RESPONSE OF SESAME VARIETIES TO DIFFERENT SOWING WINDOWS

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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MASTER OF SCIENCE
IN
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(AGRONOMY)

By
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Enrolment Number – OO-1554 **2022**

DECLARATION OF STUDENT

I hereby, declare that the experimental work and its interpretation of the Thesis entitled, **“RESPONSE OF SESAME VARIETIES TO DIFFERENT SOWING WINDOWS”** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Nagpur **(Furange Poonam Purushottam)**

Date: 22 / 11 / 2022 Enrolment No. OO-1554

CERTIFICATE

This is to certify that thesis entitled **“RESPONSE OF SESAME VARIETIES TO DIFFERENT SOWING WINDOWS”** submitted in partial fulfilment of the requirement for the degree of **“Master of Science in Agriculture (Agronomy)”** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Furange Poonam Purushottam** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Nagpur
Date: 22 / 11 / 2022

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THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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(C) Abbreviations

%	:	Per cent
/	:	Per
^{0}C	:	Degree Celsius
^{0}D	:	Degree days
CD	:	Critical difference
Cm	:	Centimeter
DAS	:	Days After Sowing
dm^2	:	Decimeter square
et al.	:	Et alia (and his associates)
Fig.	:	Figure
G	:	Gram
GM	:	General mean
Ha		Hectare
HU	:	Heliothermal unit
i.e.	:	That is
Kg	:	Kilogram
M	:	Meter
Mg	:	Milligram
Mm	:	Millimeter
MW	:	Meteorological Week
NS	:	Non-significant
No.	:	Number
Q	:	Quintal

RF	:	Rainfall
RH	:	Relative humidity
SE (m) ±	:	Standard error of mean
Sig.	:	Significant
T max.	:	Maximum temperature
T min.	:	Minimum temperature
viz.	:	Namely

(D) THESIS ABSTRACT

a)	Title of the thesis	:	**"RESPONSE OF SESAME VARIETIES TO DIFFERENT SOWING WINDOWS"**
b)	Full name of student	:	**Poonam Purushottam Furange**
c)	Name and address of Major Advisor	:	**Shri. D. J. Jiotode** Assistant professor of Agrometeorology, College of Agriculture, Nagpur
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ABSTRACT

The present investigation entitled **"RESPONSE OF SESAME VARIETIES TO DIFFERENT SOWING WINDOWS"** was carried out at Agronomy farm, College of Agriculture, Nagpur during *kharif* season of 2021-2022 to identify suitable variety and influence of sowing dates on growth and yield of sesame.

The field experiment was conducted with sesame varieties AKT-64, NT-11 and Local on field No. 10 of Agronomy farm, College of Agriculture, Nagpur. The experiment was laid out in Split Plot Design with twelve treatment combinations and three replications consisting of four levels of Meteorological weeks i.e. 26^{th} MW, 27^{th} MW, 28^{th} MW and 29^{th} MW and three varieties *i.e.* AKT-64, NT-11 and Local.

Salient conclusions arose from present investigation under growth contributing characters *viz*., plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} were significantly highest when sesame was sown during 27^{th} MW. Sowing during 29^{th} MW recorded minimum number of plant height, number of branches plant^{-1} and dry matter accumulation. Among different varieties V_1 (AKT-64) was significantly highest in growth performance.

Variety AKT-64 was found significantly superior in yield contributing characters such as total number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield plant^{-1}, straw yield plant^{-1}, test weight, total seed yield, straw yield, biological yield and harvest index were highest under sowing taken on 27^{th} MW.

In case of weather parameters, temperature requirement was highest when crop was sown on 27^{th} MW than rest of the sowing dates. Temperature requirement was recorded highest in variety AKT-64 when crop was sown in 27^{th} MW than rest of the sowing dates. Sesame varieties were not influenced due to relative humidity.

As per agrometeorological analysis, sowing of sesame crop on 27^{th} MW was found suitable while variety AKT-64 performed better than NT-11 and Local.

Chapter I

INTRODUCTION

1.1 Background Information

Oilseeds are very important component of tropical agriculture, as they provide easily available highly nutritious human food and animal feed. India has attained self sufficiency in cereals, but there is deficit in the oilseed production. Oilseeds occupy a significant place in Indian economy and serve as a raw material for more than 88% of country's vegetable oil. Oilseeds are the second largest agricultural commodity in India, sharing 15.07% of gross cropped area accounting for nearly 5% of the national gross product and 10% of the value of all agricultural products. India ranks first in area (45%), production (32%) and export (40%) of sesame in the world. The total area of sesame in India during 2020-21 was 17.22 lakh hectare with total production of 8.16 lakh tonnes and productivity was 474 kg ha^{-1} (Anonymous, 2021[a]).

Sesame (*Sesamum indicum* L.) belongs to family Pedaliaceae and the genus Sesamum. Sesame is one of the oldest cultivated oil-rich plants in the world (Janick and Whipkey, 2002; Langham *et al.* 2006) and cultivation dates back to 3050-3,500 B.C (Bedigian and Harjan, 1986). It is a non-leguminous annual flowering green plant cultivated primarily for its small edible seeds rich in oil and proteins of about 50 per cent and 25 per cent respectively, It is the queen of vegetable oils (Weiss, 1983; Langham *et al.* 2006).

In Maharashtra, the total area of sesame during 2021 was 0.28 lakh hectare with total production was 0.06 tonnes hectare and productivity was 227 kg ha^{-1} (Anonymous, 2021[b]). The important districts growing this crop in Maharashtra are Jalgaon, Nashik, Dhule, Pune and Solapur.

In India, sesame seeds are used for oil extraction (78%), edible purpose (20%) and seed purpose (2%). Out of that 70% sesame seeds are used for edible purpose as salad and cooking oil and remaining 30% for toilet soap and manufacture of maragarine (Rathore, 2005). Sesame is also known as benniseed, gingelly, sesame, sisim, til and hawari. The sesame seeds are rich source of edible oil, food, nutrition health care and biomedicine. It's oil content generally varies from 48 to 52 per cent and contains 6355 k cal kg^{-1} energy in seeds (Kumar and Goel, 1994). The seeds are also rich source of proteins (20-28%), and phosphorus (Dinosa and Gupta, 1993). It is also used as a component for the manufacture of soap and paints. Out to synergistic effect, it is used in the preparation of tonic for the hair. They enrich the blood and are useful in the snake bites, bleeding piles etc. Sesamum oil is useful for dry cough, asthma disease of lungs, burning sensation, diseases of the ear and eyes. Recently, omega-6 fatty acid desaturase also got from sesamum which is helpful for heart patients (Jin *et al.,* 2001). Sesame seeds are called as "The seeds of immortality" with the growing health consciousness and it has recently emerged valuable crop.

1.2 Importance and need of study

India is the largest oilseed growing country with 20% of world's Oilseed area, but ranks third in oilseed production due to lower productivity. Continued expansion in population has caused demand. For edible oils to rise above what the domestic output is able to meet. However, the oilseed scenario in the country has undergone a drastic change in the recent years. Whereas, the export of oilseed extracts have registered a quantum jump, placing the oilseed sector in a respectable position in Indian foreign exchange economy.

Sesame is an important edible oilseed crop in India. Sesame seeds are unusually high in oil, around 50% of the seed weight. Sesame is a fairly high value food crop. It is digestive and rich source of quality oil. Sesame is also rich source of vitamin E, A and B Complex and minerals such as Ca, P, Fe, Mg, Cu, Zn and K.

Nearly 75% of sesame seed produced in India is used for oil extraction, 25% for planting purpose and rest in confectioneries and religious Hindu ceremonies.

Time of sowing has an important influence on growth and yield of the crop. Sowing time plays an important role in crop production and remains to be the prominent factor in deciding seed as well as oil yield. Recommended sowing time is important non-monetary input and if managed properly, helps to enhance seed yield.

Kharif sesame sown at the most recommended time can't express its full yield potential in real sense. Recommended date of sowing of *kharif* sesame fall between last week of June to first week of July. But, under the climate change scenario, it is revealed from the past years data that the onset of monsoon is being delayed. This is resulting in to delayed withdrawal of the monsoon. Under such situation, the conventional sowing time of *kharif* sesame needs to be revalidated. There is a great scope for increasing the yield of sesame crop substantially by resorting to recommended sowing time which is a "non-cash" input.

Variety plays an important role on sesame yield and quality. Variations in seed yield due to varietal potential have already been reported (Raja *et al.* 2007). The seed yield of sesame crop is significantly affected by varieties or cultivars. Besides, variety, temperature affected the variation in seed yield by 39% and 69%, respectively. The seventeen genotypes of sesame evaluated by Awasthi and Thakur (2010) and they found wide variation in yield quality parameters of sesame.

Production potentiality of sesame can be fully exploited with suitable agronomic practices and genotypes as it provides optimum growing conditions such as temperature, light, humidity and rainfall. Among the different practices to obtain higher crop yield with suitable agro technique such as optimum time of sowing and selection of high yielding varieties under varying climatic conditions are the major applied research thrust.

1.3 Objectives of the study

With this background, to identify suitable variety and influencing sowing date on yield of sesame, the present investigation has been under taken with the following objectives.

1. To quantify the influence of weather parameters on the growth and yield of sesame varieties.
2. To find out suitable sowing window.
3. To work out the economics.

1.4 Hypothesis

To study the effect of sowing windows and climate change on sesame varieties, number of experiment was conducted.

Among the different dates of sowing sesame may play significant role in improvement of growth and yield of sesame to gather information regarding the varietal performance with different sowing dates in relation to weather parameters.

At Agronomy farm, College of Agriculture, Nagpur sowing during 2^{nd} to 8^{th} July proved superior in all growth characters and yield contributing characters *viz.,* plant height, number of capsule plant^{-1}, seed yield plant^{-1}, straw yield plant^{-1}, seed yield q ha^{-1}, straw yield q ha^{-1} etc. Among varieties, AKT-64 recorded the higher growth and yield contributing characters which resulted in significantly superior seed yield over the variety Western-11 (Jiotode *et al.* 2015).

In view of this, it was felt necessary to assess response of sesame varieties to different sowing windows under climate change scenario.

1.5 Scope and limitations

The sowing season of crop varies considerably from one part of a country to another owing to difference in climate, soil, variety grown and also the basis of irrigation i.e. whether the crop is raised as rainfed or under irrigated condition. It is mostly cultivated under rainfed condition on marginal or sub marginal soils. Time of sowing and the age of crop are important factor that materially influenced the yield and quality of the produce.

Now a day, attention also paid on global warming and due to global warming, climatic changes are often observed in India. That's why growth, yield, and oil per centage in sesame is greatly affected. To overcome this problem, there is necessity to study the response of the different varieties of sesame to different sowing time.

Research has however, been both limited and unevenly distributed geographically. Very little information on sowing time of sesame is available. There is a great scope for increasing the yield of sesame available substantially by resorting to optimum sowing time as a "non cash" input. It is essential to find out the suitable time of sowing to a particular variety of sesame.

Chapter II

REVIEW OF LITERATURE

It is always necessary to study the work done on the various aspects related to research problems by different research workers. To encompass the past research work, it becomes indispensable to take the review of literature that could be a proper base of the problem. It also helps in the interpretation of the problem. In this chapter an attempt is made to review the past research studies which has direct or indirect bearing on objectives of the present investigation on “Response of sesame varieties to different sowing windows”.

2.1 Effect of sowing dates

Sharma *et al.* (1998) conducted a field experiment during rainy season of 1994-95 and 1995-96 at Powarkheda (Madhya Pradesh). Sesame cv. TKG- 21 was sown in early and late July, mid August and early September. Sesame yield was decreases with delay in sowing in 1994-95. Net monetary returns and B:C ratio were greatest with sowing in July than at later sowing dates.

Jain *et al.* (1999) conducted a field trial during rainfed condition. The results showed that, sesame sown at optimum time recorded the highest seed yield, which was comparable with that of the crop sown 10 days after the optimum time of sowing.

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 19th February. The number of capsules on main stem was reduced by 70.51 and 34.98 per cent when crop was sown on 21 March and 28th April, respectively.

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

Bahale *et al.* (2001) conducted field trial during 1995 to 1998 to determine the appropriate sowing time, suitable method of layout and management of excess water in vertisols to sustain and maximize the productivity of rainfed sesame in Northern Maharashtra and showed that optimum sowing date (OST) *i.e*. 26th MW produced significantly higher seed yield and gave significantly more gross monetary returns with the highest benefit: cost ratio (4.52) than the rest of the delayed sowing times.

Muthusankaranarayanan *et al.* (2001) studied the influence of various dates of sowing and nitrogen management for irrigated sesame at the Agricultural College and Research Institute farm (TNAU), Killikulam during 1996, 1997 and 1998. The results of the study revealed that number of capsules was more with 3rd March (84.79) sown crop whereas, 16th February crop recorded considerable capsule number (73.10). Sowing from 16th February to March was the ideal time for summer irrigated sesame.

Badran (2002) conducted an experiment in Alexandria (Egypt) during summer season of 2000 and 2001 to study the effect of sowing dates 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 growth, seed 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 bears 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 seed per cent at upper and middle part of the capsule setting and the seed yield was similar to those sown on 8 June.

Radha Kumari *et al.* (2004) conducted a field experiment on sesame to study the effect of four dates of sowing (15th September, 1st October, 15th October and 1st November) during *rabi* 1999-2000 at S. V. Agriculture College Tirupati. The highest seed yield of 2.02 q ha^{-1} was obtained with 1st October sowing and decreased gradually thereafter.

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 of 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, they concluded that sesame can be grown in second week of July under agro- climatic conditions of Faisalabad.

Abdel Rahman *et al.* (2007) conducted an experiment during *kharif* 2002-2003 at the Experimental Farm, Faculty of Agriculture, Nile Valley University, Darmali (Northern Sudan). The objective of the investigation was to evaluate some promising sesame genotypes under different sowing dates (mid June, early July and mid July). Results showed that, sowing dates significantly affected number of plant m^{-2}, number of branches plant^{-1}, number of capsules plant $^{-1}$, 1000 seed weight and seed yield. The highest seed yield was recorded for early July sowing by Shuhak genotype.

Awasthi *et al*. (2007) conducted a field experiment during winter (*rabi*) 2001-2002 and 2003-2004 at Kanpur to evaluate the effect of sowing dates (15th and 30th October) of Indian mustard and found that, mustard showed the better performance when sown on 15th October.

Olowe (2007) stated that the sowing date significantly influenced number of days to 50 per cent 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 recorded 50 per cent 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).

Sarkar *et al.* (2007) carried out experiment at Agronomy field, Bangladesh Agricultural University during the period from February to June 1999, to study 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 highest from the crop sown on 26th February. The highest seed yield (251.30 kg ha^{-1}) was obtained in 26 February sown crop and there after reduced with delay in sowing.

Chakraborthy *et al.* (2010) conducted an experiment on dates of sowing (22nd February, 7th March and 22th March) and varieties (BT 894-3, Rama and BT-893-1) in three successive years (2004, 2005 and 2006) at BCKV, West Bengal to find out temperature and humidity profile within sesame canopy and their impact on various growth processes. Results revealed that, different dates of sowing exposed the crop to different range of temperature and RH (above and below the crop). From polymeric chain reaction (PCR) analysis, it is evident that temperature and RH on all data points significantly affected the biometric parameters. This crop could not be sown after 7th March under West Bengal condition, both the flowering and capsules setting would be adversely affected by higher temperature below the sesame canopy.

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 to exotic) of sesame crop were planted in January, May and September. The result revealed that, May sowing date was favoured for yield and yield components, while January and September sowing were resulted in reduction in yield.

Gade (2012) conducted a field experiment on effect of weather parameters on *kharif* sesame varieties under different sowing times at college of Agriculture, Pune during *kharif* season, 2011. The experiment was laid out in Factorial Randomized Block Design with three replications and fourty eight treatment combinations comprising of four varieties *viz*., Phule Til-1, AKT-101, JLT-7 and Padma and four sowing times *viz*., 26^{th}, 27^{th}, 28^{th} and 29^{th} MW. The result showed that, sowing of *kharif* sesame during 27^{th} MW improved all the growth component *viz*., plant height, no. of branches, plant^{-1} dry matter plant^{-1} and yield component *viz*., no. of capsules plant^{-1}, weight of seed plant^{-1}(g) and test weight (g). The highest seed and straw yield and harvest index were recorded when sesame sown during 27^{th} MW.

