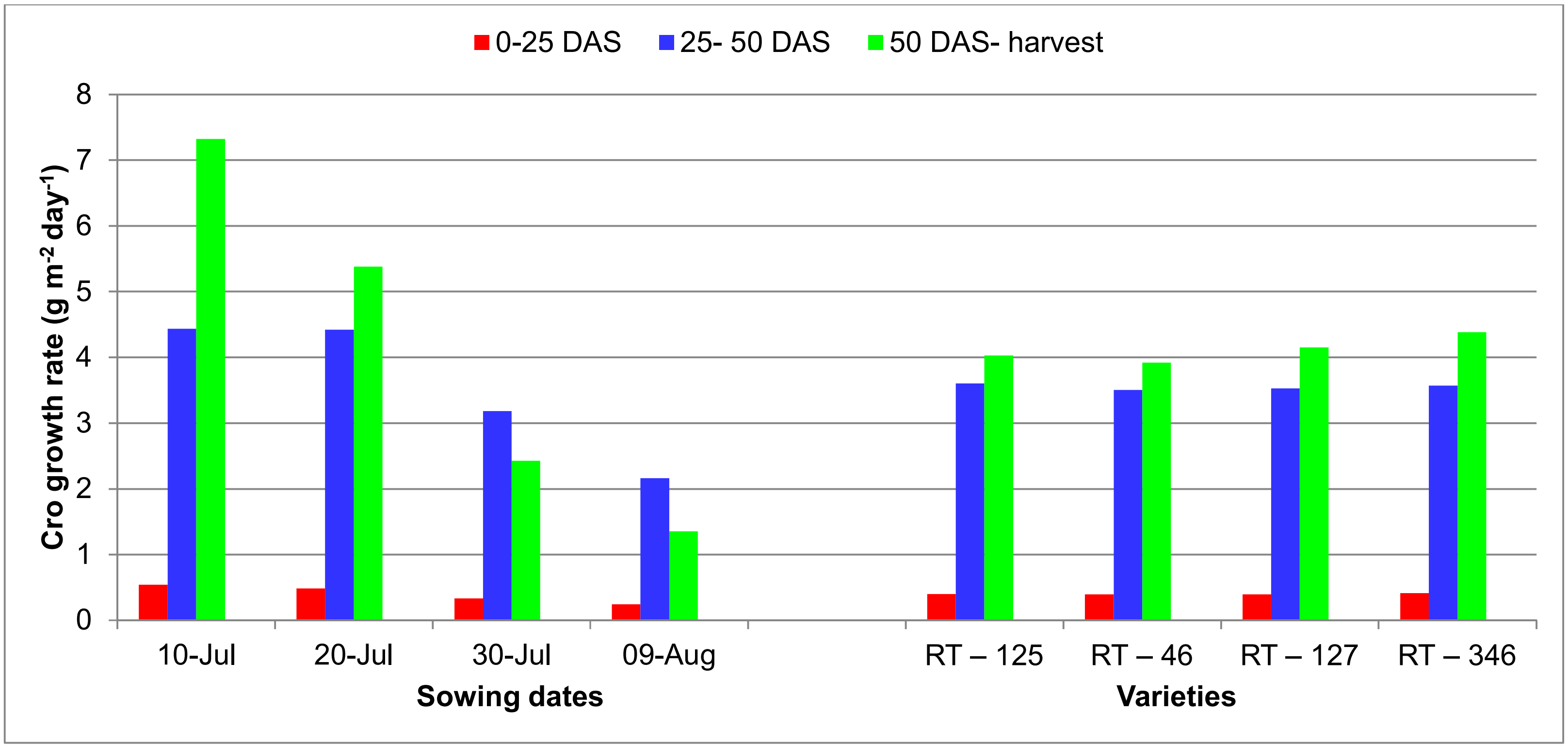


Fig 4.3 Effect of sowing dates and varieties on crop growth rate

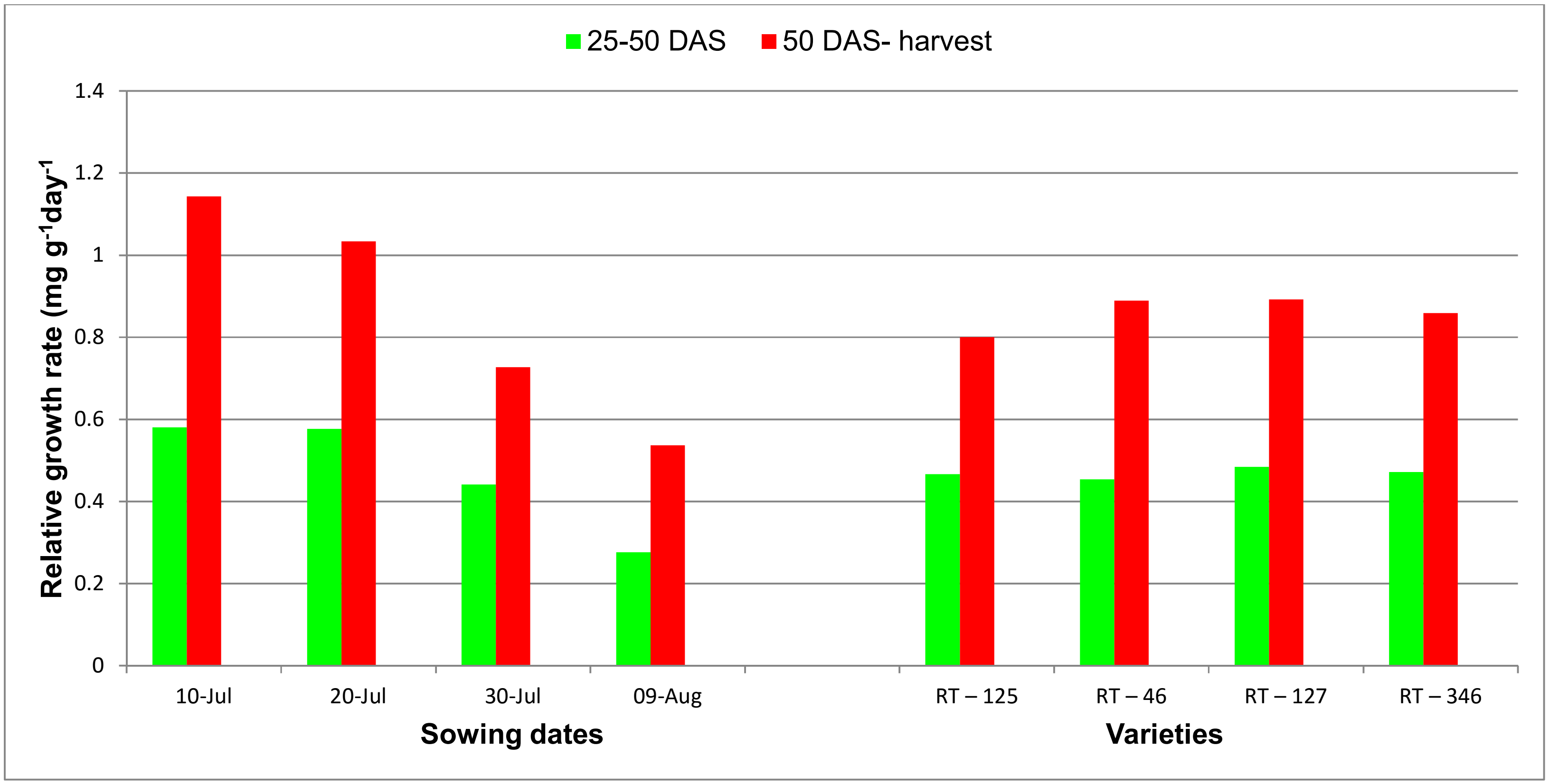


Fig. 4.4 Effect of sowing dates and varieties on relative growth rate

Varieties

Data (Table 4.4) and (Fig. 4.4) apparently show that relative growth rate of sesame was significantly affected due to different varieties.

Variety RT – 127 recorded significantly higher relative growth rate (0.484 mg g^{-1} day^{-1} and 0.892 mg g^{-1} day^{-1}) but statistically at par with RT- 346 during 25 to 50 DAS and with RT- 46 during 50 DAS to harvest as compared to 20 July, 30 July and 09 August. Relative growth rate of sesame was increased due to variety RT - 127 by 3.64, 6.60 and 2.54 per cent during 25 to 50 DAS, 11.36, 0.33 and 3.84 per cent during 50 to harvest over variety RT-125, RT-46 and RT- 346, respectively.

4.1.6 Days to 50 per cent flowering

Sowing dates

Data presented in table 4.5 reveals that effects of sowing dates show that sowing on 10 July took maximum days (44.50) to 50 per cent flowering than on onward sowing dates, but statistically at par with 20 July. Further delay in sowing, decreases the days to 50 percent flowering of sesame.

Days to 50 per cent flowering increased by 2.89, 6.38 and 15.34 per cent in sowing on 10 July as compared to 20 July, 30 July and 09 August, respectively.

Varieties

A perusal of data embodied in table 4.5 reveals that RT – 127 Flowered significantly earlier than other remaining three varieties, i.e. RT-127 while was almost one day early.

4.1.7 Chlorophyll content

Data presented in table 4.5 indicated that different dates of sowing and verities did not affect the chlorophyll content significantly. Thus, chlorophyll content almost similar at all dates of sowing and all varieties at 50 DAS.

4.1.8 Number of branches

Sowing dates

Data presented in table 4.5 reveals that numbers of branches plant^{-1} were significantly influenced due to sowing dates. Sowing on 10 July produce maximum number of branches plant^{-1} (3.82) at harvest.

Sowing of sesame on 10 July enhanced number of branches plant^{-1} by 13.35, 31.27 and 58.50 per cent over sowing on 20 July, 30 July and 09 August, respectively at harvest of crop.

Varieties

Further, data presented in table 4.5 show that number of branches plant^{-1} did significantly not influenced by different varieties but variety RT – 346 was produce more number of branches plant^{-1} at harvest.

4.1.9 Days to maturity

Sowing dates

Data presented in table 4.5 reveals that effect sowing of crop on 10 July took more number of days (84.0) to maturity than all other three sowing dates. Further delay in sowing, reduces the days to maturity of sesame significantly about 2 - 5 days

Table 4.5 Effect of sowing dates and varieties on days to 50 per cent flowering, days to maturity, chlorophyll content of sesame at 50 DAS, number of branches and heat unit efficiency.

Treatments	Days to 50% flowering	Days to maturity	Chlorophy content (mg g^{-1})	Number of branches	Heat unit efficiency (kg ha^{-1} degree day^{-1})
Sowing dates					
10 July	44.50	84.00	1.96	3.82	6.38
20 July	43.25	82.25	1.93	3.37	6.12
30 July	41.83	80.00	1.93	2.91	4.27
09 August	38.58	79.00	1.95	2.41	2.21
SEm±	0.22	0.09	0.01	0.03	0.06
CD(P=0.05)	0.76	0.32	0.04	0.10	0.19
Varieties					
RT – 125	42.58	81.25	1.94	3.15	4.88
RT – 46	42.08	81.50	1.93	3.14	4.70
RT – 127	41.08	81.25	1.94	3.05	4.54
RT – 346	42.42	81.25	1.95	3.16	4.86
SEm±	0.22	0.10	0.01	0.05	0.06
CD5%	NS	NS	NS	NS	0.18

NS = Non Significant

Varieties

A perusal of data embodied in table 4.5 shows that days to maturity did not significantly influenced by varieties and all varieties are mature almost same times.

4.1.10 Heat unit efficiency

Sowing dates

Data presented in table 4.5 shows that sowing of sesame on 10 July recorded significantly higher heat unit efficiency (6.38 kg ha^{-1} degree day^{-1}) as compared to 20 July, 30 July and 09 august.

Analysis revealed that sowing date of sesame on 10 July enhanced heat unit efficiency by 4.24, 49.41 and 188.69 per cent over late sowing on 20 July, 30 July and 09 August, respectively.

Varieties

Further, data presented in table 4.5 show that heat unit efficiency significantly influenced by varieties. Variety RT- 125 recorded higher heat unit efficiency (6.38 kg ha^{-1} $degreeday^{-1}$) as compared to RT- 46, RT- 127 and RT- 346 but statistically at par with variety RT- 346.

4.2 Yield attributes and yield

4.2.1 Number of capsules per plant

Sowing dates

Data presented in table 4.6 and (Fig. 4.5) reveals that numbers of capsules $plant^{-1}$ in sesame were significantly influenced due to sowing dates. Sowing on 10 July recorded significantly more number of capsules $plant^{-1}$ (41.23) as compared to 30 July and 09 August and statistically at par with 20 July.

Analysis revealed that sowing on 10 July enhanced number of capsules $plant^{-1}$ by 3.25, 26.58 and 91.14 per cent over late sowing on 20 July, 30 July and 09 August, respectively.

Varieties

Data presented in table 4.6 and (Fig. 4.5) show that number of capsules plant^{-1} did not influenced significantly by varieties and produces almost similar number of capsules plant^{-1}.

4.2.2 Number of seeds per capsule

Sowing dates

Data presented in table 4.6 and (Fig. 4.5) reveals that numbers of seeds capsules^{-1} in sesame were significantly influenced due to sowing dates. Sowing on 10 July recorded maximum number of seeds capsules^{-1} (33.04) as compared to 20 July, 30 July and 09 August but statistically at par with 20 July.

Analysis revealed that sowing on 10 July enhanced number of seeds capsules^{-1} by 0.33, 5.52 and 16.83 per cent over late sowing on 20 July, 30 July and 09 August, respectively.

Varieties

Further, data presented in table 4.6 and (Fig. 4.5) showed that number of seeds capsules^{-1} did not influenced by varieties but variety RT – 125 have 1.24, 0.89 and 0.79 per cent higher number of seeds capsules^{-1} over Variety RT- 46, RT- 127 and RT- 346 respectively.

4.2.3 Test weight

Sowing dates

Data presented in table 4.6 reveals that test weight of sesame was significantly influenced due to sowing dates. Sowing on 10 July recorded significantly higher test weight (2.83 g) as compared to 20 July, 30 July and 09 August.

Table 4.6 Effect of sowing dates and varieties on yield attributes of sesame

Treatments	Number of capsules ($plant^{-1}$)	Number of seeds ($capsule^{-1}$)	Test weight (g)
Sowing dates			
10 July	41.23	33.04	2.83
20 July	39.93	32.93	2.71
30 July	32.57	31.31	2.67
09 August	21.57	28.28	2.50
SEm±	0.40	0.27	0.01
CD (P=0.05)	1.39	0.93	0.05
Varieties			
RT – 125	34.40	31.62	2.68
RT – 46	33.66	31.23	2.66
RT – 127	33.58	31.34	2.66
RT – 346	33.65	31.37	2.71
SEm±	0.30	0.14	0.02
CD5%	NS	NS	NS

NS = Non Significant

Analysis revealed that sowing on 10 July enhanced test weight by 4.42, 5.99 and 13.2 per cent over late sowing on to 20 July, 30 July and 09 August, respectively.

Varieties

Further, data presented in table 4.6 show that test weight did not influenced significantly by varieties but variety RT – 346 have higher test weight.

4.2.4 Seed yield

Sowing dates:

A perusal of data (Table 4.7) and (Fig. 4.6) indicated that seed yield of sesame influenced, significantly due to different sowing dates. Sowing on 10 July produced significantly higher seed yield (810 kg ha^{-1}), compared to sowing on 20 July, 30 July and 09 August.

Sowing of sesame on 10 July increased seed yield to the tune of 3.97, 56.06 and 276.74 per cent, over sowing on 20 July, 30 July and 09 August, respectively.

Varieties:

Data (Table 4.7) and (Fig. 4.6) further show that seed yield of sesame were significantly influenced due to various varieties of sesame. Variety RT – 125 produce significantly higher seed yield (616 kg ha^{-1}) as compared to variety RT – 46, RT – 127 and R - 346.

Seed yield increased due to sesame variety RT – 125 by 11.19, 10.99 and 3.18 per cent over variety RT – 46, RT – 127 and R – 346, respectively.

4.2.5 Straw yield

Sowing dates:

Data presented in table 4.7 and (Fig. 4.6) reveals that straw yield of sesame was significantly influenced due to sowing dates. Sowing on 10 July produced significantly higher straw yield (2444 kg ha^{-1}) over 30 July and 09 August, but statistically at par with 20 July.