Ogbonna and Umar-Shaba (2012) conducted a two years study at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka to determine the effect of time of planting on growth and yield of sesame. The study determined the optimum time of sowing of sesame in the derived Savanna agro ecology of South Eastern Nigeria and identified high yielding sesame cultivar for the zone. Three sowing date (22^{nd} July, 22^{nd} August and 22^{nd} September) were tested in 2009 while in 2010, the planting dates were 22^{nd} June, 22^{nd} July and 22^{nd} August. Four sesame accessions (Zuru, NCRI-BEN 01M. 43-9-1 and NCRI-BEN 03L) were also evaluated in both years. Based on the results, time of sowing headed significant effect on growth and yield of sesame. Plant height, number of leaves, stem girth and number of branches plant^{-1} decreased with delay in time of sowing. Early sowing in the season significantly increased seed for all accessions. Seed yield decreased by 42 per cent and 91 per cent when sowing delayed from July to August and September, respectively in 2009 season. In 2010 season, seed yield decreased by 16 per cent and 32 per cent as sowing was delayed from June to July and August, respectively. Among the climatic factor rainfall appeared to contribute more to change in performance across sowing dates.

Rammohan and Sivagamy (2012) conducted a field experiment during summer season of 2006 to fix optimum time of sowing and spacing for realizing higher seed yield in sesame. Consisting two sowing dates i.e. second fortnight of February and first fortnight of March and revealed that, performance of sesame variety KS-95010 was superior when sown early during the second fortnight of February under irrigated condition in the Cauvery delta zone.

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

Bhardwaj *et al.* (2014) conducted the field experiment on planting date of sesame during 2011-2012 using two row spacings (37.5 and 75 cm). The results concluded that, the earlier planting dates using 37.5 and 75 cm space between row desirable for sesame production in Virginia and mean seed yield was 1282 kg ha^{-1}. Highest seed yield was obtained using closer row spacings and early plantings.

Rajendra Kumar and Ramesh (2014) conducted a field experiment during 2009-2010, 2010-2011 and 2011-2012 to established optimum sowing time of sesame and to enhance the productivity of sesame in the North-Coastal Zone and found that the crops sown in the 4th week of April significantly higher yield (430 kg ha^{-1}) followed by 2nd week of May sown crop (297 kg ha^{-1}). In *rabi* crop sown during 1st week of December recorded significantly highest yield of 570 kg ha^{-1} followed by 3rd week of December (487 Kg ha^{-1}). Sowing in the month of November or January should significant reduction in the yield. The normal sowing time for sesame in 2nd week of May to 3rd week of May in *kharif* and December 15th to January 15th in *rabi* was rcommended.

Chongdar *et al.* (2015) carried out a field experiment on the effect of dates of sowing having 10th and 20th February, 2nd, 12th and 22nd March and improved cultivars on growth and yield of summer sesame in North Bengal with three cultivars of sesame (Rama, Savitri and Tillotama). Among the varieties, Rama recorded higher plant height, dry matter accumulation, leaf area index and crop growth rate as compared to Savitri and Tillotama and sowing of sesame within 2nd March to 12th March is the optimum sowing dates of sesame to have optimum seed yield as compared to other sowing dates.

Jiotode *et al*. (2015) conducted a field experiment on sesame varieties under different sowing dates of sowing during 2013-14 at Agronomy farm, College of Agriculture, Nagpur. The component was laid out in Split plot design with five sowing dates *viz.,* 26th MW, 27th MW, 28th MW, 29th MW, and 30th MW and two varieties and reported that, sowing dates significantly influenced the different growth characters *viz*., plant height, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$. All the above growth characteristics were significantly higher when crop sown during 27th MW during all growth stages. Highest seed yield of 9.52 q ha^{-1} was recorded when sown in 27th MW as compared to sowing of sesame in rest of the MW.

Monpara and Vaghasia (2016) carried out the field experiment with three sowing dates (1st and 15th February and 1st March) and three row spacings for three years. The results showed that the sowing of sesame on 15th February at spacing of 30x10 cm recorded highest yield (1433 kg ha^{-1}), branches $plant^{-1}$ (2.03) and 1000 seed weight (3.06). It is recommended for sustainable cultivation in semi-arid environments with high economic benefit.

Ahmed *et al.* (2017) conducted a field experiment with four treatments of sowing dates corresponding to 1st Nov, 15th Nov, 1st Dec and 15th Dec and two diverse sesame cultivars "Promo", Um shagara. The main objective of this study was to investigate the effects of sowing dates on morpho-phenological traits and seed yield in two sesame cultivars. The results revealed that Um shagara possessing higher stem diameter, larger leaf area, higher number of fruiting branches and capsules per plant as well as seed yield as compared with Promo. Sowing dates significantly influenced the different morphological attributes in this study *viz*, plant height, stem diameter and leaf area. Most of these characters were significantly higher when sesame sown during 15th Nov but the highest leaf area was achieved in last sowing date. Among the varying dates of sowing 15th Nov and 1st Dec significantly recorded higher number of fruiting branches and capsules plant^{-1} as well as seed yield as compared with first and last sowing dates.

Muneshwar *et al.* (2019) conducted a field experiment was at Instructional farm, Department of Agronomy, COA, Parbhani during *kharif* season of 2018 to find out the effect of sowing dates (D1-15th Jun, D2-30th Jun, D3-15th July and D4-30th July) and three fertilizer levels with twelve treatments combinations. Amongst sowing dates, crop sown on 15th June recorded significantly higher growth attributes, seed yield (435 kg ha^{-1}), straw yield (1541 kg ha^{-1}) and biological yield (1975 kg ha^{-1}). Result concluded that, sowing of sesame on 15th June and 30th July was found beneficial as compared to other sowing dates.

Sawant *et al.* (2019) carried out a field experiment at Agricultural Meteorology Department farm, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during *kharif* season 2016. The field experiment was laid out in the Split spot design with three replication and four treatment combination of sowing dates *viz*., D1 (27 MW), D2 (28 MW), D3 (29 MW) and D4 (30 MW) as main plot and four genotypes Phule til-1, Gujarat-2, JLT-408 and JLT-7 as sub-plot treatment. Among the Sowing dates 28th MW produced significantly highest seed yield (226.55 kg ha^{-1}) than rest of sowing dates, whereas significantly the lowest seed yield was observed under 30th MW.

Raut *et al*. (2020) conducted an experiment entitled "Studies on relationship between crop growth, yield and physical environment within the crop canopy of Sesame (*Sesamum indicum L*.) under different weather conditions" at Department of Agronomy, College of Agriculture, Parbhani during *kharif* season 2017. An experiment was conducted in Randomize Block Design with six replications with four sowing dates in *kharif* season i.e. D1 (23rd MW), D2 (25th MW), D3 (27th MW) and D4 (29th MW), and one variety AKT-64. The results revealed that all the biometric observations were significantly highest in D2 (25th MW) followed by D1 (23rd MW). Sowing at D2 (25th MW) was found superior over the rest of treatments with production of highest seed yield (440.8 kg ha^{-1}) followed by D1 (23th MW) (386.3 kg ha^{-1}), D3 (27th MW) (317.8 kg ha^{-1}) and lowest seed yield was observed in D4 (29th MW) (237.2 kg ha^{-1}).

Abdul Qader and Ali (2021) conducted an experiment to investigate the effect of four different formula of fertilizers (NPK; NPK + Magnesium and Micro element (Zn, Fe) Magnesium and Micro element) under three sowing dates. Results showed that rapid increase of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000 seed weight (g), biological yield, seed and straw yield (t ha^{-1}) when treated with fertilizers.

Adhikary *et al.* (2021) conducted a field experiment to test the effect of four sowing dates (15th Feb, 1st March, 15th March and 1st April) on phenology and thermal indices of three varieties (Tillotama, Rama and Savitri) of sesame (*Sesamum indicum* L.) in split-plot design with 3 replications at Bidhan Chandra Krishi Vishvidyalay, Jaguli, Nadia, West Bengal during pre-*kharif* (summer) season of 2017. The duration of 15th Feb sown sesame crop was 100.2 days which was reduced by 91.1 days (1 March), 85.3 days (15 March) and 75.4 days (1 April) for delay in sowing in the investigation.

2.2 Effect of sowing varieties

Anonymous, 1997 found that the AKT-101 variety of sesame produced higher yield (941 kg ha^{-1}) over L-38 (741 kg ha^{-1}) with higher monetary return of Rs. 14990 ha and B:C ratio of 4.9.

Kadam (2001) studied the performance of two cultivars L-38 and AKT-101. AKT-101 was found to be best in respect of growth parameters, yield contributing characters, utilization of applied fertilizers, oil content and yield.

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 two sowing dates (25^{th} June and 15^{th} July) during 1996-1998 in Orissa. It was found that, a cultivar B-67 was tallest while OTM-11 and OTM-10 were the shortest among cultivars. Higher no. of capsule $plant^{-1}$ was obtained with the 25^{th} June sowing compared to the 15^{th} July sowing. Kalika produced the highest seed and oil yield followed by Kanak and B-67.

Roy *et al*. (2009) conducted a field experiment to evaluate the yield performance of sesame (*Sesamum indicum* L.) varieties at varying level of row spacing during *kharif* season of 2007 using the varieties T6, Batiaghata local Til and BINA Til. The result revealed that, the highest yield was produced by the variety BINA Til, while the lowest yield was produced by the variety Batiaghat local Til.

Korhale (2010) conducted an experiment on varietal performance of sesame with cultivars Phule Til-1 and AKT-101. He observed that, AKT-101 showed better growth and yield attributing characters with oil content over Phule Til-1 variety.

Pham *et al*. (2010) was carried out a field experiment at Vietnam. Fifteen agronomic traits were analysed to select the best varieties for use as potential breeding sources. Based an average, the order of the varieties from low to high in seed yield ranked as follows Tanzanian sesame < E1 Salvadoran sesame < Kenyan sesame < Indian sesame < Vietnamese sese < Cambodian sesame. Several of the Cambodian and Vietnamese varieties were identified as high yielding and potential sources to be included in future breeding activities.

Gade (2012) conducted a field experiment on effect of weather parameters of *kharif* sesame varieties under different sowing times at College of Agriculture, Pune during *kharif* season, 2011. The experiment was laid out in Factorial Randomized Block design with three replications and fourty eight treatment combinations comprising of four varieties *viz*., Phule Til-1, AKT-101, JLT-7 and Padma and four sowing times *viz*., 26^{th}, 27^{th}, 28^{th} and 29^{th} MW. Among the four different varieties of sesame, AKT-101 recorded significantly higher growth parameters *viz*., plant height, no of branches $plant^{-1}$, dry matter accumulation $plant^{-1}$ and yield attributing characters. The variety AKT-101 was found significantly superior over JLT-7.

Patil (2012) conducted an experiment on response of sesame with cultivars Phule *viz.,* Til-1, AKT-101, JLT-7 and Padma under summer condition. He observed that, AKT-101 showed better growth and yield attributing characters.

Ali and Jan (2014) carried out the experiment on sowing dates and nitrogen level effect on yield and yield attributes of sesame cultivars. The results concluded that, 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%) as compared to cultivar local white.

Bharthi *et al.* (2014) noted the genotypes *viz*., RT 384, DS 18-46, VS 15-014. RT 385, LT 15-26, LT 15-28, SVT 333, which was recorded significantly more number of capsules $plant^{-1}$ compared to the national check TKG 22 (30) and GT 10 (25).

Katang and Buba (2014) conducted at Kano and Dutse, in the savanna ecological zone of Nigeria during 2009 rainy season the experiment to determine the effect of sowing method, seed rate and variety on the growth of sesame (*Sesamum indicum* L.) The treatments evaluated consist of three sowing methods (broadcasting, dibbling and drilling), four seed rate (2.5, 5.0, 7.5 and 10 Kg) and two varieties (Ex-Sudan and E8). Split- Split plot design was used such that variety was allocated to the main plot, sowing method to the sub-plot and seed rate to the sub-sub plot. The treatments were replicated thrice. Result showed that, plant height and number of leaves plant^{-1} were significantly affected by variety and seed rate. The results established that, Ex-Sudan attained 50% flowering and maturity earlier than variety E8 at both sites.

Bodhale *et al.* (2015) reported that, the highest seed yield (kg ha^{-1}) was recorded by the genotypes JLS-116, JLS-506 3. JLS-613-1-1 and JLT-7, JLSG-05-11 due to higher rate of photosynthesis, transpiration rate, stomatal conductance, water use efficiency, CO_2 concentration and water vapour at atmospheric and intercellular partial pressure, photosynthetically active radiations, yield contributing characters *viz*., number of capsules plant^{-1}, seed yield plant^{-1} and seed yield (kg) plot^{-1} and harvest index (%). The oil per cent, carbohydrate, protein, oleic acid, linoleic acid and linolenic acid content were higher in the genotype KMK-28, JLS-608-2-1, JLS 301-24, SI-2334-2, JL-Sel-07-11 and JLS-301-24. There were significant differences in the oil content of the genotypes ranging from 41.33 to 59.57 per cent. The genotypes JLT-7, JLS-506-3, JLS-613-1-1, JLSG 05-11 and JLS-116 may be utilized for the yield heterosis, whereas the genotypes KMK-28, JLS-608-2-1, JLS-301-24, SI- 2334-2, JL-Sel-07-11 and JLS-301-24 for improving oil per cent, carbohydrate, protein, oleic acid, linoleic acid and linolenic acid content in further breeding programme.

Jiotode *et al.* (2015) conducted the experiment at agronomy field of College of Agriculture, Nagpur during 2013-14. The component was laid out in split plot design with five sowing dates and two varieties replicated thrice. In respect of growth attributing characters, variety AKT-64 attained higher height (116.27 cm) than Western-11 (115.27 cm). AKT-64 possessing higher number of branches plant^{-1} (7.66) and higher dry matter accumulation plant^{-1} (42.80 g) as compared to variety Western-11. Significantly higher seed yield plant^{-1} (3.95 g) and seed yield ha^{-1} (885 qha^{-1}) was recorded by variety AKT- 64 as compared to Western-11.

Shaikh *et al.* (2015) conducted the field experiment at Agronomy Farm, College of Agriculture, Pune during summer, 2011. The experiment was laid out in a Split plot design with three replications. Twelve treatment combinations were formed considering different sowing times and varieties (Phule til-1, AKT- 101, JLT-7 and Padma). The results showed that, the variety AKT-101 reported significantly higher values for dry matter accumulation plant^{-1} (11.14 g) as compared to the variety Padma (9.49 g). AKT-101 has more number of branches as compared to Padma.

Kumar *et al.* (2016) conducted the experiment was laid out in randomized block design with three replications consisting of 14 sesame lines *viz*., IAVT 14-1, IAVT-14-2, IAVT-14-3, IAVT-14-4, IAVT-14-5, IAVT-14-6, IAVT-14-7, IAVT 14- 8, IAVT-14-9 IAVT-14-10, IAVT-14-11, 1AVT-14-12, IAVT-14-13 and local as check. Results indicated that, significant variations were observed in growth and yield attributes of sesame lines during the experiment. All the sesame lines showed better performance and produced outstanding seed yield as compared to local (check). However, sesame lines IAVT-14-1 produced significantly higher seed yield (708.33 kg ha^{-1}) as compared to the other lines.

Tripathy *et al.* (2016) concluded a set of sesame genotypes including popular ruling varieties was characterized for genetic diversity based on 14 agro-economic traits including seed yield. Cluster IV genotypes (TC 25 and RT 103) had shown dwarf plant type along with capsule bearing from lower height indicating possibility of more scope for increased number of capsules plant^{-1}. Cluster 1 (Pratap) bore longer and bold capsule resulting highest number of seeds capsule^{-1} coupled with increased 500-seed weight. Besides, Pratap maintained very high degree of genetic divergence with most of the test genotypes and it happens to be maximum with B67 followed by RT 103, TC 25, BS 5-18-6, T 13 and TMV5

Zehra *et al.* (2017) conducted an experiment to study the screening of different varieties of sesame (*Sesamum indicum* L.) for growth, yield and response under warm climatic conditions. Four sesame varieties such as TH- 6, TS-5, Till-89 and TS-3 were used to study growth, yield and oil response under warm climatic conditions. The result indicated that the growth and yield parameters like Plant height, No. of branches plant^{-1}, No. of capsules plant^{-1}, length of roots, dry weight of plant, weight of capsules plant^{-1}, seed weight plant^{-1}, Number of seed plant^{-1}, biological yield and economical yield were significantly higher in TS-5 variety of sesame as compared to all others.