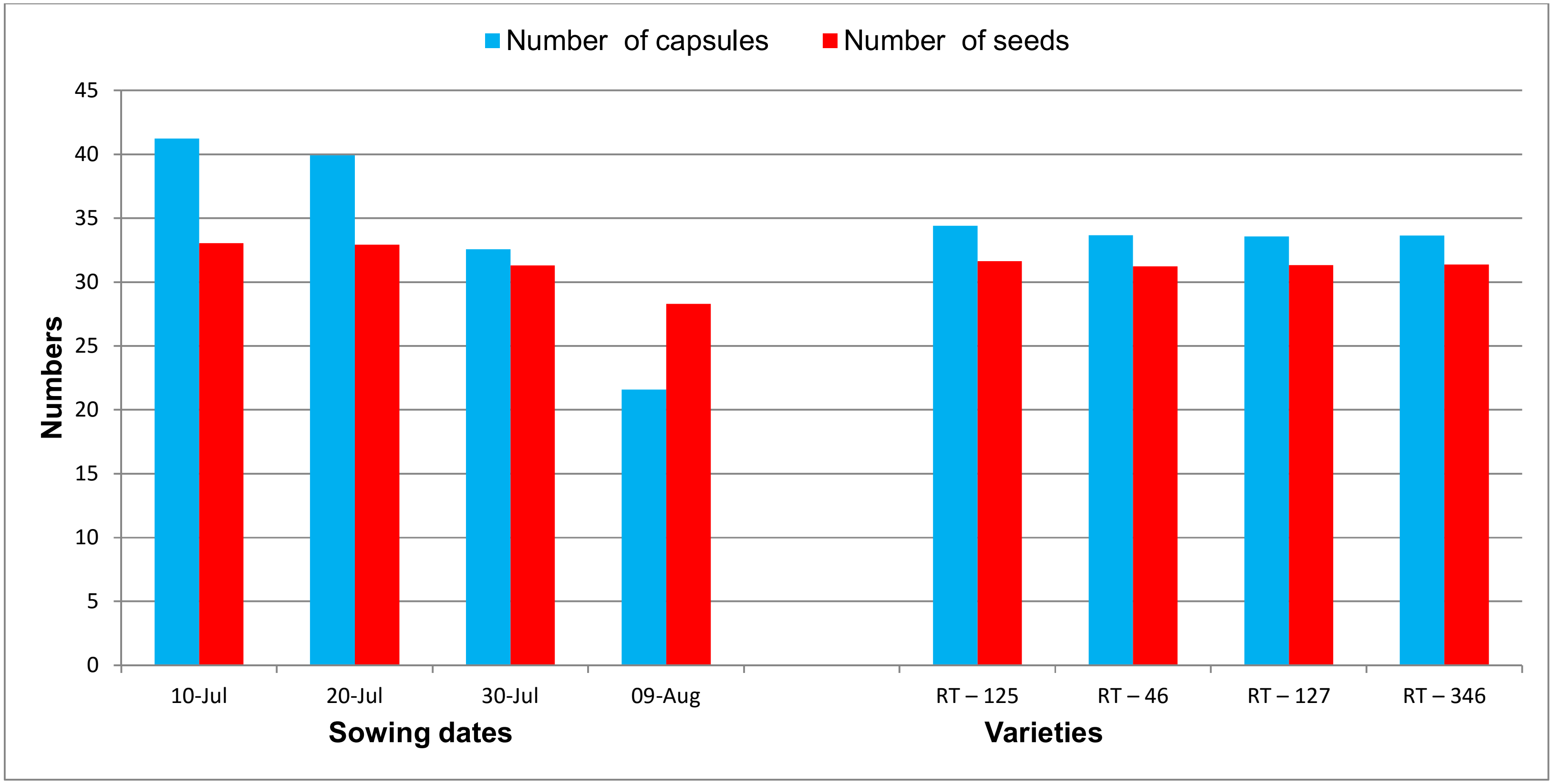


Fig. 4.5 Effect of sowing dates and varieties on yield attributes of sesame

Analysis revealed that sowing on 10 July enhanced straw yield by 2.38, 4.94 and 148.62 per cent over sowing on 20 July, 30 July and 09 August, respectively.

Varieties:

Further, data presented in table 4.7 and (Fig. 4.6) showed that straw yield did not influence significantly by varieties but variety RT-346 have higher straw yield as compared to RT- 125, RT- 46 and RT-127.

4.2.6 Biological yield

Sowing dates:

Data presented in table 4.7 and (Fig. 4.6) reveals that biological yield of sesame was significantly influenced due to sowing dates. Sowing on 10 July produced significantly higher biological yield (3242 kg ha^{-1}) over 30 July and 09 August, but statistically at par with 20 July.

Analysis revealed that sowing on 10 July enhanced biological yield by 2.40, 44.99 and 170.61 per cent over late sowing on 20 July, 30 July and 09 August, respectively.

Varieties:

Further, data presented in table 4.7 and (Fig. 4.6) show that biological yield did not influenced significantly by varieties.

Table 4.7 Effect of sowing dates and varieties on yield and harvest index of sesame

Treatments	Yield ($kg\ ha^{-1}$) Seed	Straw	Biological	Harvest index (%)
Sowing dates				
10 July	810	2444	3242	25.12
20 July	779	2387	3166	24.70
30 July	519	1734	2236	23.76
09 August	215	983	1198	18.13
SEm±	8	26	32	0.14
CD (P=0.05)	29	88	110	0.49
Varieties				
RT – 125	616	1868	2485	23.96
RT – 46	554	1901	2426	22.15
RT – 127	555	1870	2426	22.36
RT – 346	597	1908	2505	23.25
SEm±	6	28	29	0.29
CD5%	16	NS	NS	0.84

NS = Non Significant

4.2.7 Harvest index

Sowing dates

It is evident from data (Table 4.7) that harvest index of sesame were significantly influenced due to sowing dates. Sowing on 10 July recorded significantly higher harvest index (25.12 per cent) over 30 July and 09 August being statistically at par with 20 July.

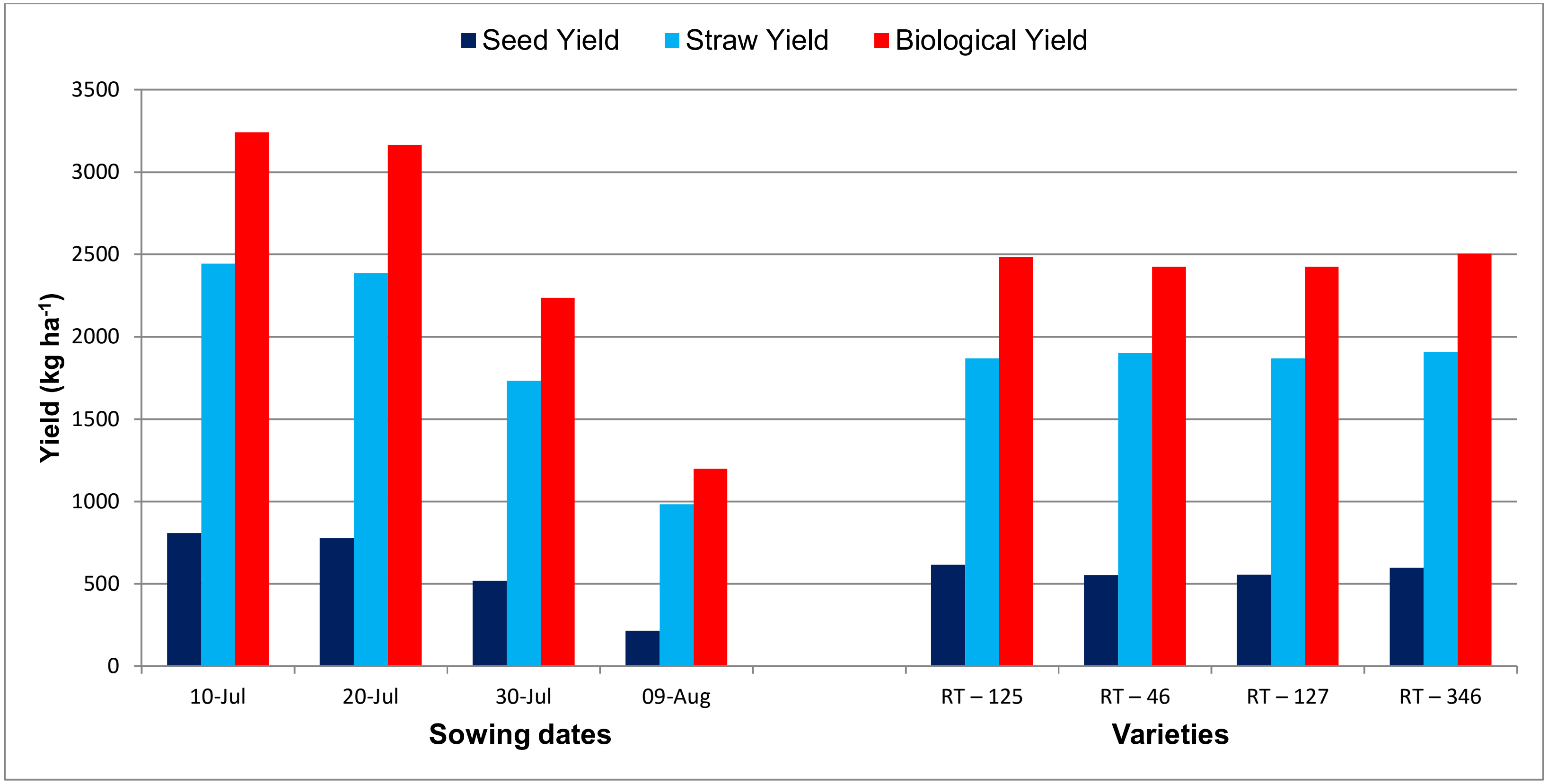


Fig. 4.6 Effect of sowing dates and varieties on yield of sesame

Analysis of data revealed that sowing on 10 July enhanced harvest index 1.70, 5.76 and 38.55 per cent over 20 July, 30 July and 09 August, respectively.

Varieties

Data (Table 4.7) further shows that harvest index of sesame were significantly influenced due to various varieties of sesame. Variety RT - 125 gave significantly higher harvest index (23.96) as compared to variety RT- 46 and RT - 127 but statistically at par with RT - 346.

Harvest index increased due to sesame variety RT – 125 by 8.17, 7.15 and 3.05 per cent over variety RT - 46, RT - 127 and RT-346, respectively.

4.3 Chemical studies

4.3.1 Nitrogen content in seed

Sowing dates:

A critical examination of data presented in table 4.8 shows that nitrogen content in seed increased significantly with delay in sowing. Sowing on 09 August recorded significantly higher nitrogen content (2.45 per cent) in seed in as compared to sowing on 10 July, 20 July and 30 July, respectively.

Sowing on 09 August increased nitrogen content seed by 14.95, 13.51 and 4.60 per cent over sowing on 10 July, 20 July and 30 July, respectively.

Table 4.8 Effect of sowing dates and varieties on nitrogen and phosphorus content in seed of sesame

Treatments	N content in seed (%)	P content in seed (%)
Sowing dates		
10 July	2.133	0.483
20 July	2.160	0.493
30 July	2.344	0.489
09 August	2.452	0.528
SEm±	0.024	0.006
CD (P=0.05)	0.083	0.022
Varieties		
RT – 125	2.245	0.493
RT – 46	2.306	0.511
RT – 127	2.277	0.494
RT – 346	2.261	0.496
SEm±	0.027	0.006
CD5%	NS	NS

NS = Non significant

Varieties:

Data presented in table 4.8 show that nitrogen content by seed did not influenced significantly by varieties. Nitrogen content in seed was 2.25, 2.31, 2.28and 2.26 per cent in RT-125, RT-46, RT-127 and RT- 346; it was almost near to each other.

4.3.2 Phosphorus content in seed

Sowing dates:

A critical examination of data presented in table 4.8 shows that phosphorus content in seed was affected significantly due to different sowing dates. Sowing on 09 August recorded significantly higher phosphorus content in seed (0.53 per cent) over sowing on 10 July, 20 July and 30 July.

Sowing on 09 August increased phosphorus content in seed to the tune of 9.31, 7.09 and 7.97 per cent respectively, as compared to sowing on 10 July, 20 July and 30 July.

Varieties:

Data presented in table 4.8 show that difference in phosphorus content was non significant in all varieties by seed did not influenced by varieties.

4.3.3 Nitrogen uptake by seed

Sowing dates:

A critical examination of data presented in (Table 4.9 and Fig. 4.7) show that nitrogen uptake by seed decreased significantly with delay in sowing. The seed uptake of nitrogen (17.20 kg ha^{-1}) sowing on 10 July over sowing on 20 July, 30 July and 09 August but statistically at par with 20 July.

It increased 1.12, 40.29 and 227.61 per cent, over sowing on 20 July, 30 July and 09 August, respectively.

Varieties:

Data (Table 4.9 and Fig. 4.7) further show that nitrogen uptake by seed were significantly influenced due to different varieties of sesame. Variety RT – 125 have significantly higher nitrogen uptake (13.66 kg ha^{-1}) as compared to variety RT – 46, RT – 127 and RT – 346 and it.

Nitrogen uptake increased by to sesame variety RT – 125 by 10.78, 9.54 and 3.72 per cent over variety RT – 46, RT – 127 and RT– 346, respectively.

4.3.4 Phosphorus uptake by seed

Sowing dates:

A critical examination of data presented in (Table 4.9 and Fig. 4.7) show that phosphorus uptake by seed was affected significantly due to sowing dates. Sowing on 10 July recorded significantly higher phosphorus uptake (3.91 kg ha^{-1}) by seed over sowing on 30 July and 09 August, but statistical at par with 20 July.

Sowing of sesame on 10 July increased phosphorus uptake by seed was 1.55, 53.93 and 240 per cent, over sowing on 20 July, 30 July and 09 August, respectively.

Varieties:

Data (Table 4.9 and Fig. 4.7) further reveals that phosphorus uptake by seed was significantly influenced due to different varieties of sesame. Variety RT - 125 (3.0 kg ha^{-1}) significantly higher nitrogen uptake as compared to variety RT– 46, RT - 127 and RT - 346.

Table 4.9 Effect of sowing dates and varieties on nitrogen and phosphorus uptake in seed of sesame

Treatments	N uptake by seed (kg ha^{-1})	P uptake by seed (kg ha^{-1})
Sowing dates		
10 July	17.20	3.91
20 July	16.93	3.85
30 July	12.26	2.54
09 August	5.25	1.15
SEm±	0.31	0.05
CD (P=0.05)	1.08	0.17
Varieties		
RT – 125	13.66	3.00
RT – 46	12.33	2.85
RT – 127	12.47	2.69
RT – 346	13.17	2.90
SEm±	0.15	0.05
CD5%	0.44	0.13

Nitrogen uptake by sesame variety RT – 125 increased by 5.26, 11.52 and 3.44 per cent higher over variety RT – 46, RT – 127 and RT – 346, respectively.

4.4 Quality parameters

4.4.1 Crude protein content in seed

Sowing dates

It is evident from data (Table 4.10) that protein content in seed significantly influenced due to different sowing date.

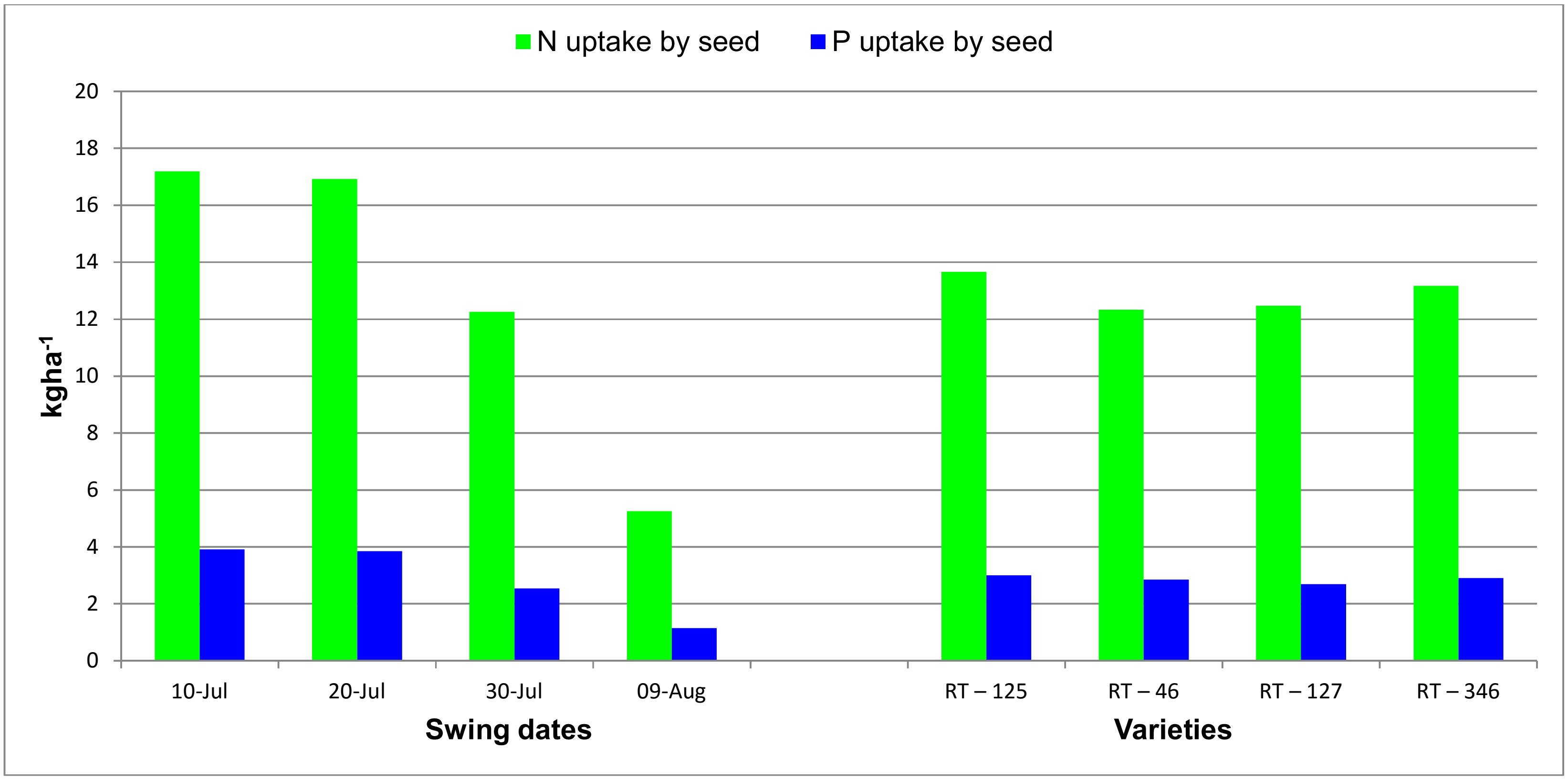


Fig. 4.7 Effect of sowing dates and varieties on nitrogen and phosphorus uptake by seed

Table 4.10 Effect of sowing dates and varieties on crude protein content in seed of sesame

Treatments	Crude protein content (per cent)
Sowing dates	
10 July	13.33
20 July	13.50
30 July	14.65
09 August	15.32
SEm±	0.15
CD (P=0.05)	0.52
Varieties	
RT – 125	14.03
RT – 46	14.41
RT – 127	14.23
RT – 346	14.13
SEm±	0.17
CD5%	NS

NS = Non significant

Sowing on 09 August recorded significantly highest protein content (15.32 per cent), over 10 July, 20 July and 30 July and it was higher 14.92, 13.48 and 4.57 per cent over early sowing on 10 July, 20 July and 30 July, respectively.

Varieties

A reference to data presented in table 4.10 revealed that protein content in seed did not influenced significantly by variety, but variety RT- 46 contain higher protein content as compared to RT-125, RT-127 and RT- 346.

4.4.2 Oil content in seed

Sowing dates

A critical examination of data presented in table 4.11 shows that oil content in seed was significantly affected due to sowing dates. Sowing on 10 July recorded highest oil content in seed (46.11 per cent) as compared to 20 July, 30 July and 09 August but statistically at par with 20 July. Sowing of sesame on 10 July increased oil content in seed to the tune of 0.46, 1.36 and 6.32 per cent over sowing on 20 July, 30 July and 09 August, respectively.

Varieties

A reference to data presented in table 4.11 reveals effect of varieties were non significant on oil content in seed. Varieties RT-125, RT-46, RT- 127 and RT- 346 contain 45.42, 45.15, 45.17 and 45.14 per cent oil in seed, respectively.

4.4.3 Oil yield

Sowing dates

It is evident from data (Table 4.11) that oil yield in seed significantly influenced due to different sowing date. Sowing 10 July recorded higher oil yield (399 kg ha^{-1}) as compared to 20 July, 30 July and 09 August.

Sowing on 10 July enhanced oil yield by 7.54, 69.06 and 329.03 per cent over sowing on 20 July, 30 July and 09 August, respectively.

Varieties

A reference to data presented in table 4.11 reveals that oil yield in seed significantly affected by different varieties of sesame.