Manpara and Gohil (2018) reported the yield potential of AT-231 and tested with two predominant varieties over years and manifested seed yield data and recorded for this newly developed variety along with checks during summer 2010-14 at two location of Saurashtra region. The AT 231 recorded the mean seed yield of 1241 kg ha^{-1} as compared to that of 999 kg ha^{-1} of G-Til-2 and 1014 kg ha^{-1} of G-Til 3 with the yield improvement of 24.22% and 22.39% over check variety G-Til 2 and G-Til 3 respectively.

Adhikary *et al.* (2021) conducted a field experiment on effect of four sowing dates (15th Feb, 1st March, 15th March and 1st April) for studying phenology and thermal indices of three varieties (Tillotama, Rama and Savitri) of sesame (*Sesamum indicum* L.) in split-plot design with 3 replications at Bidhan Chandra Krishi Vishvvidyalay, Jaguli, Nadia, West Bengal during pre-*kharif* (summer) season of 2017. The duration of 15th Feb sown sesame crop was 100.2 days which was reduced by 91.1 days (1 March), 85.3 days (15 March) and 75.4 days (1 April) for delay in sowing in the investigation.

2.3 Effect of weather parameters

Meena and Rao (2013) conducted an experiment at Research Farm CAZRI, Jodhpur (Rajsthan) during 2010-2011 to investigate the Growing Degree Days requirement of sesame (*Sesamum indicum* L.) in relation to growth and phenological stages of sesame cv. RT 127 during the *kharif* season. It observed that, plant height increased with accumulation of GDD and attained a height of 124 cm after accumulation of about 1266 ^{0}C-day GDD during 2010 crop season. Similarly, crop attained to a height of 132 cm after accumulation of 1240 ^{0}C-day GDD during 2011 crop season.

Jiotode *et al*. (2015) reported that the weather parameters like temperature, rainfall and humidity were favourable at 2nd sowing i.e. 27th MW during all growth stages. It found significantly higher yield as compare to sowing of sesame in rest of the MW.

Kumar *et al. (*2017) conducted a field experiment during *rabi* season of year of 2014-15 at Research Farm, Department of Agril. Meteorology, CCSHAU, Hisar on influence of weather parameters on yield and yield attributes of Mustard (*Brassica juncea* L.) They concluded that the crop sown on 26th October performed significantly better in respect of yield and yield attributes as followed to 5th and 15th November mustard sown.

Varsha *et al.* (2018) conducted a field experiment during 2014-15 to evaluate the effect of climate on sesame (*Sesamum indicum* L.). The objective of this work was to evaluate the oil per cent and protein per cent as well as the morphology in two sesame variety

PRACHI (Black seed) and HT-2 (White seed). The results showed that, monthly temperature and rainfall had significantly effect on number of branches plant^{-1}, seed weight, seed yield plant^{-1}, oil content, protein content, carbohydrate content and oxalic acid content as well as free fatty acid.

Sawant *et al.* (2019) conducted a field experiment during *kharif* season of 2016 with phenological studies on Sesamum (*Sesamum indicum* L.) varieties under varied weather conditions. The results concluded that, the total rainfall recorded during growing period (27th MW to 44th MW) of sesamum crop was 990.7 mm in 45 rainy days. During the crop growing period, maximum temperature (32.5 ^{0}C) was recorded in 29th MW, and minimum temperature (28.2 ^{0}C) was recorded in 31st MW, respectively. The D2 sowing i.e. 28 MW (09 to15 July) was superior over rest of treatments with production of highest seed yield (226.55 kg ha^{-1}) followed by first sowing date D1.

Raut *et al.,* (2020) conducted a field experiment entitled "Studies on relationship between crop growth and yield of sesame (*Sesamum indicum* L.) under different weather condition at College of Agriculture, Parbhani, during *kharif* season 2017. The results concluded that, sowing at D2 (25th MW) found superior over the rest of treatments with production of highest seed yield (440.8 kg ha^{-1}) followed by sowing date D1 (23rd MW), D3 (27th MW) and D4 (29th MW) respectively.

Adhikary *et al.* (2021) conducted a field experiment to study the effect of four sowing dates (15th Feb, 1st March, 15th March and 1st April) on phenology and thermal indices of three varieties (Tillotama, Rama and Savitri) of sesame (*Sesamum indicum* L.) in split-plot design with 3 replications at Bidhan Chandra Krishi Vishvvidyalay, Jaguli, Nadia, West Bengal during pre-*kharif* (summer) season of 2017. Mean GDD from sowing to emergence, Flowering initiation, capsule initiation and maturity were 76, 512, 188 and 807 ^{0}C days, respectively. Like phenophase duration summed GDD for entire life cycle of sesame was gradually decreased with delay in sowing from 15th Feb (1710 ^{0}C days) to 1st April (1452 ^{0}C days). Tilottama required max. summed GDD (1654 ^{0}C day) to complete the life cycle, while Rama had lowest GDD (1532 ^{0}C day) from sowing to maturity.

Bath *et al*. (2021) revealed the temperature dependencies of growth and reproductive yield in sesame and estimated cardinal temperature that would allow the development of crop models for sesame to enhance management strategies. The vegetative growth of sesame was found to be sensitive at cold temperature (<15 ^{0}C).

Chapter III

MATERIAL AND METHODS

A field experiment was conducted to study the "Response of sesame varieties to different sowing windows" during *kharif* season of 2021-2022 at Agronomy Farm, College of Agriculture, Nagpur. The details of the experimental materials used and the technique adopted during the course of investigation are given in this chapter under the following heads.

3.1 Basic resource information

3.1.1 Experimental site

The experimental site was selected on the merit in respect of suitability of land for sesame cultivation with uniform fertility and topography. With this consideration, the experiment was laid out on field No. 10 of the Agronomy farm, College of Agriculture, Nagpur, during *kharif* season of 2021-2022.

3.1.2 Soil characteristics

The experimental field was fairly uniform and levelled. Soil of experimental plot was medium black. Soil samples were collected from randomly selected spots at a depth of 0-30 cm from the experimental area, mixed well and a composite sample of One kg was then prepared and analyzed for various physio-chemical properties of the soil. The details of analysis done, methods adopted and values obtained are presented in Table-1, showing mechanical and chemical composition of the soil.

From the data presented in Table-1 it would be observed that, soil of the experimental site was loamy clay in texture, low in available nitrogen, phosphorous and sulphur and rich in available potash. Organic carbon content was medium and soil reaction was slightly alkaline.

Table 1. Physical and chemical composition of the soil

Sr. No.	Particulars	Value	Method followed
A.	**Mechanical composition**		
1	Coarse sand (%)	13.30	Standard International pipette method (Piper, 1966)
2	Fine sand (%)	7.50	
3	Silt (%)	24.18	
4	Clay (%)	55.02	
5	Textural class	Clay soil	
B.	**Chemical composition**		
1	Available nitrogen (kg ha^{-1})	264.32	Alkaline potassium gangmaster method (Subbiah and Asija, 1956)
2	Available phosphorus (kg ha^{-1})	21.17	Olsen's method (Jackson, 1967)
3	Available potassium (kg ha^{-1})	394.20	Flame emission Phototype setter (Jackson, 1967).
4	Available sulphur (mg ha^{-1})	7.38	Turbidimetric method (Chesnin and Yien, 1951).
5	Organic carbon (%)	0.55	Walkey and Black method (Jackson, 1967)
C.	**Soil reaction**		
1	pH	7.6	Glass electrode pH meter (Jackson, 1967)

3.1.3 Cropping history of the experimental site

The cropping history of the experimental field during last three years is given in Table-2.

Table 2. Cropping history of the experimental site

Year	Season		
	Kharif	***Rabi***	**Summer**
2019-20	Dhaincha	Wheat	-
2020-21	Soybean	Linseed	-
2021-22	Sesame (Present investigation)	-	-

3.2 Weather and Climatic conditions

Nagpur is a part of central Vidarbha zone of Maharashtra, It is situated at 21^0 8' North latitude and 79^0 4' East longitude having an elevation of 321 m above MSL and has subtropical climate. The climate is hot and slightly moist. The weekly weather data in respect of temperature, rainfall, humidity recorded at Meteorological Observatory, Agronomy Farm, College of Agriculture, Nagpur during June, 2021 to October, 2021 is presented in Table 3 and graphically depicted in Fig.1.

Table 3. Weekly meteorological data from June, 2021 to November, 2021 recorded at Agronomy farm, College of Agriculture, Nagpur

Month	Date	Met Week	Total Rainfall (mm)	No. of Rainy Days	Temp ^{0}C		R.H. %		Evaporation (mm)
					Max.	Min.	Mor.	Eve.	
	28 to 3	22	0.0	0	42.5	26.3	32	20	11.7
Jun, 21	04 to10	23	44.4	3	37.3	25.5	57	35	9.4
	11 to17	24	99.0	4	33.5	23.5	85	67	4.9
	18 to 24	25	83.8	3	33.3	23.3	88	71	2.4
	25 to 1	26	83.6	3	33.5	24.7	87	67	2.5
Jul, 21	02 to 8	27	16.2	1	35.5	24.7	78	54	3.0
	9 to 15	28	155.6	4	33.9	23.9	89	69	1.7
	16 to 22	29	90.8	2	32.9	23.7	86	76	2.2
	23 to 29	30	88.4	2	32.3	23.5	89	74	1.9
	30 to 05	31	38.2	4	30.5	23.9	89	79	1.6
Aug, 21	6 to 12	32	13.8	1	33.7	24.1	83	63	2.5
	13 to 19	33	178.2	4	33.5	23.5	90	70	2.0
	20 to 26	34	21.4	1	32.5	23.5	89	65	2.9
	27to 2	35	82.4	3	32.5	23.1	93	71	2.3
Sept, 21	03 to 09	36	141.4	5	32.1	23.1	95	70	2.0
	10 to 16	37	90.4	6	31.5	23.1	95	66	1.6
	17 to 23	38	64.6	6	31.7	22.1	93	64	2.3
	24 to 30	39	45.4	3	31.9	22.5	93	70	3.2
Oct, 21	01 to 07	40	0.0	0	32.3	23.3	83	63	4.3
	08 to 14	41	0.0	0	33.6	21.1	68	45	5.6
	15 to 21	42	0.0	0	32.8	21.1	70	44	4.9
	22 to 28	43	0.0	0	30.8	19.3	58	37	4.4
	29 to 4	44	0.0	0	31.1	17.5	48	33	4.5

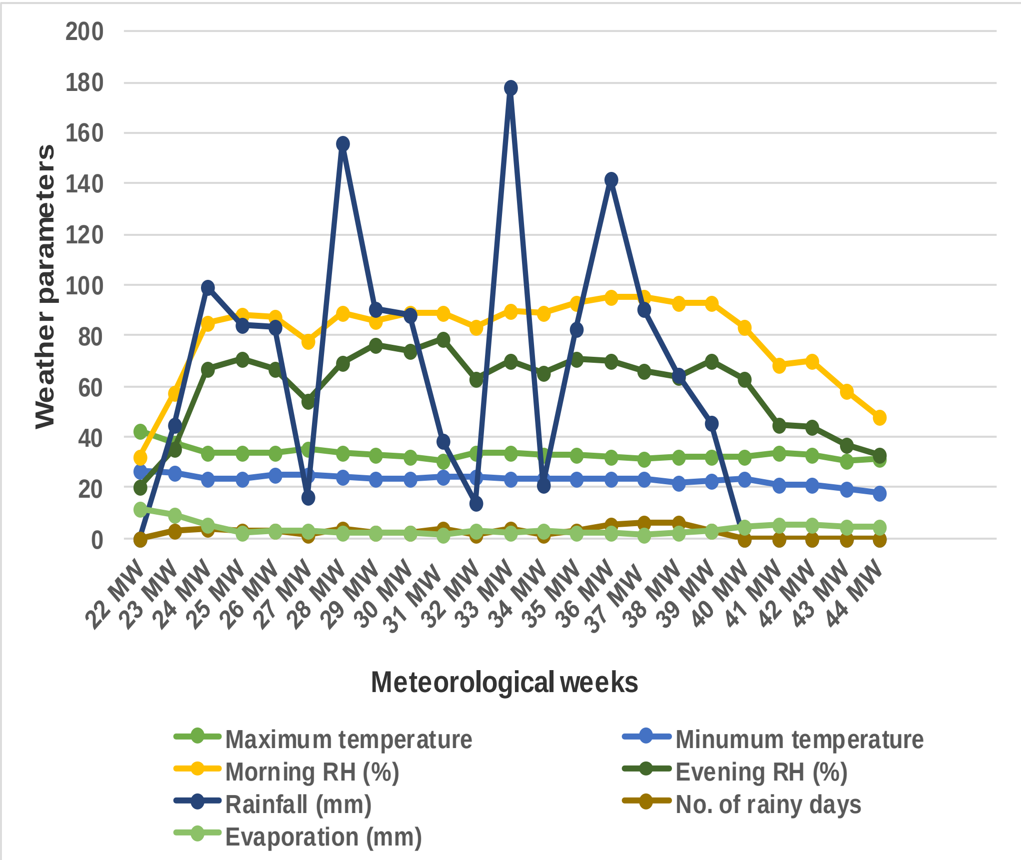


Fig. 1. Weekly weather parameters during crop period

Weekly weather data in respect of maximum and minimum temperature, relative humidity (morning and evening) rainfall, number of rainy days and evaporation during the *kharif* season of 2021-22 recorded at Meteorological Observatory, Agronomy farm College of Agriculture, Nagpur along with its normal values are presented in Table-3 and graphically depicted in Fig.1.

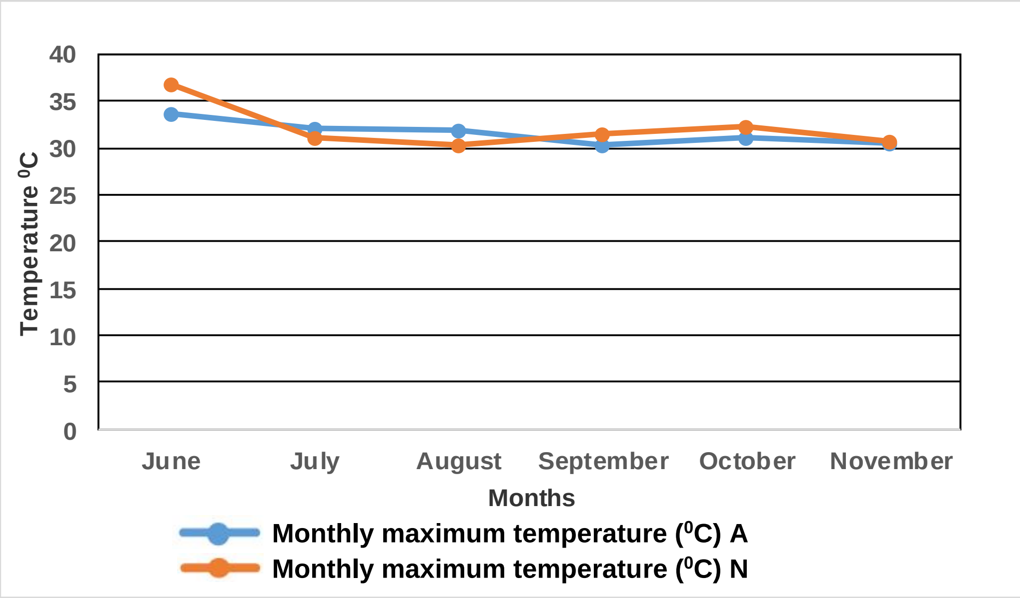
The total rainfall during crop growth period i.e. Jun, 2021 to October, 2021 was 1337.6 mm received in 55 rainy days. The maximum temperature ranged from 30.5 to 42.5 ^{0}C, the minimum temperature ranged from 17.5 to 26.3 ^{0}C, the morning relative humidity ranged from 32 to 95 per cent, the evening relative humidity ranged from 20 to 79 per cent and total evaporation was 83.8 mm.