Table 4.11 Effect of sowing dates and varieties on oil content and oil yield in seed of sesame

Treatments	Oil content in seed (%)	Oil yield (kg ha^{-1})
Sowing dates		
10 July	46.11	399
20 July	45.90	371
30 July	45.49	236
09 August	43.37	93
SEm±	0.14	5
CD (P=0.05)	0.48	16
Varieties		
RT – 125	45.42	299
RT – 46	45.15	258
RT – 127	45.17	261
RT – 346	45.14	281
SEm±	0.13	3
CD5%	NS	10

NS = Non Significant

Variety RT - 125 gave significantly higher oil yield (299 kg ha^{-1}) as compared to RT–46, RT–127 and R–346. In variety RT -125 increased oil yield by 15.89, 14.55 and 6.40 per cent, respectively as compared to variety RT– 46, RT–127 and RT–346.

4.5 Economics

4.5.1 Cost of cultivation

A critical examination of data presented in table 4.12 (Fig. 4.8) indicated that cost of cultivation (18886 ` ha^{-1}) did not influenced significantly due to different sowing dates and varieties of sesame.

4.5.2 Gross return

Sowing dates:

A critical examination of data presented in table 4.12 (Fig. 4.8) indicated that gross return (54210 ` ha^{-1}) influenced significantly due to different sowing dates of sesame. Sowing of sesame on 10 July recorded significantly higher gross return as compared to sowing on 20 July, 30 July and 09 August.

Varieties:

A reference of data presented in table 4.12 and (Fig. 4.8) indicated that gross return (41289 ` ha^{-1}) were found significant due to different varieties of sesame. Variety RT- 125 recorded significantly, higher gross return over RT- 46, RT- 127 and RT- 346.

4.5.3 Net return

Sowing dates:

A critical examination of data presented in table 4.12 (Fig. 4.8) indicated that net returns (35324 ` ha^{-1}) influenced significantly due to different sowing dates of sesame.

Sowing of sesame on 10 July recorded significantly higher net return as compared to sowing on 20 July, 30 July and 09 August.

Table 4.12 Effect of sowing dates and varieties on Cost of cultivation, Gross return and Net return (₹ ha^{-1})

Treatments	Cost of cultivation	Gross return	Net return
Sowing dates			
10 July	18886	54210	35324
20 July	18886	52308	33422
30 July	18886	35083	16197
09 August	18886	15009	-3877
SEm±	-	-	-
CD (P=0.05)	-	-	-
Varieties			
RT – 125	18886	41289	22403
RT – 46	18886	37389	18503
RT – 127	18886	37664	18778
RT – 346	18886	40270	21384
SEm±	-	-	-
CD5%	-	-	-

Varieties:

A reference of data presented in table 4.12 and (Fig. 4.8) indicated that net return (22403 ` ha^{-1}) were found significant due to different varieties of sesame. Variety RT- 125 recorded significantly, higher net return over RT- 46, RT- 127 and RT- 346.

4. 6 Correlation and regression studies

4.6.1 Correlation

Correlation coefficient were work out between yield and number of capsules, number of seeds, test weight, nitrogen and phosphorus uptake. The calculated presented in table 4.13. The result of correlation coefficient revealed that seed yield was significantly and positively correlated with number of capsules plant^{-1}(r = 0.972), number of seeds capsules^{-1}(r = 0.930) test weight (0.850), nitrogen uptake (0.952) and phosphorus uptake (0.976).

4.6.2 Regression

The regression equations (Table 4.13) show that the every unit increase of number of capsules plant^{-1} number of seeds capsules$^{-1,}$ test weight, nitrogen uptake and phosphorus uptake the seed yield by 49.50, 37.81, 3.064, 21.52 and 4.80 kg ha^{-1}, respectively.

Table 4.13 Correlation coefficient and linear regressions equations showing relationship between independent variable (yield attributes and nutrient uptake) and dependent variable (seed yield)

Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equations (Y= a+bx)
	Capsule plant^{-1}	0.972**	$Y= -1.956x + 49.50X_1$
	Seeds capsule^{-1}	0.930**	$Y = -0.912x + 37.81X_2$
	Test weight	0.850**	$Y= -0.054x + 3.064X_3$
	N uptake	0.952**	$Y = -1.035x + 21.52X_4$
	P uptake	0.976**	$Y = -0.227x + 4.800X_5$

** Significant at 1 % level of significance

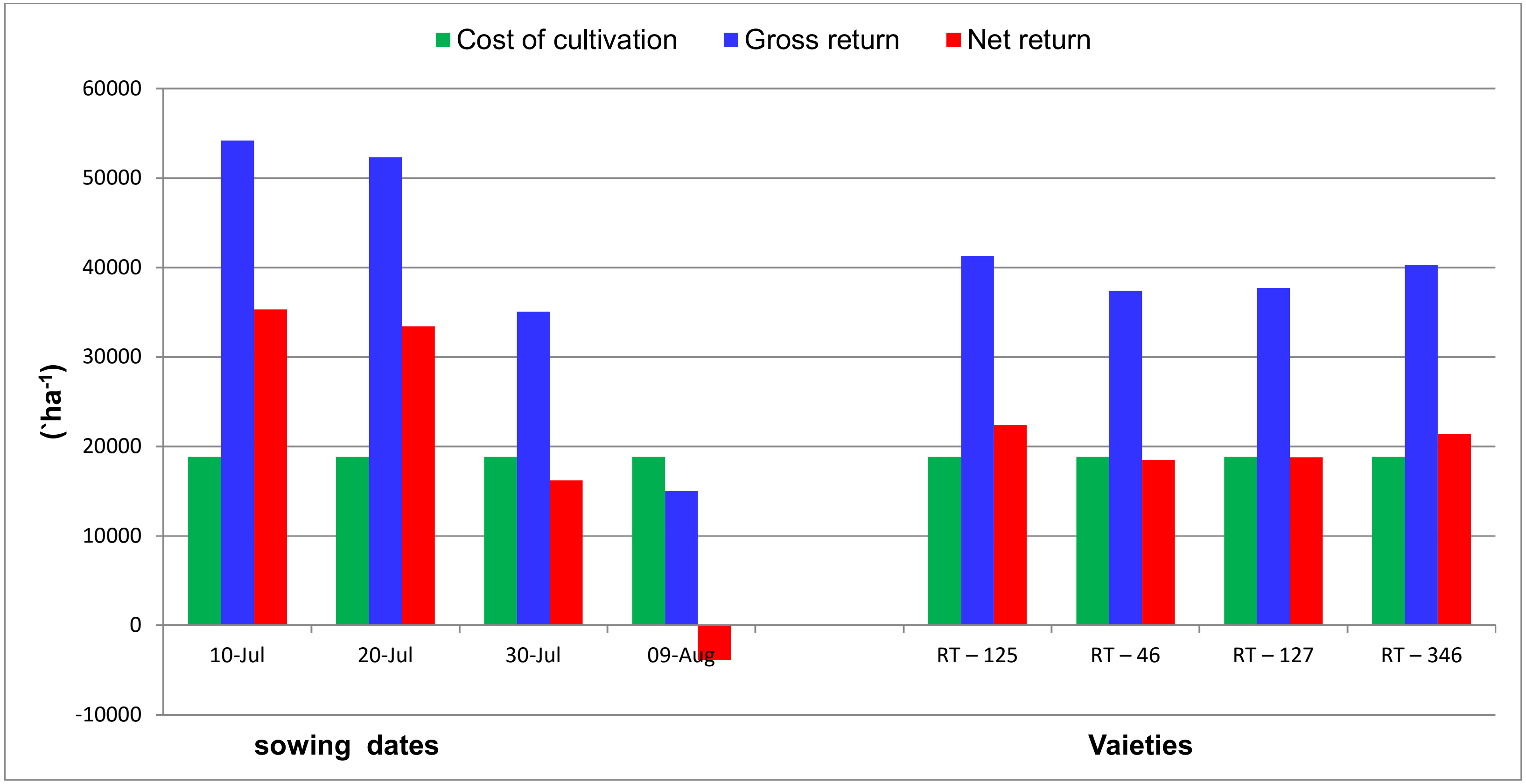


Fig. 4.8 Effect of sowing dates and varieties on gross return and net return

5. DISCUSSION

In the course of presenting the results of the experiment entitled experiment "**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan"** significant variations in the criteria used for evaluating the treatments were observed. In this chapter, it is endeavored to discuss the significant events or those assuming a definite pattern in respect of various parameters studied, so as to establish cause and effect relationship in the light of available evidence and literature.