Table 4. Monthly meteorological data from June, 2021 to November, 2021 in comparison with last ten year average recorded at Agronomy farm, College of Agriculture, Nagpur

Month	Temperature (^{0}C)				Total Rainfall (mm)		Rainy days		Relative Humidity (%)	
	Maximum		Minimum							
	A	N	A	N	A	N	A	N	A	N
June	33.6	36.8	25.3	25.7	310.8	221	15	10	75	65
July	32.1	31.2	24.4	23.9	379	357.0	10	14	86	82
August	32.0	30.4	24.4	23.9	284.0	284.0	8	11	88	83
September	30.4	31.5	23.3	23.6	396.8	231.9	19	10	93	83
October	31.1	32.3	21.9	21.1	0.0	51.5	0	2	68	72
November	30.5	30.7	18.5	16.4	0.0	2.48	0	1	55	66

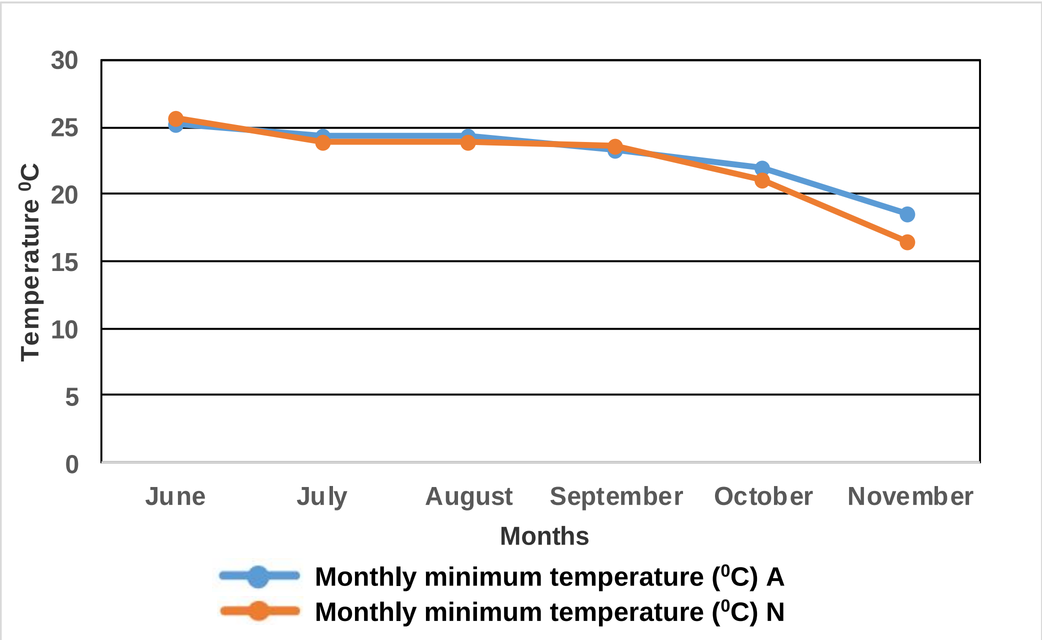
N = Normal (10 years average) A = Actual monthly

Graphical depicted in figure- 2, 3, 4, 5 and 6



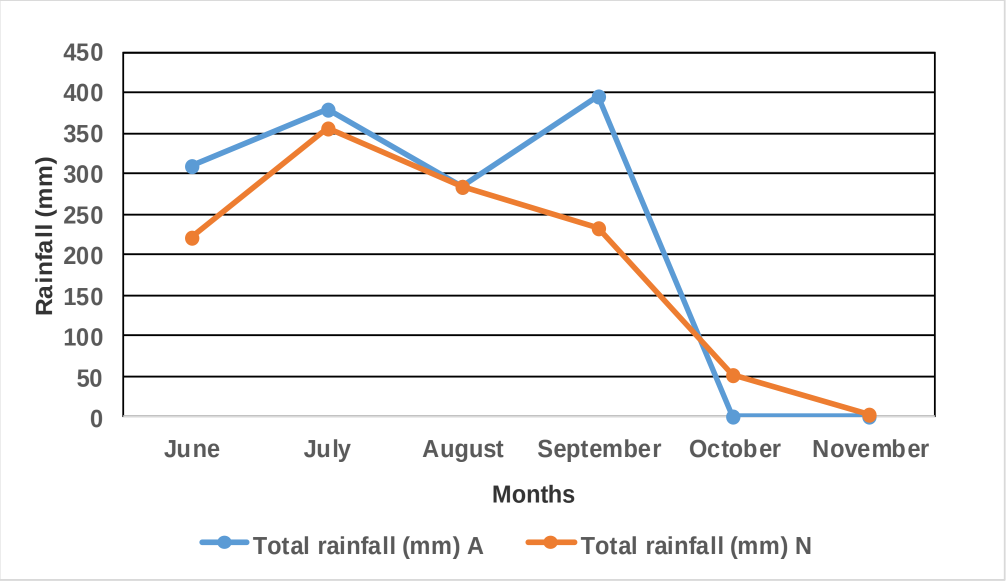
N – Normal (10 years average)   A – Actual monthly

Fig. 2. Monthly normal and actual maximum temperature during *kharif* season (^{0}C)



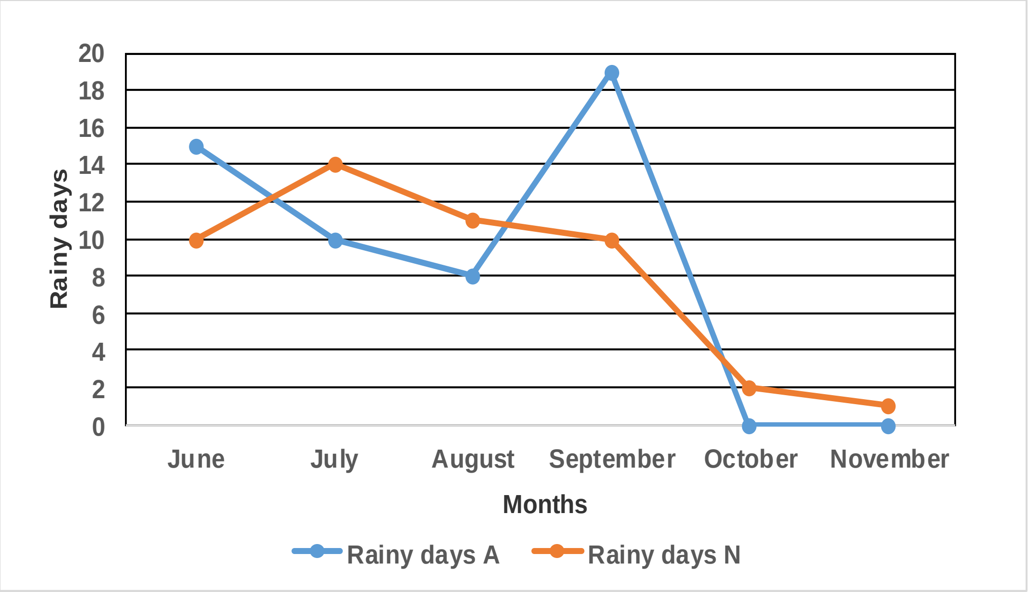
N – Normal (10 years average)   A – Actual monthly

Fig. 3. Monthly normal and actual minimum temperature during *kharif* season (^{0}C)



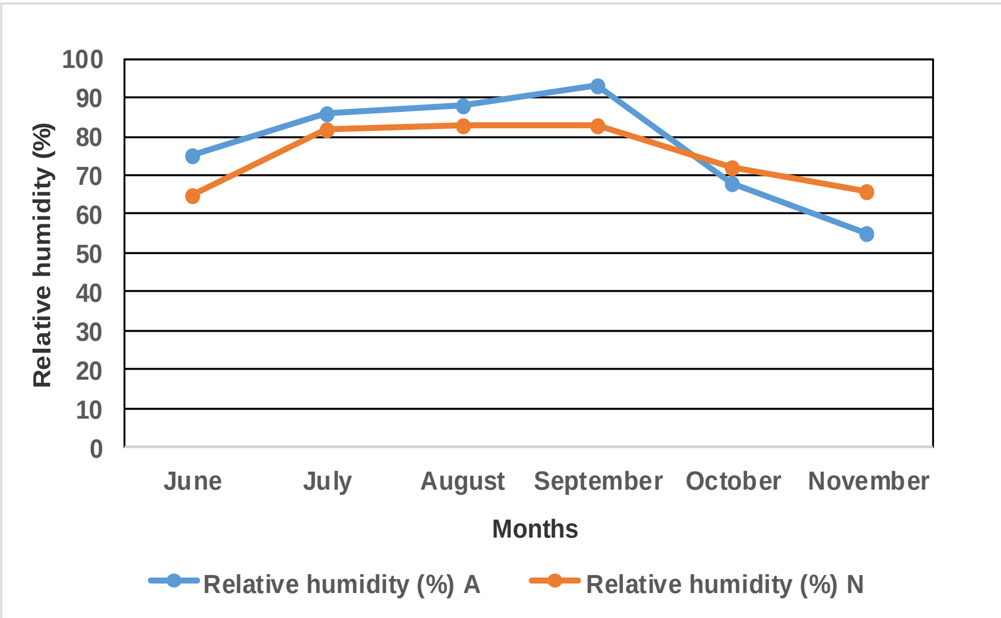
N – Normal (10 years average)   A – Actual monthly

Fig. 4. Monthly normal and actual rainfall during *kharif* season (mm)



N – Normal (10 years average)   A – Actual monthly

Fig. 5. Monthly normal and actual no. of rainy days during *kharif* season



N – Normal (10 years average)   A – Actual monthly

Fig. 6. Monthly normal and actual relative humidity % during *kharif* season

3.3 Experimental details

The experiment was laid out in Split Plot Design with two factors i.e. four sowing dates as main plot treatment and three varieties as sub plot treatment, thus making twelve treatment combinations, replicated thrice.

3.3.1 Experimental design and treatments

The present investigation, "Response of sesame varieties to different sowing windows" was laid out in Split Plot Design with twelve treatment combinations and three replications. The details of the treatments along with symbols used to denote the treatments are given in Table-5.

3.3.2 Details of experimental layout

1	Crop	:	Sesame
2	Experimental Design	:	Split Plot Design
3	No. of replications	:	3
4	Treatment combinations	:	12
5	Total no. of plots	:	36
6	Plot size	:	
	Gross plot size	:	4.8 m × 3.6 m
	Net plot size	:	4.2 m × 2.7 m
7	Spacing		
	Spacing between the rows	:	30 cm
	Spacing between replication	:	0.9 m
	Spacing between plots	:	0.6 m
8	Variety	:	V_{1}- AKT-64, V_{2}- NT-11 and V_{3}-Local.
9	Recommended fertilizer dose	:	40:25:00 kg NPK ha^{-1}
11	Seed rate	:	4-5 kg ha^{-1}
12	Season	:	*Kharif*-2021

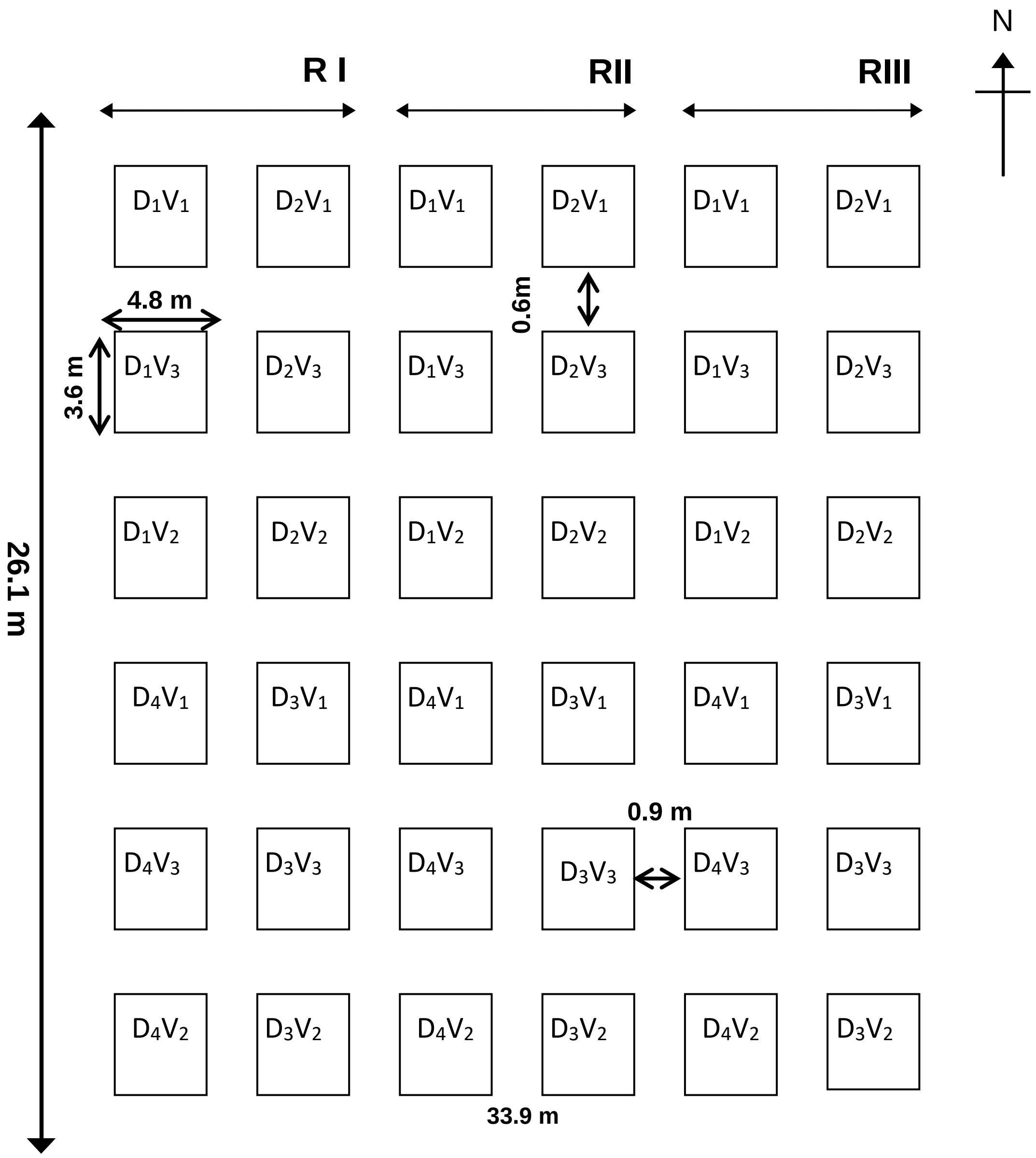


Fig. 7. Plan of Layout

Design	Split Plot Design
Replications	Three
Treatment combinations	Twelve
Total no. of plots	36
Gross plot size	4.8 m x 3.6 m
Net plot size	4.2 m x 2.7 m

Table 5. Treatment details

Factor A	Main Plot - Sowing windows
D_1	26th MW (25th Jun – 1st July)
D_2	27th MW (2nd July – 8th July)
D_3	28th MW (09th July – 15th July)
D_4	29th MW (16th July – 22nd July)
Factor B	**Sub Plot - Varieties**
V_1	AKT-64
V_2	NT-11
V_3	Local

3.3.3 Layout of the experiment

The experimental field was laid out as per the plan after preparatory operation. There were twelve treatment combinations laid out in Split Plot Design with three replications. The plan of layout for the present investigation is depicted in Figure-7.

The distance between two replications was 0.90 m and 0.60 m between the plots. The gross and net plot size were 4.8 m × 3.6 m and 4.2 m × 2.7 m, respectively.

3.4 Cultural operations

3.4.1 Cultural operations carried out during experiment are given in Table 6.

3.4.2 Seeds and sowing

Three varieties of sesame *viz.,* AKT-64, NT-11 and Local were sown in four different dates to evaluate the optimum sowing date for *kharif*. sesame. Sowing of sesame was done by manually, keeping 30 cm distance between the rows.

Table 6. Details of cultural operations

Sr. No.	Name of Operation	Frequency	Dates of sowing				
				D_1 26th MW	D_2 27th MW	D_3 28th MW	D_4 29th MW
A.	**Pre sowing operations**						
1.	Ploughing	1		20/05/21	20/05/21	20/05/21	20/05/21
2.	Harrowing	1		17/06/21	17/06/21	17/06/21	17/06/21
3.	Field layout	1		23/06/21	23/06/21	23/06/21	23/06/21
B.	**Sowing and fertilizer application**						
1.	Fertilizer application	1		27/06/21	05/07/21	13/07/21	21/07/21
2.	Seed treatment and sowing	1		27/06/21	05/07/21	13/07/21	21/07/21
C.	**Post sowing operation**						
1.	Thinnig and Gap filling	1		07/07/21	14/07/21	22/07/21	3/07/21
2.	Hand Weeding	2		18/07/21	26/07/21	05/08/21	15/08/21
				30/08/21	05/09/21	17/09/21	25/09/21
D.	**Harvesting**		V_1	15/10/21	22/10/21	24/10/21	26/10/21
			V_2	15/10/21	22/10/21	24/10/21	26/10/21
			V_3	15/10/21	22/10/21	24/10/21	26/10/21
E.	**Threshing**			23/10/21	29/10/21	02/11/21	05/11/21

3.4.3 Fertilizer application

A basal dose of 25 kg P_2O_5 ha^{-1} was applied through single super phosphate while Nitrogen dose @ 40 kg ha^{-1} was applied through urea in two equal split doses i.e. at sowing and 30 DAS.