5.1 Effect of sowing dates

5.1.1 Growth parameters

The data show that sowing date treatments significantly influenced plant height at 25 DAS and harvest. Dry matter accumulation at 25 DAS, 50 DAS and harvest, crop growth rate between 0 to 25 DAS, 25 to 50 DAS and 50 DAS to harvest, relative growth rate between 25 to 50 DAS, 50 to harvest, days to 50 per cent flowering, chlorophyll content at 50 DAS, numbers of branches plant^{-1} at harvest, days to maturity and Heat unit efficiency (Table 4.2 to 4.5). Sowing of sesame on 10 July resulted significantly improved in dry matter accumulation, crop growth rate, relative growth rate, number of branches and heat unit efficiency as compared to delayed sowing on 20 July to 09 August. This might be due to most congenial environment available throughout the crop period during this date of sowing. This is attributed to maximum period available to 10 July sown crop in comparison to 20 July, 30 July and 09 August crop for vegetative growth of crop. With delayed in sowing, significant reduction in growth attributes was observed. Similar results were found by (Nath *et al.,* 2003). The reduction in total dry matter accumulation and its allocation to various plant parts under delayed sowing could be attributed to unfavourable temperature and sunshine hours during crop growing season. The reduction in biomass production and its allocation to various plant parts under delayed sowing could have been caused due to sudden drop in temperature particularly during the grand growth period. The highest crop growth rate and relative growth rate during 0 to 25 DAS, 25 to 50 DAS and 50 to harvest, recorded when sesame sowing on 10 July (Table 4.4). It could be due to optimal temperature at every periodically growth stages as a consequence of stomatal conductance, which might have resulted in higher rate of cell division and cell elongation more accumulation of photosynthesis and their higher mobilization from various plants part. The results are in confirmation with the findings of (Chonder *et al*., 2015 and Meena *et al.,* 2015). The highest number of branches plant^{-1} influenced significantly by sowing times. Sesame crop sown on 10 July recorded higher number of branches plant^{-1} as compared to 20 July, 30 July and 09 August. It might be due to favourable environment available for sowing date 10 July. Similar results were found by (Abdel Rahman *et al*., 2003), (Mohamad *et al*., 2012), (Ogbonna and Umarshaba, 2012). The days to 50 percent flowering and days to maturity influenced significantly by different dates of sowing. Sowing date 10 July took maximum number of days to 50 per cent flowering and days to maturity as compared to other dates of sowing. Similar results were found by (Shegro *et al*., 2010). The heat unit efficiency influenced significantly by sowing time. Sowing on 10 July recorded higher heat unit efficiency as compared to 20 July, 30 July and 09 August. It is depends upon the temperature and total biomass produce. Similar results were found by (Meena *et al.,* 2015).

5.1.2 Yield attributes and yield

In the present investigation, yield attributing characters viz. number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, seed yield, Straw yield and biological yield were affected due to sowing time of sesame (Table 4.6 and 4.7). Distinct positive effect of dates of sowing was noticed on these yield attributing and yield. All these parameters attained higher values with timely sown crop and reduced by delaying sowing. In number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, seed yield. Straw yield and biological influenced significantly by the dates of sowing. The potentiality of these characters was restricted extent when the crop was sown late. The 10 July sown crop produce maximum number of capsules plant^{-1} that of minimum by 09 August. It might be attributed due to the fact that when the crop was sown late, there would have been high temperature in beginning but after (Sep.- Oct.) the temperature start decreasing and the plant do not get sufficient favourable environment to express their full potentiality. Such observations were also reported by (Patra, 2001 and Ali *et al.,* 2005). Number of seeds capsule^{-1} significantly influenced by sowing time and it gradually decreased as sowing was delayed. It is influenced by environment particularly that of temperature prevailed during the time of sowing and vegetative and reproductive stages. In 10 July sown crop the number of seeds capsule^{-1} was more which positively contributed to high yield. Low temperature and low rainfall during the later part of the reproductive stage of 09 August sowing caused early maturity of the crop resulting in development of less number of seeds capsule^{-1} which was small shrivelled and low weight. Such observations were also reported by (Ali *et al.* 2005) and (Alam Sarkar, 2007). Test weight influenced by environment particularly that of temperature prevailed during the time of reproductive stages. Test weight was significantly influenced by dates of sowing, it was highest in the crop sown on 10 July and decreased as sowing was delayed. This might be due to the fact that under later sown conditions the seeds were forced to mature early. Thus, the seeds obtained from 10 July sown crops were small and shrivelled and ultimately resulted in lower test weight. Such observations were also reported by (Thanki, 2004) and (Abdel Rahman *et al.,* 2007).

Seed, straw and biological yield of sesame influenced significantly by sowing times. Seed, straw and biological yield decreased significantly as sowing was delayed. Thus, might be due to cumulative effect of poor expression of vegetative growth and yield contributing characters *i.e.* number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight under late sown conditions accompanied with low relative humidity, low rainfall and high evapotranspiration which leads toward forced maturity of the crop and ultimately resulted in lower seed, straw and biological yield. Similar results have been also reported by (Churlwhan *et al.*, 2006), (Abdel Rahman *et al.*, 2007), (Alam Sarkar, 2007), (Ajalli *et al*., 2008), (Nafe *et al*., 2010), (Mohan Kumar *et al.*, 2011) and (Khajuria *et al.*, 2017).

5.1.3 Nutrients and quality parameters

Effect of dates of sowing on nitrogen and phosphorus content and their respective uptake by seed and protein content in seed varied significantly due to sowing time (Table 4.8 to 4.10). The highest nitrogen and phosphorus content in seed and protein content in seed recorded in late sown condition. Whereas, the highest amount of nitrogen and phosphorus uptake was recorded 10 July sown crop and lowest in the crop sown on 09 August (Table4.9). This might be due to that the high temperature during the crop period of 10 July sown crop induced more of an increase in nitrogen accumulation. Similar were found by (Kalita *et al.*, 2005) and (Singh *et al*., 2006).

The sowing time generated a large effect on the amount of total protein, probably driven by the different thermal conditions prevailing during the seed setting period. The high temperature during the crop period of 10 July sown crop induces more of an increase in nitrogen accumulation leading to higher protein content (Table 4.10). Similar results were found by Kafitiri and deckers (2001), Lewis *et al.* (2003) and Mshelia *et al.* (2014). The oil content and oil yield were influenced significantly by sowing times (Table 4.11). Sowing on 10 July crop gave higher oil content and oil yield as compared to delayed sowing. It might due to higher temperature during the 10 July sown crop period were leading to higher oil content and oil yield. Similar results were found by (Kafitiri and deckers, 2001), (sardana and kondhola, 2007), (Sardand, 2008) and (Mondal *et al.,* (2011).

5.1.4 Economics

The highest net return obtained in the crop sown on 10 July followed by the crop sown on 20 July, 30 July and 09 August, respectively (Table 4.12). It was due to the significantly higher seed and straw yield on 10 July sown crop than the crop sown on 20 July, 30 July and 09 August, which resulted in higher net return. Similar results have been reported earlier by (Ramchandra, P.B., 2011) and (Lakhran, 2015).

5.2 Effect of varieties

5.2.1 Growth parameters

The data show that different sesame varieties did not influenced significantly plant stand and plant height at 25 DAS and harvest, dry matter accumulation 25 DAS, 50 DAS and at harvest, chlorophyll content, number of branches, Days to 50 per cent flowering, days to maturity and heat unit efficiency. Relative growth rate was also significantly affected by varieties. Crop growth rate were influenced significantly by different verities of sesame. Variety RT-346 attained maximum crop growth rate during 0- 25 DAS, 25 to 50 DAS and 50 DAS to harvest. Similar results were found by (Chonder *et al.,* 2015). Relative growth rate were influenced significantly by different verities of sesame. Variety RT-127 attained maximum relative growth rate during 25 to 50 DAS and 50 DAS to harvest. It might be due to high rainfall and favourable environment condition between 25 to 50 DAS, 50 DAS to harvest.

5.2.2 Yield attributes and yield

In the present investigation, yield attributing characters viz. number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, Straw yield and biological yield were did not influenced significantly by different varieties of sesame. Number of capsules plant^{-1} and Number of seeds capsules^{-1} were recorded higher in variety RT- 125 as compared to variety RT-46, RT- 127 and RT- 346. Test weight was recorded higher in RT- 346 as compared to RT-125, RT- 46 and RT- 127.

Straw yield and harvest index influenced significantly by different varieties. Similar results were found by (Patra, 2001) and (Ali and Jan, 2014). Straw yield and biological yield were recorded higher in variety RT- 346 as compared to RT-125, RT- 46 and RT- 127. The seed yield is the sum total of different yield contributing factors controlled both genetically and environmentally. Since, sesame yield formation is a complex process and interaction governed by complimentary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organs). In this experiment, the seed yield was significantly influenced by different varieties and all varieties were noticed significant difference to each other. The highest seed yield was produced by Variety RT- 125 gave significantly, higher seed yield over RT-46, RT- 127 and RT- 346. High yield RT- 125 may be attributed to its higher biomass accumulation due higher number of leaves and its proper partitioning as evident from equally higher harvest index; and good yield attributes i.e. higher number of capsules plant^{-1}, higher number of seed capsule^{-1}. Variety RT-46 recorded low seed yield due to lower biomass accumulation as a result of less number leaves and its lower test weight. These findings are similar by (sharer *et al.,* 2002), (Sarala *et al.,* 2002), (Tripathi *et al.,* 2007), (Muhammad *et* al., 2012), (Ali and Jan 2014) and (Chonder *et al*., 2015). The harvest index controlled by the seed yield and biological yield. Biological yield is governed by the governed by complimentary interaction between source (photosynthesis and availability of assimilates) and sink component (storage organs). The highest harvest index was produced by Variety RT- 125 have significantly, higher harvest index over RT-46, RT- 127 and RT- 346. These findings are similar by (Hamza and Salam, 2015).