3.4.4 Thinning and Gap filling

To maintain optimum plant population thinning and gap filling was carried out at 10 days after sowing by keeping only one healthy seedling per hill.

3.4.5 Hand weeding

Two hand weeding were given to keep the plots weed free at 20 and 40 days of crop.

3.4.6 Harvesting and threshing

The crop plant was harvested at physiological maturity stage. The observation plants were harvested first and then border rows and plants on either sides of gross plot were removed and then plants from net plot area were harvested. The harvesting was done with the help of sickle. The produce was tied in bundles plot wise and carried to threshing yard for sun drying. After complete drying the produce from each net plot area was threshed, winnowed, cleaned separately and seed weight was recorded for each net plot.

3.5 Details of observation

The details of biometric observation recorded in the field are given in Table-7.

3.5.1 Sampling technique

In order to represent the plot, five plants from each net plot were selected randomly for recording various biometric observations of growth studies. The selected five plants were labelled properly and all biometric observations were recorded on these sample plants. Five randomly selected plants from border rows of each plot were uprooted for dry matter studies. They were kept in brown paper bag and labelled properly. These sample plants were first dried in sun and then in hot air oven at 105 ^{0}C.

3.5.2 Pre-harvest studies

3.5.2.1 Emergence count

The initial emergence count was recorded by counting all the plants from each net plot at 12th day after sowing. By counting number of seedling meter^{-1} row length at five randomly selected rows, emergence count net^{-1} plot was worked out.

3.5.2.2 Final plant stand

Final plant stand existed in each net plot was recorded at the time of harvesting. By counting number of plants meter^{-1} row length at five recorded randomly selected rows in each net plot, final plant stand was recorded.

3.5.3 Growth studies

3.5.3.1 Plant height (cm)

Height of randomly selected five sample plants were measured at 20, 40, 60, 80 DAS and at harvest from ground level up to the tip of main shoot and average was worked out.

3.5.3.2 Number of branches plant^{-1}

Number of branches arising from main stem were counted at 20, 40, 60, 80 DAS and at harvest from five selected sample plants and average number of branches plant^{-1} was worked out.

3.5.3.3 Dry matter accumulation plant^{-1} (g)

Randomly selected five plants from each border rows of each plot were uprooted for recording dry matter accumulation at 20, 40, 60, 80 DAS and at harvest and kept in brown paper bag and labelled properly. These sample plants were first dried in sun and then in hot air oven at 105 ^{0}C and their weight recorded as dry matter accumulation plant^{-1}.

3.5.4 Post-harvest studies

3.5.4.1 Number of capsules plant^{-1}

The numbers of capsules plant^{-1} from the five observational plants were counted and average number of capsules plant^{-1} was worked out.

Table 7. Observations to be recorded

Sr. No.	Observations	Frequency	Stages of observation
A.	**Pre-harvest studies**		
a)	**Crop stand**		
1.	Emergence count	1	At 12 DAS
2.	Final plant stand	1	At harvest
b)	**Growth studies**		
1.	Plant height (cm)	5	20, 40, 60,80 DAS and at harvest
2.	Number of branches plant^{-1}	5	20, 40, 60,80 DAS and at harvest
3.	Dry matter accumulation plant^{-1} (g)	5	20, 40, 60,80 DAS and at harvest
B.	**Post-harvest studies**		
1.	No. of capsules plant^{-1}	1	At harvest
2.	No. of seed capsule^{-1}	1	At harvest
3.	Seed yield plant^{-1} (g)	1	At harvest
4.	Straw yield plant^{-1} (g)	1	At harvest
5.	Test weight (g)	1	At harvest
C.	**Yield**		
1.	Seed yield (q ha^{-1})	1	At harvest
2.	Straw yield (q ha^{-1})	1	At harvest
3.	Biological yield (q ha^{-1})	1	At harvest
4.	Harvest index (%)	1	At harvest
D.	**Weather parameter**		
1.	Temperature requirement under different sowing windows.		
2.	Relative humidity requirement under different sowing windows.		
E.	**Economic studies**		
1.	GMR (Rs. ha^{-1})	1	At harvest
2.	NMR (Rs. ha^{-1})	1	At harvest
3.	B:C Ratio	1	At harvest

3.5.4.2 Number of seeds capsules^{-1}

Numbers of seeds in each capsule were counted from five capsules each from five observation plants. Then average number of seed capsules^{-1} were worked out.

3.5.4.3 Seed yield (g plant^{-1})

Seed yield (g) plant^{-1} was recorded by threshing five observation plants. Threshed seeds were separated from straw and then weighed average yield of seed (g) plant^{-1} was worked out.

3.5.4.4 Straw yield (g plant^{-1})

Straw yield (g) plant^{-1} was recorded after threshing five observation plants. Straw were separated from threshed seeds and then weighed average yield of straw (g) plant^{-1} was worked out.

3.5.4.5 Test weight (Thousand seed weight)

A representative sample was taken from the produce of each treatment and from the sample, thousand seeds were counted and weight was recorded for each treatment.

3.5.5 Yield of Sesame

3.5.5.1 Seed yield (q ha^{-1})

After harvesting, produce from every net plot was sun dried weighed and then threshed. After cleaning seed yield net plot^{-1} was recorded and seed yield q ha^{-1} was calculated.

3.5.5.2 Straw yield (q ha^{-1})

After removing the seeds from capsules, the straw along with empty capsules were dried in the sun. Upon drying, the weight of the bundles of straw plot^{-1} (q ha^{-1}) was recorded. The weight plot^{-1} was transferred on hectare.

3.5.5.3 Biological yield (q ha^{-1})

The plants from net plot were cut close to the ground and tied into bundles. The bundles were dried in the sun and their weight was recorded before threshing as per treatments. From this biological yield hectare was worked out.

3.5.5.4 Harvest index (%)

Harvest index was calculated at harvest.

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

3.5.6 Agro-meteorological observations

3.5.6.1 Temperature requirement of each variety under different sowing windows (^{0}C day)

Thermal (temperature) requirement, also referred as thermal unit, for each calendar day during the crop period, for all the treatment were calculated from daily weather data on maximum and minimum temperature as under.

$$\text{Temperature requirement} = \frac{T\ max + T\ min}{2} - T\ base$$

Where,

T_{max} – maximum temperature (^{0}C)
T_{min} – minimum temperature (^{0}C)
T_{base} – base temperature as 4.4 ^{0}C

Base temperature is the temperature below which the physiological activities in plant practically ceases and as a result plant does not show any growth. It is considered as 10 ^{0}C for sesame crop.

Further total thermal unit requirement over crop period under each treatment was calculated by summation.

In present study, the base temperature of sesame was taken as 10 ^{0}C.

3.5.6.2 Relative humidity requirement of each variety under different sowing windows

Relative humidity for each crop growth period in respect of each treatment were added together so as to obtain relative humidity requirement in per centage during that crop period. Mean relative humidity over crop period under each treatment was calculated by summation.

Relative humidity is the ratio between the amount of water vapour present in the air and the amount of water vapour required for saturation at a particular temperature and pressure. It can be expressed as per centage or ratio.

$$\text{Relative humidity (RH)} = \frac{\text{Water vapour present in the air}}{\text{Water vapour required for saturation}} \times 100$$

The instruments used for measuring RH are called psychrometer or hygrometer.

3.5.7 Economic studies

It is the study of cost of cultivation and total production subject with calculation of approximate total income generated from sesame crop ha^{-1}.

3.5.7.1 Cost of cultivation (Rs. ha^{-1})

The total cost of cultivation was calculated considering the inputs used in each treatment with prevailing market rates.

3.5.7.2 Gross monetary returns (Rs.ha^{-1})

The total production of crop including both seed yield and straw yield in terms of rupees is known as gross monetory return. It was estimated on ha^{-1} basis.

3.5.7.3 Net monetary returns (Rs.ha^{-1})

The net production of crop after reducing the total cost of cultivation from gross monetary returns in terms of rupees is known as net monetary returns. It was estimated on ha^{-1} basis.

3.5.7.4 Benefit: cost ratio

The benefit cost ratio was worked out by dividing the gross monetary returns (Rs.ha^{-1}) with total cost of cultivation (Rs.ha^{-1}).

$$\text{B:C ratio} = \frac{\text{Gross monetary returns (Rs.ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs.ha}^{-1}\text{)}}$$

3.5.8 Statistical analysis

Standard method of analysis, known as Analysis of Variance was used for statistical analysis (Fisher, 1970). The Critical Difference was worked out at 5% level of significance and F value used to differentiate significant or non-significant effects.

The treatment effects are presented by preparing tables of means with appropriate Standard Error of Means (SE(m)±) and Critical Difference (CD) values, in respect of various aspects studied. Important effects are illustrated by graphs.

3.5.9 Crop weather relations

Crop weather relationship was studied, in order to know the relationship of weather parameters with the growth and yield of crop.

Chapter IV

RESULTS AND DISCUSSION

A field experiment entitled “Response of sesame varieties to different sowing windows” was carried out during *kharif* 2021 at Agronomy farm, College of Agriculture, Nagpur. Response of various parameters subjected to statistical analysis are presented here with proper justification wherever necessary.

4.1 Soil, season and growth

The experimental site was fairly uniform and levelled. The soil analyzed in experimental site have loamy clayey in texture, low in nitrogen and phosphorous content and rich in potash. Organic carbon content was medium and soil reaction was slightly alkaline (7.7) in nature.

The meteorological data presented in Table-3 indicated that, there was slightly variation in mean maximum temperature during 2021 as compared to their average. The maximum temperature ranged from 30.5 ^{0}C to 42.5 ^{0}C, the minimum temperature ranged from 17.5 ^{0}C to 26.3 ^{0}C and the morning relative humidity ranged from 32 to 95 per cent and the evening humidity ranged from 20 to 79 per cent during the growth period of the crop. The total rainfall during crop growth period i.e. Jun 2021 to Oct 2021 was 1337.6 mm. Crop sown during 26th MW and 27th MW experienced favorable temperature and moisture condition which showed better germination and crop growth. However, crop sown during 28th and 29th MW badly affected due to heavy rainfall during germination which hampers poor germination and the initial growth was stunted. As the rainfall was higher during germination and seedling stage of the crop growth sown during 28th MW, as well as it affects vegetative growth, flowering, capsule formation, seed filling resulting into low yield. The temperature and moisture condition for the crop sown during 26th MW and 27th MW were most favorable throughout the cropping period and thus shows better growth and yield.

4.1 Pre-harvest studies

4.1.1 Emergence count

Emergence count of sesame at 12 DAS and final plant stand at harvest are presented in Table-8. The mean emergence count was 272 plants $plot^{-1}$ and final plant stand was 243 plants $plot^{-1}$.

A. Effect of sowing windows

The data presented in Table-8 revealed that emergence count and final stand at harvest of sesame as influenced by different sowing dates was statistically non-significant during the investigation.

Table 8. Emergence count and final plant stand of sesame as influenced by various treatments

Treatments		Emergence count		Final plant stand	
		Plants $plot^{-1}$	Plants ha^{-1}	Plants $plot^{-1}$	Plants ha^{-1}
A.	**Sowing windows**				
	D_1 - 26th MW	273	172488	243	153549
	D_2 - 27th MW	274	172909	245	154741
	D_3 - 28th MW	272	171857	242	152917
	D_4 - 29th MW	270	170173	240	151234
	SE(m) ±	1.52	959.86	1.34	845.39
	C.D. at 5%	NS	NS	NS	NS
B.	**Varieties**				
	V_1 – AKT-64	273	172505	244	153829
	V_2 – NT-11	273	172137	243	153303
	V_3 – Local	271	170927	241	152198
	SE(m) ±	0.73	465.62	0.85	537.36
	C.D. at 5%	NS	NS	NS	NS
C.	**Interaction**				
	SE(m) ±	1.47	931.24	1.70	1074.73
	C.D. at 5%	NS	NS	NS	NS
	GM	272	171856	243	153110

B. Effect of varieties

The data presented in Table-8 revealed that emergence count at 12 DAS and final stand at harvest as influenced by variety of sesame was found to be non-significant during the experiment.

C. Interaction effect

The data presented in Table-8 revealed that interaction effect due to sowing windows and varieties on emergence count at 12 DAS and final plant stand at harvest was found to be non-significant during the study.

4.2 Growth studies

Growth studies covered pre-harvest plant observations such as plant height, number of branches, dry matter accumulation etc. all collected data have been presented in Table 9 to 11.

4.2.1 Plant height

Data collected in respect of mean periodical plant height (cm) of sesame as influenced by different treatments are presented in Table-9 and graphically depicted in figure 8.

From the data in Table-9, it was observed that the mean plant height increased with advancement in the age of crop till harvest. The mean initial plant height was 13.44 cm at 20 days and increased up to 106.74 cm at harvest.

A. Effect of sowing windows

The data (Table-9) revealed that, the plant height influenced by sowing windows recorded at 20 DAS was found non-significant. Whereas the plant height recorded at 40, 60, 80 DAS and at harvest was found significant.

The *kharif* sesame sown during 27th MW has recorded maximum plant height at harvesting stage (107.21 cm). However, it was at par with sowing during 26th MW at 40, 60, 80 DAS and at harvest and significantly superior over sowing carried out on 28th MW and 29th MW at 40, 60, 80 DAS and at harvest.

The higher plant height in timely sowing might be due to congenial climatic condition like temperature and other growth parameters during crop growth of *kharif* sesame. Similar results were reported by Sarkar *et al.* (2007), Shaikh *et al.* (2015) and Raut *et al.* (2020).

Table 9. Mean plant height of sesame (cm) as influenced periodically by various treatments

Treatments		Mean plant height (cm)				
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
A	**Sowing dates**					
	D_1 – 26th MW	13.99	44.02	84.66	103.50	107.21
	D_2 – 27th MW	14.23	45.33	85.58	104.90	109.24
	D_3 – 28th MW	13.48	43.07	83.58	101.79	105.81
	D_4 – 29th MW	13	42.51	82.43	100.67	104.70
	S.E. (m) ±	0.26	0.40	0.42	0.51	0.64
	C.D. at 5%	NS	1.40	1.46	1.79	2.23
B	**Varieties**					
	V_1 – AKT-64	13.98	44.44	84.98	104.00	108.03
	V_2 – NT-11	13.75	43.73	84.06	102.43	106.53
	V_3 – Local	13.30	43.03	83.14	101.72	105.67
	S.E. (m) ±	0.18	0.26	0.33	0.53	0.52
	C.D. at 5%	NS	0.78	0.99	1.59	1.57
C	**Interaction**					
	S.E. (m) ±	0.36	0.52	0.66	1.06	1.04
	C.D. at 5%	NS	NS	NS	NS	NS
	GM	13.67	43.7	84.06	102.71	106.74

B. Effect of varieties

The data (Table-9) revealed that height of plant recorded at 40, 60, 80 DAS and at harvest was significantly influenced by different varieties except at 20 DAS. The variety AKT-64 recorded significantly maximum plant height *viz.*,

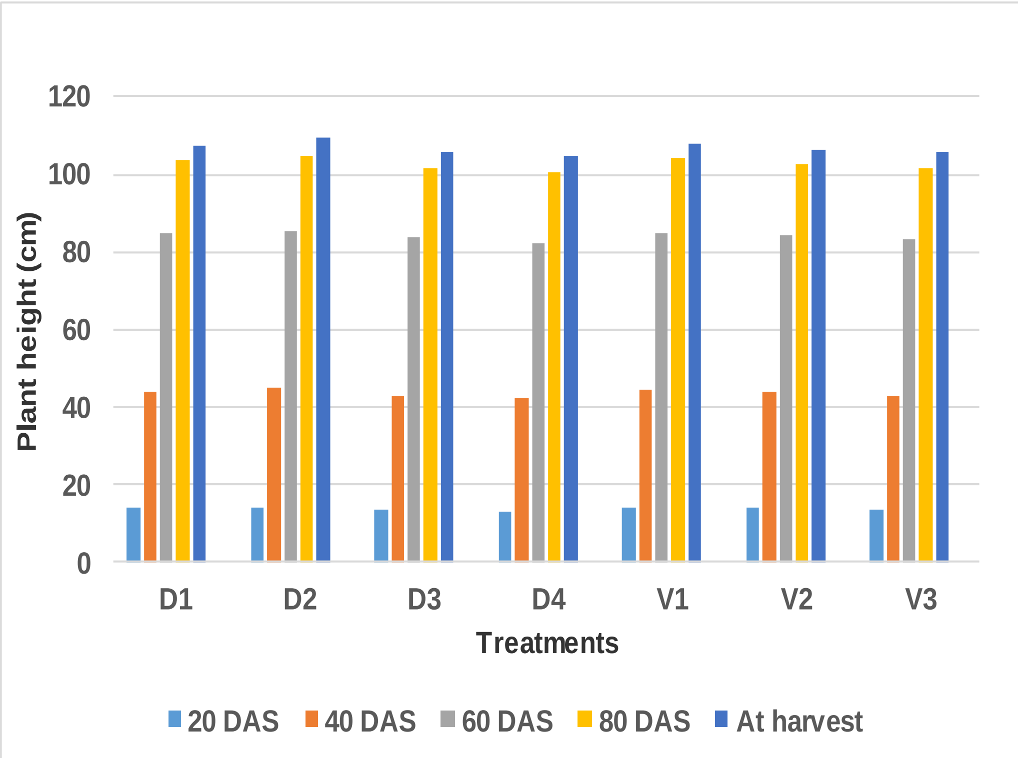


Fig. 8. Plant height (cm) as influenced periodically by different treatments

45.33 cm, 85.58 cm, 104.90 cm and 109.24 cm at 40, 60, 80 DAS and at harvest respectively, whereas it was at par with variety NT-11 at 40, 60, 80 DAS and at harvest. Lowest plant height was recorded by local variety.

This might be due to genetic characters of AKT-64. The similar findings were reported by Korhale (2010), Patil (2012), Shaikh *et al.* (2015) and Sawant *et al.* (2019).

C. Effect of interaction

Interaction due to sowing windows with varieties was found to be non-significant at all the stages of crop growth.

4.2.3 Number of branches plant^{-1}

Data regarding number of branches plant^{-1} at various growth stages are presented in Table-10 and graphically depicted in figure 9. The mean initial number of branches plant^{-1} was 0.89 at 20 DAS and increased upto 6.76 at harvest.

A. Effect of sowing windows

The data presented in (Table-10) revealed that effect of sowing dates on number of branches plant^{-1} was found significant at 40, 60, 80 DAS and at harvest. The number of branches plant^{-1} were significantly more on 27th MW *viz*., 3.42, 6.96, 7.24 and 7.24 at 40, 60, 80 and at harvest, respectively than other sowing dates except 26th MW at all stages than other sowing dates. The same results were reported by Abdel Rahman *et al.* (2007), Patil (2012), Jiotode *et al.* (2015) and Sawant *et al*. (2019).

B. Effect of varieties

The data presented (Table-10) indicated that the effect of varieties on number of branches plant^{-1} was found significant at 40, 60, 80 DAS and at harvest but was found non-significant at 20 DAS. The higher number of branches plant^{-1} were produced with AKT-64 variety (7.03) at harvest and was found at par with variety NT-11 variety at 40, 60 and 80 DAS and at harvest. Lower number of branches plant^{-1} were recorded by variety local at all the crop growth stages.

This might be due to varietal performance to *kharif* growing period. These results are in accordance with those reported by Korhale (2010), Katang and Buba (2014) and Sawant *et al*. (2019).

Table 10. Mean number of branches plant^{-1} as affected periodically by various treatments

Treatments		Number of branches plant^{-1}				
A	**Sowing dates**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
	D_1 – 26th MW	0.98	3.31	6.79	6.89	6.89
	D_2 – 27th MW	1.29	3.42	6.96	7.24	7.24
	D_3 – 28th MW	0.76	2.94	6.33	6.60	6.60
	D_4 – 29th MW	0.63	2.69	6.11	6.33	6.33
	S.E. (m) ±	0.09	0.08	0.12	0.12	0.12
	C.D. at 5%	0.33	0.30	0.43	0.43	0.43
B	**Varieties**					
	V_1 – AKT 64	1.10	3.45	6.80	7.03	7.03
	V_2 – NT-11	0.93	3.11	6.56	6.78	6.78
	V_3 – Local	0.72	2.72	6.28	6.48	6.48
	S.E. (m) ±	0.10	0.13	0.08	0.09	0.09
	C.D. at 5%	NS	0.40	0.24	0.28	0.28
C	**Interaction**					
	S.E. (m) ±	0.20	0.27	0.16	0.19	0.19
	C.D. at 5%	NS	NS	NS	NS	NS
	GM	0.89	3.09	6.54	6.76	6.76

C. Effect of interaction

Interaction effect between sowing windows with varieties was found to be non-significant at all stages of crop growth in respect of number of branches plant^{-1}.

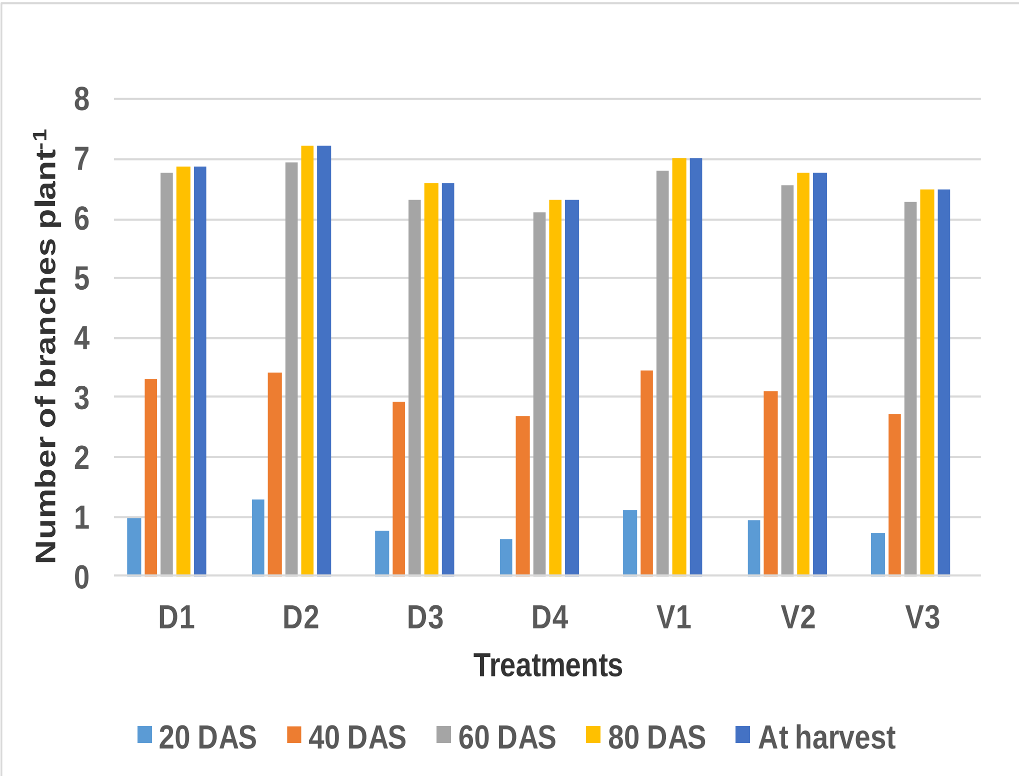


Fig. 9. Number of branches plant^{-1} as influenced periodically by different treatments

4.2.4 Dry matter accumulation plant^{-1}

Data regarding mean dry matter accumulation plant $^{-1}$ at various growth stages are presented in Table-11 and graphically depicted in figure 10. The mean initial dry matter accumulation was 3.12 g at 20 DAS and increased upto 33.88 g at harvest.

A. Effect of sowing windows

Date presented in Table-11, indicated that, dry matter accumulation was significantly influenced by sowing windows. Sowing on 27th MW recorded maximum dry matter accumulation (35.12 g) at harvest and significantly superior over sowing carried out on 28th and 29th MW at all growth stages. However, it was found at par with 26th MW at all growth stages. Lowest dry matter accumulation was recorded when sowing was taken on 29th MW was 32.32 g at harvest. Similar result were reported by Jiotode *et al*. (2015), Shaikh *et al*. (2015), and Raut *et al.* (2020).

During the present investigation, it was observed that there was progressive decrease in dry matter accumulation as sowing was delayed. Optimum sowing period facilitates luxurious crop growth resulting in maximum dry matter accumulation at harvest stage.

B. Effect of varieties

Data presented in Table-11, indicated that dry matter accumulation plant^{-1} was significantly influenced by the different varieties. The significantly maximum dry matter accumulation plant^{-1} was recorded by variety AKT-64 over local variety. Whereas, it was found at par with variety NT-11 at all stages of growth.

This might be due to genetic makeup of variety AKT-64. Similar results were reported by Patil (2012), Chongdar *et al.* (2015) and Shaikh *et al.* (2015).

C. Interaction effect

Interaction effect between sowing windows and varieties was found non-significant at all the stages of crop growth in respect of dry matter accumulation.

Table 11. Dry matter accumulation plant^{-1} as influenced by various treatments

Treatments		Dry matter accumulation plant^{-1}				
A	**Sowing dates**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
	D_1 – 26th MW	3.29	11.60	28.20	32.23	34.66
	D_2 – 27th MW	3.40	11.89	28.83	32.67	35.12
	D_3 – 28th MW	3.02	11.10	28.00	31.98	33.46
	D_4 – 29th MW	2.80	10.62	27.11	31.23	32.32
	S.E. (m) ±	0.05	0.09	0.21	0.16	0.22
	C.D. at 5%	0.19	0.31	0.73	0.58	0.78
B	**Varieties**					
	V_1 – AKT-64	3.26	11.58	28.38	32.34	34.29
	V_2 – NT-11	3.16	11.33	28.04	32.06	33.99
	V_3 – Local	2.97	11.00	27.75	31.68	33.38
	S.E. (m) ±	0.03	0.09	0.13	0.14	0.10
	C.D. at 5%	0.11	0.28	0.40	0.44	0.31
C	**Interaction**					
	S.E. (m) ±	0.07	0.19	0.27	0.29	0.20
	C.D. at 5%	NS	NS	NS	NS	NS
	GM	3.12	11.30	38.04	32.02	33.88

4.3 Post harvest studies

The data pertaining to yield contributing characters recorded at harvest are presented in Table-12 and graphically depicted in figure 11.

4.3.1 Number of capsules plant^{-1}

The data regarding number of capsules plant^{-1} at harvest as influenced by sowing windows and varieties are presented in Table-12 and graphically depicted in figure 11. The number of capsules plant^{-1} at harvest was significantly influenced due to varieties and sowing windows. The mean number of capsules plant^{-1} at harvest was 32.92.

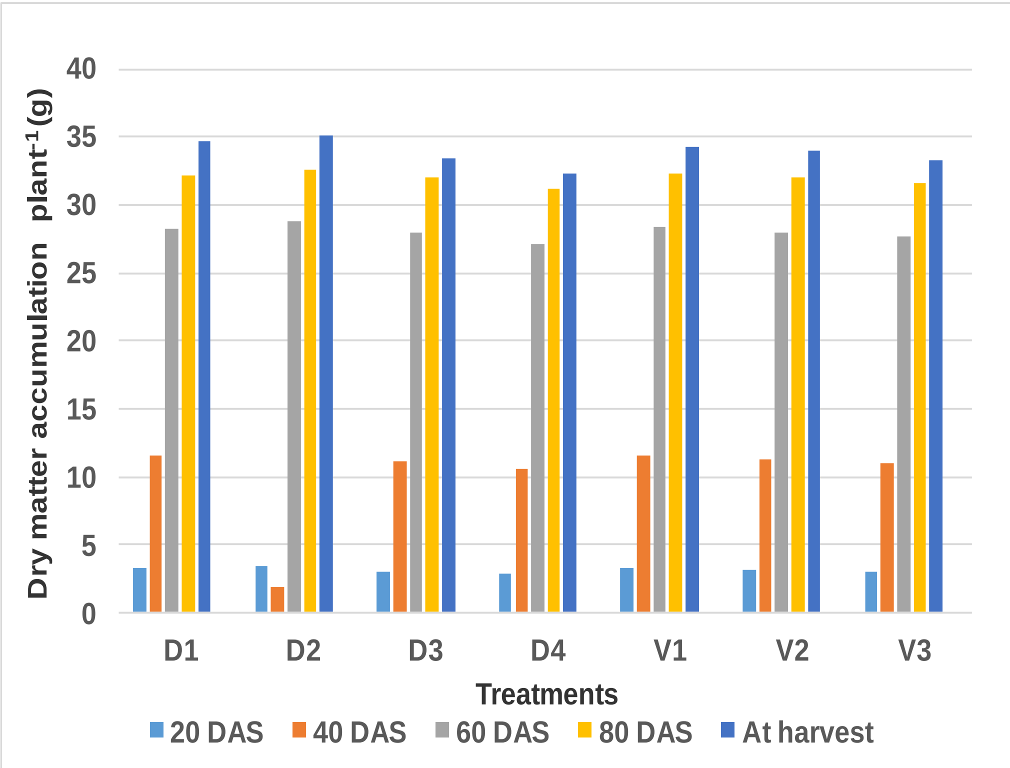


Fig. 10. Dry matter accumulation plant^{-1} (g) as influenced periodically by different treatment

A. Effect of sowing windows

A mean number of capsules plant^{-1} was significantly influenced by different sowing windows. Sowing taken on 27th MW recorded higher number of capsules plant^{-1} (33.90) which was significantly superior over sowing carried out on 28th MW and 29th MW, respectively and found at par with sowing on 26th MW.

The higher number of capsules plant^{-1} was due to timely sowing of seeds and exposure to favorable weather during the entire growth period. Similar results were reported by Tripathy *et al*. (2016) and Sawant *et al.* (2019).