5.2.3 Nutrients and quality parameters

The varieties under study did not influenced significantly in their nitrogen and phosphorus content in seed, whereas nitrogen and phosphorus uptake by seed was differed significantly. Highest amount of nitrogen and phosphorus was taken up by RT-125 (Table 4.9) Nutrient uptake is depending on concentration of cellular level and seed yield. Hence, in spite of marginal variation in higher nutrient uptake could be due to increased seed yield. Similar results were found by Kumar and (Badiyala, 2001) and (Salunke *et al*., 2012). The protein content in seeds of varieties did not significant variation. RT- 127 (14.03 per cent) highest protein content than rest of the varieties, whereas RT- 346 recorded lowest protein content. The high protein content in RT- 127 might be due to its high nitrogen content and equally high nitrogen accumulation in seed. The varieties under study did not influenced significantly in their oil content in seed, whereas oil yield was differed significantly. Highest yield of oil given by variety RT- 125 as compared to RT- 127, RT- 46 and RT- 346. Oil yield is depending upon the oil content in seed and seed yield. The variety RT- 125 has higher oil content and seed yield. Similar results were found by (Patra and Mishra, 2000), (*Raja et al*., 2007), (Korhale, 2010), (Adak *et al.*, 2011) and (Salem and Emad M.M., 2016).

5.2.4 Economics

Varieties exhibited differences in their economics and the highest net return was obtained in RT- 125 followed by RT- 127, RT- 46 and RT- 346, respectively (Table 4.12). The lead of RT- 125 was due to the highest seed yield production in comparison to other varieties. These findings are similar to that of (Ramchandra, P. B., 2011), (Chonder *et* al., 2015) and (Meena, J. K., 2015).

6. SUMMARY AND CONCLUSION

The field experiment entitled “**Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan”** was conducted at Research Farm, College of Agriculture, S.K.R.A.U., Bikaner during *kharif* 2017. The results presented and discussed in the preceding chapters are summarized below.

6.1 Effect of Sowing Dates

1. Sowing of sesame on 10 July being statistically at par with sowing on 20 July, recorded significantly higher plant height at 25 DAS and at harvest as compare to sowing on 30 July and 09 August.
2. Sowing of sesame on 10 July, recorded significantly higher dry matter accumulation at 25 DAS, 50 DAS and harvest as compared to 20 July, 30 July and 09 August but statistically at par with 20 July at 50 DAS.
3. Sowing of sesame on 10 July, recorded significantly higher crop growth rate during 0 to 25 DAS, 25 to 50 DAS and 50 Das to harvest but statistically at par with sowing on 20 July during 25 to 50 and 50 DAS to harvest as compared to 20 July, 30 July and 09 August.
4. Sowing of sesame on 10 July, recorded significantly higher relative growth rate during 25 to 50 DAS, and 50 to harvest as compared to 20 July, 30 July and 09 August.
5. Sowing on 09 August recorded minimum days to take 50 per cent flowering as compared to 10 July, 20 July and 30 July.
6. Sowing of sesame on 10 July, recorded significantly higher number of branches plant^{-1} as compared to 20 July, 30 July and 09 August.
7. Sowing of sesame on 10 July, recorded significantly higher heat unit efficiency as compared to 20 July, 30 July and 09 August.

8. Sowing of sesame on 10 July being statistically at par with sowing on 20 July, produced higher number of capsules plant^{-1} and higher number of seeds capsule^{-1} but significantly as compare to sowing on 30 July and 09 August.
9. Sowing of sesame on 10 July, recorded significantly higher test weight as compare to sowing on 20 July, 30 July and 09 August.
10. Sowing of sesame on 10 July produced significantly higher seed, straw and biological yield and harvest index as compared to sowing on 20 July, 30 July and 09 August.
11. Crop sown on 09 August recorded the significantly higher N and P and protein content in seed as compared to sowing on 20 July, 30 July and 09 August but N content in seed statistically at par with 20 July.
13. Crop sown on 10 July recorded the significantly higher N and P uptake by seed as compared to sowing on 20 July, 30 July and 09 August.
14. Sowing of sesame on 10 July recorded higher oil content significantly as compare to sowing on 30 July and 09 August but being statistically at par with sowing on 20 July.
15. Sowing on 10 July recorded the significantly higher oil yield as compared to sowing on 20 July, 30 July and 09 August.
16. Sowing on 10 July recorded the significantly highest net return as compared to sowing on 20 July, 30 July and 09 August.

6.2 Effect of Varieties

1. Sesame variety RT- 125 recorded significantly maximum crop growth rate during 20 to 50 DAS over RT- 46 and RT- 127 but statistically at par with each other RT- 46 during25 to 50 DAS.
2. Sesame variety RT-127 being statistically at par with RT- 346 during 25 to 50 DAS recorded significantly maximum relative growth rate over RT- 46 and RT- 125 and RT- 346.
3. Variety RT- 125 recorded significantly higher seed yield and higher harvest over RT- 46 and RT- 127 and RT- 346.

4. Variety RT- 125 recorded significantly higher N and P uptake by seed over RT- 46 and RT- 127 and RT- 346.
6. Variety RT- 125 recorded significantly higher oil yield over RT- 46 and RT- 127 and RT- 346.
7. Varity RT- 125 has significantly highest net returns as compared to RT- 45, RT- 127 and RT- 346.

Conclusion

Keeping in view the objectives framed for undertaking study and the results obtained after experimental period, under mentioned conclusions may be drawn.

1. The date of sowing on 10 July recorded significantly higher seed and straw yield with net return of sesame.
2. The maximum seed, straw and biological yield and net return was recorded under variety RT- 125.
3. The variety RT- 125 produced significantly higher seed with maximum net returns (22403 ₹ ha^{-1}) as compared to varieties RT-46, RT- 127 and RT- 346.

Based on the finding of the present investigation, it is recommended that 10 to 20 July optimum time of sowing and sesame varieties RT- 125 should be sown, however, these results are only indicative and required further experimentation to arrive at some more consistent and final conclusion.

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Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan

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ABSTRACT

An experiment entitled "Evaluation of Sesame (*Sesamum indicum* L.) Varieties under Different Dates of Sowing in North – Western Rajasthan" was carried out at the Agronomy Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif* 2017 on loamy sand soil. The experiment comprising total 16 treatment combinations; four date of sowing (10 July, 20 July 30 July and 09 August) and four varieties (RT-125, RT-46, RT- 127 and RT- 346) in split plot design with three replications.

Results showed that sowing of sesame on 10 July gave significantly higher plant height, matter accumulation, crop growth rate, relative growth rate, number of branches plant^{-1}, days to 50 per cent flowering, days to maturity, number of capsules plant^{-1} number of seeds capsule^{-1}, seed (810 kg ha^{-1}), straw (2444 kg ha^{-1}), biological yield (3242 kg ha^{-1}), harvest index (25.12 per cent), nitrogen and phosphorus uptake by seed, oil content, oil yield, heat unit efficiency and net returns (35324 ₹ ha^{-1}) of the crop. However, nitrogen, phosphorus content and protein content in seed were significantly higher when sowing on 09 August.

Results further showed that RT- 125 gave significantly higher seed yield, harvest index, nitrogen and phosphorus uptake by seed, oil yield, heat unit efficiency and net returns (22403 ₹ ha^{-1}) as compared to varieties RT- 46, RT- 127 and RT- 346 Whereas, relative growth rate was significantly higher in verity RT- 127 and other growth and yield parameters are almost similar to each other.

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उत्तरी –पश्चिमी राजस्थान में तिल (*सिसेमम इण्डिकम* एल.) की किस्मों का विभिन्न बुवाई तिथियों के अन्तर्गत मूल्याकंन

श्री राकेश* डॉ. आर.सी. बैरवा. **

शोधार्थी मुख्य सलाहकार

अनुक्षेपण

खरीफ 2017, कृषि महाविद्यालय, स्वामी केशवानन्द राजस्थान कृषि विश्वविद्यालय, बीकानेर (राज.) के शस्य विज्ञान फार्म पर बलुई दोमट मृदा में "उत्तरी–पश्चिमी राजस्थान में तिल (*सिसेमम इण्डिकम* एल.) की किस्मों का विभिन्न बुवाई तिथियों के अन्तर्गत मूल्यांकन" पर एक शोध कार्य किया गया । प्रयोग में कुल 16 उपचारों; बुवाई की चार तिथियों (10 जुलाई, 20, जुलाई, 30 जुलाई और 09 अगस्त) एवं चार किस्मों (आर.टी. 125, आर.टी. 46, आर.टी. 127 और आर.टी. 346) का विभाजित भूखण्ड अभिकल्पना में तीन पुनरावृतियों के साथ परीक्षण किया गया।

परिणाम दर्शाते हैं कि तिल की बुवाई 10 जुलाई को करने पर पौधों की ऊँचाई, शुष्क संचयी पदार्थ, फसल वृद्धि दर, सापेक्ष वृद्धि दर, शाखाओं की संख्या प्रति पौधा, 50 प्रतिशत फूल आने के दिन, पकाव के दिन, प्रति पौधा संपुटों की संख्या, प्रति संपुट बीजों की संख्या, परीक्षण भार, दाने की उपज (810 किलोग्राम प्रति हैक्टेयर), चारे की उपज (2444 किलोग्राम प्रति हैक्टेयर), जैविक उपज (3243 किलोग्राम प्रति हैक्टेयर), कटाई सूचकांक (25.12 प्रतिशत,) बीज द्वारा नत्रजन और फॉस्फोरस उदग्रहण, तेल की मात्रा, तेल उपज, ऊष्मा इकाई दक्षता एवं शुद्ध लाभ (35324 रुपये प्रति हैक्टेयर) अन्य तिथियों की अपेक्षा सार्थक रूप से अधिक पाई गई। जबकि बीज में नत्रजन, फॉस्फोरस एवं प्रोटीन की मात्रा 09 अगस्त को बुवाई करने पर सार्थक रूप से अधिक पाई गई।