Table 12. Yield contributing characters of sesame as affected by various treatments

Treatments		Number of capsules plant^{-1}	Number of seeds capsule^{-1}	Seed yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Test weight (g)
A	**Sowing dates**					
	D_1 – 26th MW	33.22	56.62	5.17	14.93	3.14
	D_2 – 27th MW	33.90	57.30	5.61	15.02	3.34
	D_3 – 28th MW	32.37	55.71	4.39	12.43	3.03
	D_4 –29th MW	32.20	54.74	3.69	12.13	2.88
	S.E. (m) ±	0.33	0.29	0.14	0.12	0.05
	C.D. at 5%	1.40	1.00	0.51	0.44	0.19
B	**Varieties**					
	V_1 – AKT-64	33.91	56.96	5.02	14.03	3.42
	V_2 – NT-11	33.03	56.27	4.81	13.73	3.0
	V_3 – Local	31.83	55.06	4.32	13.14	2.88
	S.E. (m) ±	0.30	0.25	0.11	0.15	0.04
	C.D. at 5%	0.90	0.76	0.33	0.46	0.13
C	**Interaction**					
	S.E. (m) ±	0.60	0.50	0.22	0.31	0.08
	C.D. at 5%	NS	NS	NS	NS	NS
	GM	32.92	56.09	4.71	13.63	3.09

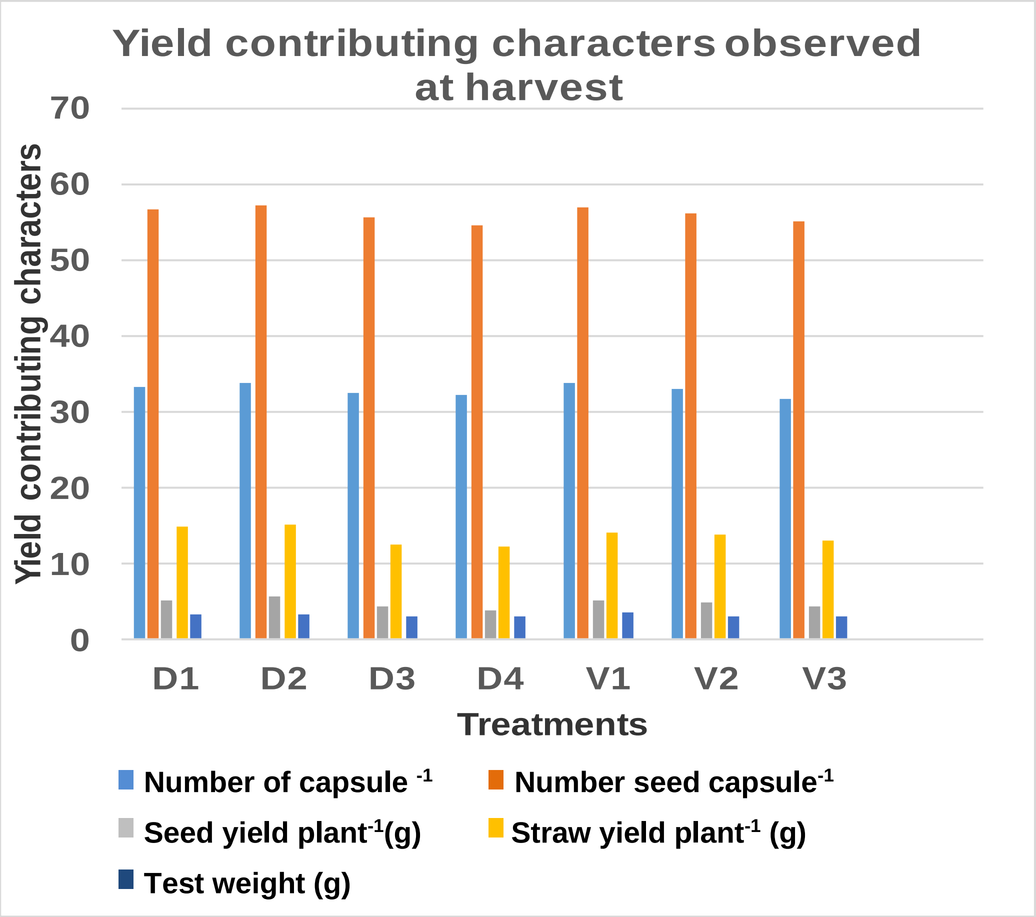


Fig. 11. Yield contributing characters of sesame as influenced by various treatments

B. Effect of varieties

Mean number of capsules plant^{-1} was significantly influenced by the different varieties. The variety AKT-64 recorded significantly higher number of capsules plant^{-1} (33.91) than Local variety (31.83). The NT-11 variety was found at par with variety AKT-64.

It was found that the significant difference in number of capsules plant^{-1} was might be due to genetically makeup of these varieties were different for seed settling and seed development in capsule.

Similar results were reported by Kumar *et al.* (2016), Sawant *et al.* (2019) and Raut *et al*. (2020).

C. Interaction effect

The interaction between sowing times and varieties were found non-significant in respect of number of capsule plant^{-1}.

4.3.2 Number of seed capsule^{-1}

The data in respect of seed per capsule was presented in Table-12 and graphically depicted in Figure-11 revealed that mean number of seed capsule^{-1} at harvest was 56.09.

A. Effect of sowing windows

A mean number of seed capsule^{-1} was significantly influenced by different sowing windows. The sowing of sesame on 27th MW recorded significantly higher number of seed capsule^{-1} (57.30) than 28th and 29th sowing windows. Sowing sesame during 26th MW (56.62) was at par with 27th MW of number of seeds capsule^{-1}.

The higher number of seeds capsule^{-1} might be due to prevalence of favorable climatic factors such as temperature and light energy, which provide the plant full of chance to develop well canopy and biomass and its increased with sowing on 27th MW.

Results obtained during the course of investigation are similar to the finding of Ali and Jan (2014).

B. Effect of varieties

Mean number of seeds capsule^{-1} was significantly influenced by the different varieties. The sesame variety AKT-64 recorded significantly higher number of seed capsule^{-1} (56.27) and lowest number of seeds capusule^{-1} was recorded by Local variety (55.06).

It was found that the significant difference in number of seed capsule^{-1} might be due to more number of branches plant^{-1} and due to genetic potential of variety. Similar result were reported by Ali and Jan (2014) and Sawant *et al*. (2019).

C. Effect of interaction

The interaction between sowing times and varieties was found to be non-significant for no. of seeds capsule^{-1}.

4.3.3 Seed yield plant^{-1} (g)

The data pertaining to seed yield plant^{-1} as influenced by different treatments are presented in Table-12 and graphically depicted in figure-11. The seed yield plant^{-1} (g) was significantly influenced due to sowing dates and varieties. The mean seed yield plant^{-1} was 4.71.

A. Effect of sowing windows

The data pertaining to seed yield plant^{-1} (g) was significantly influenced by different sowing dates. Sowing during 27th MW recorded maximum seed yield plant^{-1} (5.61 g) and was significantly superior over sowing carried out on 28th MW and 29th MW and at par with 26th MW.

This was due to timely sowing and crop exposure to favorable weather during the whole growth period and thus different phases of crop were completed at appropriate timings, which ultimately resulted in production of more number of branches plant^{-1} providing more sites for reproductive structure *viz*., number of capsules plant^{-1}, number of seeds capsule^{-1}.

Kadam (2001) and Patil (2012) also supported the favorable effect of sowing times on seed yield in sesame.

B. Effect of varieties

Significantly higher seed yield plant^{-1} (5.02 g) was recorded by variety AKT-64 followed by variety NT-11 (4.81 g) and Local variety (4.32 g).

This might be due to genetical makeup of these varieties were different for seed settling and seed development in capsule. Similar results were reported by Chongdar *et al*. (2015), Shaikh *et al.* (2015) and Sawant *et al*. (2019).

C. Effect of interaction

The interaction effect between sowing dates and varieties was found to be non-significant for seed yield plant^{-1} at harvest.

4.3.4 Straw yield plant^{-1} (g)

The data recorded on mean straw yield plant^{-1} are presented in Table-12 and graphically depicted in figure-11. The mean straw yield plant^{-1} was 13.63 g.

A. Effect of sowing windows

The mean straw yield plant^{-1} of sesame at harvest. It was significantly influenced by different sowing windows. Sowing taken on 27th MW recorded significantly superior straw yield plant^{-1} (15.02) over sowing windows.

This was due to production of more number of branches plant^{-1} and dry matter accumulation plant^{-1}. Similar result were reported by Ali and Jan (2014) and Raut *et al*. (2020).

B. Effect of varieties

The data pertaining to mean seed yield plant^{-1} as influenced by different varieties are presented in Table-14. Variety AKT-64 recorded maximum straw yield plant^{-1} (14.03) followed by variety NT-11(13.73) and Local variety (13.14).

This might be due to genetic characteristics of variety AKT-64. The similar result reported by Ali and Jan (2014) and Jiotode *et al.* (2015).

C. Effect of interaction

The interaction effect between sowing dates and varieties was found to be non-significant for straw yield plant^{-1} (g) at harvest.

4.3.5 Test weight

Thousand seed weight was influenced by sowing dates and varieties in sesame. The data presented in Table-12 and graphically depicted in figure-11 revealed that the mean thousand seed weight was 3.09 g.

A. Effect of sowing windows

The data pertaining to thousand seed weight at harvest as influenced by different sowing dates are presented in Table-12.

Sowing of sesame during 27th MW significantly influenced mean thousand seed weight (3.34 g) which was significantly superior over sowing carried out on 26th MW, 28th MW and 29th MW. Lowest test weight (2.88 g) was recorded under 29th MW.

This might be due to timely sown crop gets an advantages because after having completed its vegetative growth satisfactory it comes in the capsuling stage when the temperature is quite favorable.

Similar results reported by Ali and Jan (2014) and Raut *et al.* (2020).

B. Effect of varieties

The data pertaining to thousand seed weight at harvest as influenced by different varieties are presented in Table-12. It was significantly influenced by different varieties.

The mean thousand seed weight of AKT-64 variety was (3.42 g). Which was significantly higher than Local variety and was at par with variety NT-11 (3.0 g). Lowest test weight (2.88 g) was recorded by Local variety. Similar result was reported by Kumar *et al.* (2016).

C. Effect of interaction

The interaction effect between sowing dates and varieties was found to be non-significant for test weight (g) at harvest.

4.4 Yield Observation

The data pertaining to seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) as influenced by different sowing windows and varieties are presented in Table-13 and graphically depicted in figure 12.

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

The data presented in Table-13 indicated that seed yield was significantly affected by different treatments and the mean seed yield was 7.20 q ha^{-1}.

A. Effect of sowing windows

Sowing taken on 27^{th} MW had recorded significantly higher seed yield (8.68 q ha^{-1}) over rest of the sowing windows. Sowing on 26^{th} MW also recorded higher seed yield over sowing on 28^{th} and 29^{th} MW respectively. Lowest seed yield (5.58 q ha^{-1}) was recorded under 29^{th} MW.

This might be due to timely sown crop received favorable weather conditions for longer duration and recorded better growth and yield attributes and resulted in greater productivity. Optimum temperature prevailed during flowering resulted in lower flower drop and higher capsule formation. Similar results were reported by Gade (2012), Shaikh *et al*. (2015), Sawant *et al*. (2019) and Raut *et al.* (2020).

B. Effect of varieties

Data presented in Table-13 revealed that variety AKT-64 had recorded significantly higher seed yield (7.73 q ha^{-1}) over Local variety (6.58q ha^{-1}) but was found at par with variety NT-11 (7.40 q ha^{-1}).

This might be due to the less flower drop and more number of branches $plant^{-1}$ which was helped in increased seed yield ha^{-1}. Similar results were reported by Jiotode *et al*. (2015), Shaikh *et al.* (2015), Sawant *et al*. (2019) and Adhikary *et al*. (2021).

C. Effect of interaction

The interaction effect between sowing dates and varieties was found to be non-significant for seed yield (q ha^{-1}) at harvest.

4.4.2 Straw yield (q ha^{-1})

Data in respect of mean straw yield (20.48) as influenced by different sowing windows and varieties are presented in Table-13. The mean straw yield was 20.88 q ha^{-1}.

A. Effect of sowing windows

Sowing during 27th MW had recorded significantly higher straw yield (23.25 q ha^{-1}) than sowing taken on 28th MW and 29th MW and was found at par with sowing on 26th MW. Lowest straw yield was recorded under 29th MW (18.35 q ha^{1}).

This may be attributed due to the higher number of capsules and branches plant^{-1}. Similar results were also reported by Ali and Jan (2014) and Jiotode *et al*. (2015).

B. Effect of varieties

Data presented in Table-13 revealed that variety AKT-64 produced significantly higher straw yield (21.59 q ha^{-1}) than Local variety (20.01 q ha^{-1}) and at par with variety NT-11 (21.06).

This might be due to the higher number of branches plant^{-1} and ultimately the higher dry matter accumulation per plant and also due to genetic potentially of variety AKT-64. Similar results were reported by Korhale (2010) and Jiotode *et al*. (2014).

Table 13. Seed yield, straw yield, Biological yield and harvest index as influenced by various treatments

Treatments		Seed Yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
A	**Sowing dates**				
	D_1 – 26th MW	7.97	22.94	30.80	25.87
	D_2 – 27th MW	8.68	23.25	31.79	27.30
	D_3 – 28th MW	6.71	19.01	25.68	26.12
	D_4 – 29th MW	5.58	18.35	23.89	23.35
	S.E. (m) ±	0.21	0.20	0.34	-
	C.D. at 5%	0.72	0.70	1.19	-
B	**Varieties**				
	V_1 – AKT-64	7.73	21.59	29.18	26.49
	V_2 – NT-11	7.40	21.06	28.40	26.03
	V_3 – Local	6.58	20.01	26.54	24.79
	S.E. (m) ±	0.16	0.26	0.27	-
	C.D. at 5%	0.50	0.78	0.83	-
C	**Interaction**				
	S.E. (m) ±	0.33	0.52	0.55	
	C.D. at 5%	NS	NS	NS	
	GM	7.20	20.88	28.04	25.70

C. Effect of interaction

The interaction effect between sowing windows and varieties was found to be non-significant for straw yield (q ha^{-1}) at harvest.

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

Data in respect of total biological yield is presented in Table-13 and graphically depicted in Figure. The mean biological yield of sesame was 28.04 q ha^{-1}.

A. Effect of sowing windows

Biological yield differed significantly due to various sowing windows. The crop sown at 27^{th} MW recorded significantly higher biological yield (31.79 q ha^{-1}). However, it was significant superior over sowing taken on 28^{th} and 29^{th} MW. Lowest Biological yield was recorded under 29^{th} MW (23.89 q ha^{-1}).

Sowing on 27^{th} MW has accumulated higher photosynthates which helped in higher accumulation of dry matter which resulted in higher biological yield. Similar results were found by Jiotode *et al.* (2015), Muneshwar *et al.* (2019) and Raut *et al.* (2020).

B. Effect of varieties

Data presented in Table-13 revealed that variety AKT-64 produced significantly higher biological yield (29.18 q ha^{-1}) than Local variety (26.54 q ha^{-1}) and at par with variety NT-11 (28.40 q ha^{-1}).

This might be due to genetic makeup of variety AKT-64. Similar results were reported by Jiotode *et al*. (2015).

C. Interaction effect

Interaction due to sowing windows and varieties in respect of biological yield was found to be non- significant.

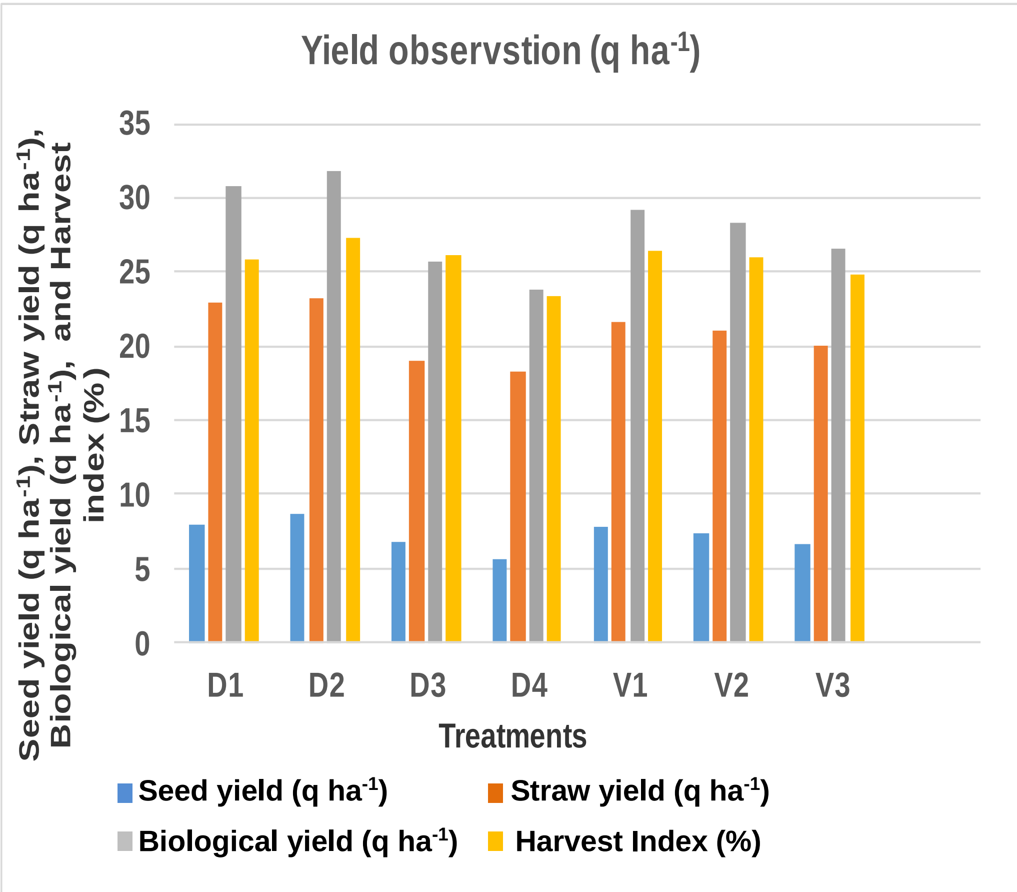


Fig. 12. Grain yield (q ha^{-1}), Straw yield (q ha^{-1}), Biological yield (q ha^{-1}) and Harvest index (%) as influenced by various treatments

4.4.3 Harvest Index (%)

The data in respect of harvest index is presented in Table-13. The mean harvest index was 25.70.