तिल की किस्म आर.टी. 125 में आर.टी. 46, आर.टी. 127, आर.टी. 346 किस्मों की तुलना में दाना उपज, कटाई सुचकांक, बीज द्वारा नत्रजन एवं फॉस्फोरस उदग्रहण तेल की उपज, ऊष्मा इकाई दक्षता एवं शुद्ध लाभ (22403 रुपये प्रति हैक्टेयर) सार्थक रूप से अधिक पाई गई। जबकि किस्म आर.टी. 127 में सापेक्ष वृद्धि दर सार्थक रूप से अधिक पाई गई। अन्य वृद्धि एवं उपज मापदण्ड सभी किस्मों लगभग समान पाये गये।

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Appendix-I

Analysis of variance (MSS) for plant stands (ha^{-1}) and plant height (cm) of sesame

Source of variation	d. f.	M.S.S.			
		Plant stand (Number of plants ha^{-1})		Plant height (cm)	
		20 DAS	At harvest	25 DAS	At harvest
Replication (R)	2	0.008958	0.001019	4.789201	187.93083
Sowing dates (D)	3	0.001627	0.000158	41.65777*	15706.726*
Error (a)	6	0.007109	0.002866	2.245006	114.18719
Varieties (V)	3	0.000902	0.001158	0.498468	27.773924
Sowing dates X Varieties(D X V)	9	0.012320	0.014417	7.247256	262.38722
Error (b)	24	0.006991	0.009779	4.706175	171.8522

*Significant at 5% level of significance

Appendix- II

Analysis of variance (MSS) for dry matter accumulation

Source of variation	d. f.	M.S.S.		
		Dry matter accumulation (g $plant^{-1}$)		
		25 DAS	50 DAS	At harvest
Replication (R)	2	0.005768	0.335326	0.203306
Sowing dates (D)	3	0.07486*	10.142440*	305.4329*
Error (a)	6	0.001987	0.175366	1.285592
Varieties (V)	3	0.000783	0.024938	0.252525
Sowing dates X Varieties(D X V)	9	0.044749	0.401350	15.24513
Error (b)	24	0.006914	0.483002	1.613057

*Significant at 5% level of significance

Appendix- III

Analysis of variance (MSS) for crop growth rate

Source of variation	d. f.	M.S.S.		
		Crop growth rate (g m^{-2} day^{-1})		
		0-25 DAS	25 -50 DAS	50-At harvest
Replication (R)	2	0.00005	-0.89184	-0.78506
Sowing dates (D)	3	0.22501*	215.4265*	357.0362*
Error (a)	6	0.00811	0.83099	81.55037
Varieties (V)	3	0.00102	201.0351	268.0281
Sowing dates X Varieties(D X V)	9	0.08921	-66.5244	-78.8866
Error (b)	24	0.01220	0.83742	2.808305

*Significant at 5% level of significance

Appendix- IV

Analysis of variance (MSS) for relative growth rate

Source of variation	d. f.	M.S.S.	
		Relative growth rate(mg g^{-1} day^{-1})	
		25 - 50AS	50 DAS-At harvest
Replication (R)	2	0.010463	0.000113
Sowing dates (D)	3	0.248830*	1.014539*
Error (a)	6	0.002656	0.001447
Varieties (V)	3	0.001857*	0.034537*
Sowing dates X Varieties(D X V)	9	0.009427	0.042788
Error (b)	24	0.008807	0.002937

*Significant at 5% level of significance

Appendix- V

Analysis of variance (MSS) for number of branches and chlorophyll content

Source of variation	d. f.	M.S.S.	
		Number of branches plant^{-1}	Chlorophyll content (mg g^{-1})
Replication (R)	2	0.403242	0.008678
Sowing dates (D)	3	4.353728*	0.003422
Error (a)	6	0.122895	0.023592
Varieties (V)	3	0.032339	0.000853
Sowing dates X Varieties(D X V)	9	0.185163	0.037861
Error (b)	24	0.300968	0.020698

*Significant at 5% level of significance

Appendix- VI

Analysis of variance (MSS) for Days to flowering, days to maturity and heat unit efficiency

Source of variation	d. f.	M.S.S.		
		Days to flowering	Days to maturity	Heat unit efficiency (kg ha-^{1} degree day^{-1})
Replication (R)	2	1.58333	4.7500	135.4674
Sowing dates (D)	3	78.02778*	60.6875*	305834.6*
Error (a)	6	6.86111	1.2500	4646.645
Varieties (V)	3	5.41667	0.1875	508.9222
Sowing dates X Varieties(D X V)	9	2.17593	1.3727	5369.514
Error (b)	24	7.23611	4.7500	3089.275

*Significant at 5% level of significance

Appendix- VII

Analysis of variance (MSS) for yield attributes of sesame

Source of variation	d. f.	M.S.S.		
		Yield attributes		
		No. of capsules plant^{-1}	No. of seeds capsule^{-1}	Test weight (gm)
Replication (R)	2	41.36	2.12	0.127815
Sowing dates (D)	3	975.77*	59.28*	0.211858*
Error (a)	6	23.38	10.43	0.026303
Varieties (V)	3	1.79	0.32	0.007924
Sowing dates X Varieties(D X V)	9	6.12	3.00	0.012545
Error (b)	24	12.86	2.89	0.067040

*Significant at 5% level of significance

Appendix- VIII

Analysis of variance (MSS) for yield and Harvest index of sesame

Source of variation	d. f.	M.S.S.			
		Yield (kg ha^{-1})			Harvest index (%)
		Seed	Straw	Biological	
Replication (R)	2	4270	13594	2676	20.33
Sowing dates (D)	3	919340*	5603638*	11013046*	126.78*
Error (a)	6	9880	93648	144404	2.88
Varieties (V)	3	11535*	5094	20036	8.37*
Sowing dates X Varieties(D X V)	9	10020	153659	168434	22.73
Error (b)	24	4358	110446	118315	11.99

*Significant at 5% level of significance

Appendix- IX

Analysis of variance (MSS) for nitrogen and phosphorus content in seed of sesame

Source of variation	d. f.	M.S.S.	
		Nitrogen content (%)	**Phosphorus content (%)**
		Seed	**Seed**
Replication (R)	2	0.062452	0.007777
Sowing dates (D)	3	0.277969*	0.004935*
Error (a)	6	0.083547	0.005719
Varieties (V)	3	0.008081	0.000819
Sowing dates X Varieties(D X V)	9	0.326968	0.006541
Error (b)	24	0.104506	0.005333

*Significant at 5% level of significance

Appendix- X

Analysis of variance (MSS) for nitrogen and phosphorus uptake by seed of sesame

Source of variation	d. f.	M.S.S.	
		Nitrogen uptake (kg ha^{-1})	**Phosphorus uptake (kg ha^{-1})**
		Seed	**Seed**
Replication (R)	2	1.46274	0.592792
Sowing dates (D)	3	374.37242*	20.53149*
Error (a)	6	14.07473	0.337556
Varieties (V)	3	4.58898*	0.202983*
Sowing dates X Varieties(D X V)	9	21.38273	0.620206
Error (b)	24	3.23523	0.292364

*Significant at 5% level of significance

Appendix- XI

Analysis of variance (MSS) for protein, oil content and Oil yield (kg ha^{-1}) of sesame

Source of variation	d. f.	M.S.S. Protein content in seed (%)	Oil content (%)	Oil yield (kg ha^{-1})
Replication (R)	2	**seed**	1.46274	0.592792
Sowing dates (D)	3	2.439535	374.37242*	20.53149*
Error (a)	6	10.85818*	14.07473	0.337556
Varieties (V)	3	3.263536	4.58898	0.202983
Sowing dates X Varieties(D X V)	9	0.315647	21.38273	0.620206
Error (b)	24	12.77217	3.23523	0.292364

*Significant at 5% level of significance

Appendix- XII

Analysis of variance (MSS) for net returns (₹ ha^{-1}) of sesame

Source of variation	d.f.	M.S.S. Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})
Replication (R)	2	208646937.6	208646937.6
Sowing dates (D)	3	3997048216*	3997048216*
Error (a)	6	63213301.02	63213301.02
Varieties (V)	3	44564486.95*	44564486.95*
Sowing dates X Varieties(D X V)	9	36966853.83	36966853.83
Error (b)	24	16678322.02	16678322.02

*Significant at 5% level of significance

Appendix- XIII

Comparative economics of various treatments combinations

S.NO.	Treatments	Total cost of cultivation (` ha^{-1})	Seed (kg ha^{-1})	Straw (kg ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})
1.	D_1V_1	18886	833	2243	55218	36332
2.	D_1V_2	18886	750	2760	50990	32104
3.	D_1V_3	18886	760	2333	51078	32192
4.	D_1V_4	18886	898	2440	59556	40670
5.	D_2V_1	18886	861	2690	57653	38767
6.	D_2V_2	18886	735	2133	48795	29909
7.	D_2V_3	18886	808	2435	54303	35417
8.	D_2V_4	18886	714	2289	48480	29594
9.	D_3V_1	18886	561	1563	37469	18583
10.	D_3V_2	18886	541	1587	35898	17012
11.	D_3V_3	18886	422	1807	29458	10572
12.	D_3V_4	18886	550	1980	37510	18624
13.	D_4V_1	18886	211	977	14817	-4069
14.	D_4V_2	18886	192	1123	13872	-5014
15.	D_4V_3	18886	231	907	15816	-3070
16.	D_4V_4	18886	226	925	15532	-3354

Sales price of sesame seed = 53` kg^{-1}
Sales price of sesame seed = 2` kg^{-1}