A. Effect of sowing windows

The data in Table-13 revealed that the sowing on 27th MW recorded comparatively higher harvest index (27.30%) as compared to all other sowing dates. Similar results were reported by Ali and Jan (2014) and Adhikary *et al.* (2021).

B. Effect of varieties

The harvest index was comparatively higher in sesame variety AKT-64 (26.49%) than varieties NT-11 and Local variety. Similar results reported by Ali and Jan (2014) and Adhikary *et al.* (2021).

4.5 Weather parameters

4.5.1 Temperature requirement

Temperature requirement of sesame is actually workout and presented in Table-14 and graphically depicted in figure-13.

The temperature requirement (GDD) for sesame was calculated by using daily maximum and base temperature of sesame. Mean temperature requirement of sesame during growth period was 361.72 ^{0}C days.

A. Effect of sowing windows

The temperature requirement was reduced as the sowing was delayed. Sowing on 27th MW recorded highest (386.7 ^{0}C days) temperature requirement and sowing in 29th MW recorded lowest (329.7 ^{0}C days) temperature requirement.

It might be due to difference in duration of crop growth and difference in maximum and minimum temperatures.

B. Effect of varieties

The different varieties recorded different temperature requirement. Variety AKT-64 recorded highest (376.29 ^{0}C days) temperature requirement followed by variety NT-11 (370.92 ^{0}C days) and the lowest in Local variety (362.31 ^{0}C days).

Table 14. Temperature requirement (^{0}C days) of sesame as influenced by various treatments

Treatments		Temperature (Thermal requirement) (^{0}C days)
A	**Sowing dates**	
	D_1 – 26th MW	356.53
	D_2 – 27th MW	386.75
	D_3 – 28th MW	348.85
	D_4 – 29th MW	329.73
B	**Varieties**	
	V_1 – AKT-64	376.29
	V_2 – NT-11	370.92
	V_3 – Local	362.31
	GM	361.72

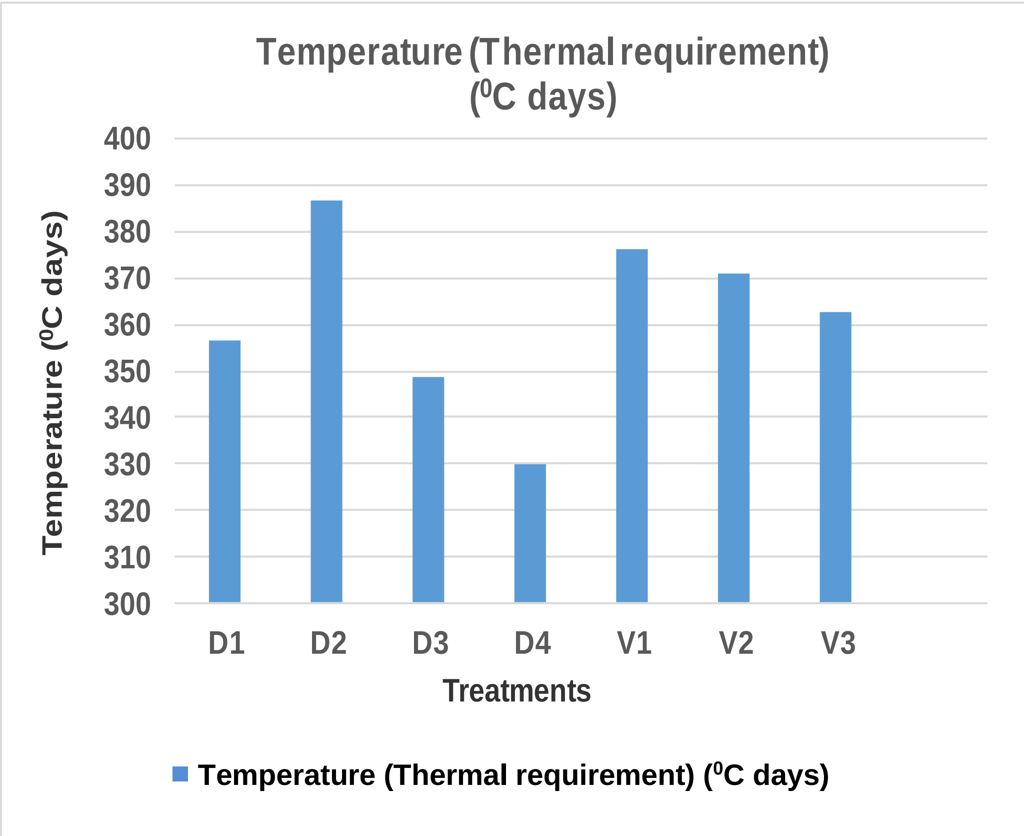


Fig. 13. Temperature requirement (^{0}C days) of sesame as influenced by various treatments

4.5.2 Effect of relative humidity on each variety of sesame as influenced by sowing windows

The data on relative humidity requirement are presented in Table-15 and graphically depicted in figure 14. The relative humidity requirement for *kharif* sesame was calculated by using average relative humidity during crop period.

Table 15. Seasonal variation in relative humidity during crop period

Meteorological Weeks		Relative Humidity (%)		
		Maximum	Minimum	Variation
26th MW	(1st Sowing)	87	67	20
27th MW	(2nd Sowing)	78	54	24
28th MW	(3rd Sowing)	89	69	20
29th MW	(4th Sowing)	86	76	10
30th MW	-	89	74	15
31th MW	-	89	79	10
32th MW	-	83	63	20
33th MW	-	90	70	20
34th MW	-	89	65	24
35th MW	-	93	71	22
36th MW	-	95	70	25
37th MW	-	95	66	29
38th MW		93	64	15
39th MW		93	70	29
40th MW		83	63	20
41th MW		68	45	23
42th MW	(1st Harvesting)	70	44	26
43th MW	(2nd, 3rd and 4th Harvesting)	58	37	21

A. Effect of sowing windows

As regard effect of sowing dates on relative humidity requirement of crop, the average variation in maximum and minimum relative humidity during 27th MW was slightly greater than sowings carried out on 27th, 28th and 29th MW respectively.

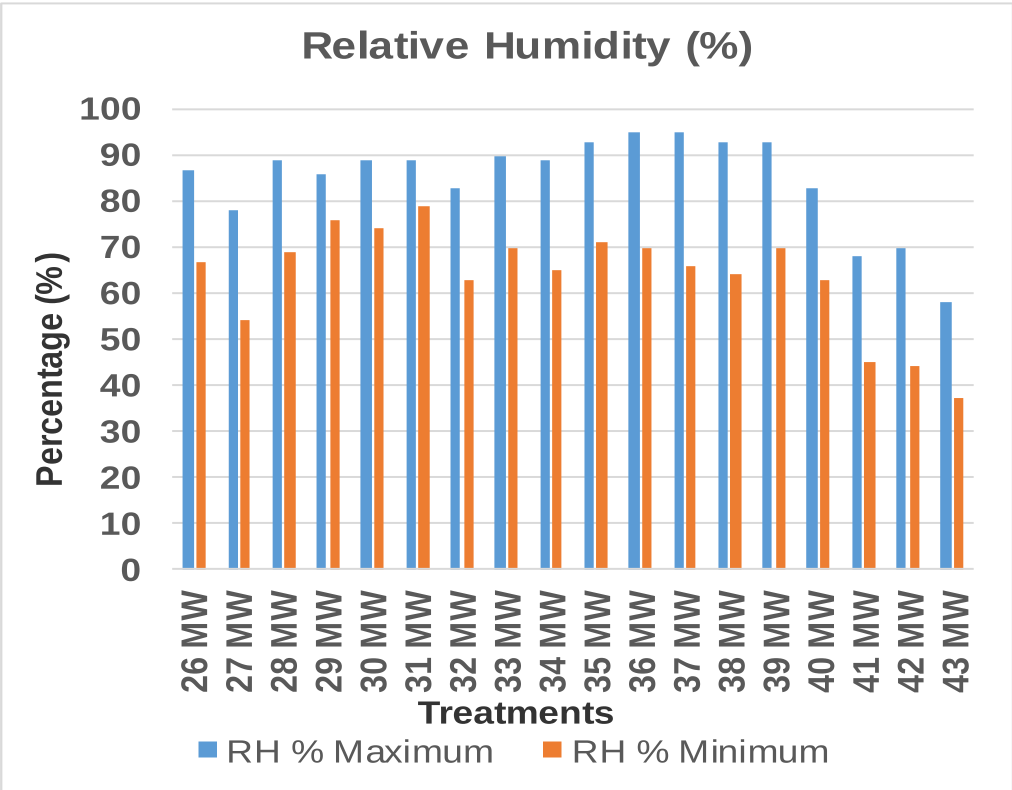


Fig. 14. Seasonal variation in relative humidity during crop period

However, sowing on 26th MW and 28th MW the variation in relative humidity was less as compared to other sowing dates. This indicates that, sowing on different dates was not influence due to relative humidity.

B. Effect of varieties

The different variety was not influenced due to relative humidity on growth and development during crop period.

4.6 Economics study

4.6.1 Gross monetary returns

Data on gross monetary returns as influenced by various treatments are presented in Table-16 and graphically depicted in figure 15(a). Mean gross monetary returns was found to be Rs. 54,312 respectively.

A. Effect of sowing windows

Highest gross monetary returns of Rs. 65,170 ha^{-1} were recorded when crop sown during 27th MW which was significantly superior over 29th MW and it was found at par with sowing 26th MW.

B. Effect of varieties

Highest gross monetary returns of Rs. 57,997 ha^{-1} were recorded with variety AKT-64 which was significantly superior to Local variety and was found at par with variety NT-11.

C. Effect of interaction

Interaction effect of sowing dates and different varieties was found to be non-significant.

4.6.2 Net monetary returns

Data on net monetary return as affected by different treatments are presented in Table-16 and graphically depicted in figure 15(a). Mean net monetary returns was Rs. 29,687 ha^{-1}.

A. Effect of sowing windows

Highest net monetary returns of Rs. 40,511 ha^{-1} were recorded when crop sown on 27th MW which was significantly superior over crop sown on 28th and 29th MW and found at par with crop sown on 26th MW. Increase in net monetary return is due to significant increase in the economic yield of sesame.

Table 16. Economic studies of sesame as influenced by various treatments

Treatments		Cost of cultivation (Rs. ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio
A	**Sowing dates**				
	D_1 – 26th MW	24620	59811	35191	2.42
	D_2 – 27th MW	24620	65170	40511	2.64
	D_3 – 28th MW	24620	50372	25753	2.04
	D_4 – 29th MW	24620	41897	17277	1.70
	S.E. (m) ±	-	1577	1577	-
	C.D. at 5%	-	5458	5458	-
B	**Varieties**				
	V_1 – AKT-64	24620	57997	33377	2.35
	V_2 – NT-11	24620	55577	30958	2.25
	V_3 – Local	24620	49363	24744	2.00
	S.E. (m) ±	-	1263	1263	-
	C.D. at 5%	-	3786	3786	-
C	**Interaction**				
	S.E. (m) ±	-	2526	2526	-
	C.D. at 5%	-	NS	NS	-
	GM	24620	54312	29687	2.20

B. Effect of varieties

Highest net monetary returns of Rs. 33,377 ha^{-1} were recorded with variety AKT-64 which was significantly superior Local variety and was found at par with variety NT-11.

C. Effect of interaction

Interaction effect of sowing dates and varieties was found to be non-significant.

4.6.3 Benefit:Cost ratio

Data pertaining to benefit cost ratio are presented in Table-16 and graphically depicted in figure 15(b). Mean benefit cost ratio was found to be 2.20.

A. Effect of sowing windows

Highest B:C ratio of (2.64) was recorded with sowing on 27th MW as compare to other sowing dates. Increase in B:C ratio is due to significant increase in gross monetary returns.

B. Effect of varieties

Comparatively higher B:C ratio of 2.35 was recorded with variety AKT-64 over Local variety (2.00).

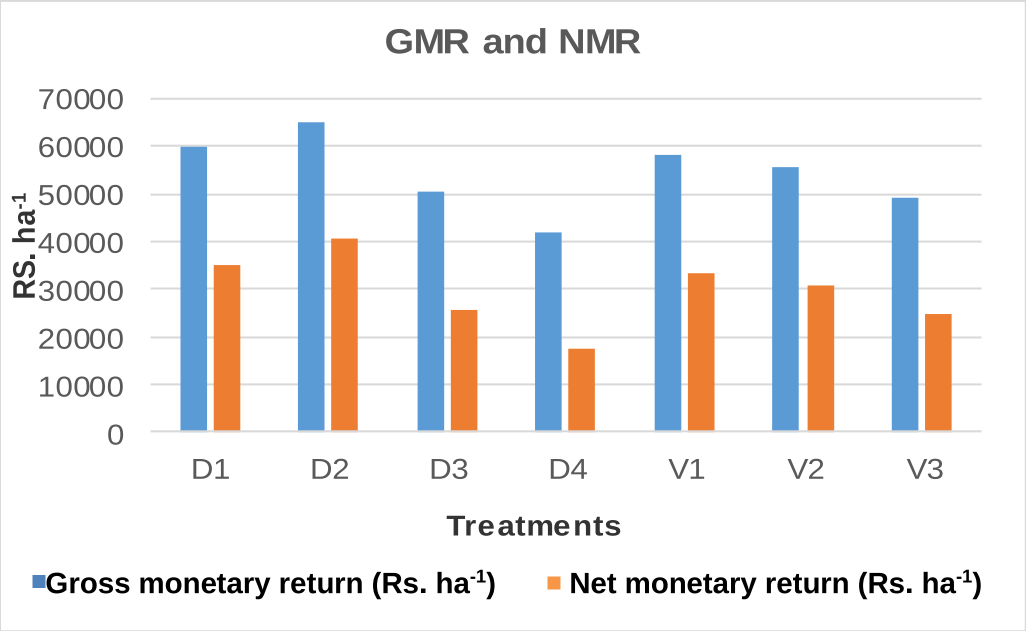


Fig. 15(a). Gross monetary return and Net monetary return in terms of Rs. ha^{-1} as influenced by various treatments

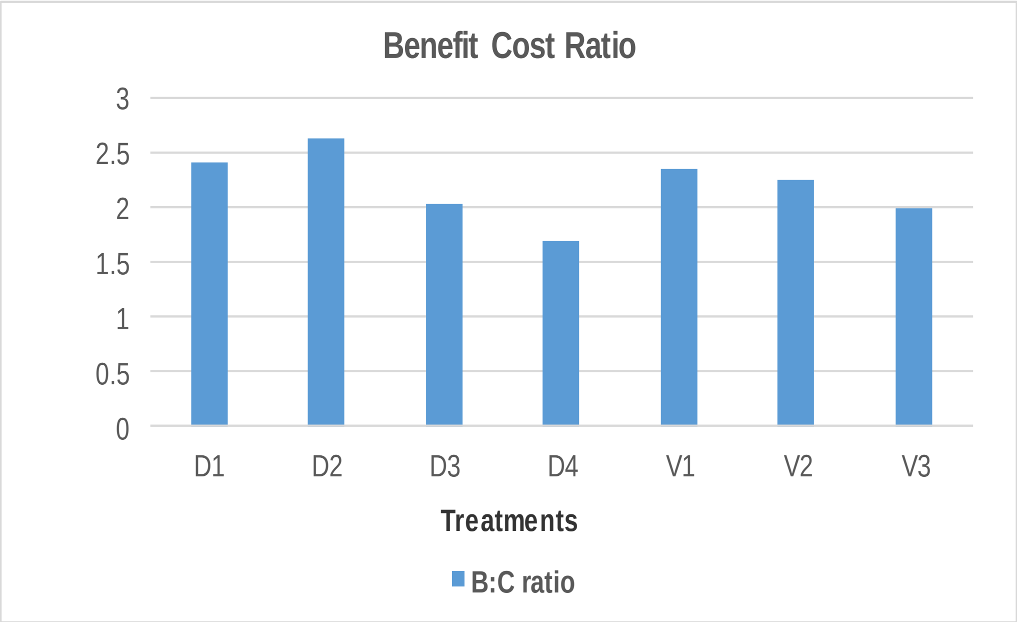


Fig. 15 (b). Benefit cost ratio as influenced by various treatments

Chapter V

SUMMARY AND CONCLUSIONS

The present investigation entitled “Response of sesame varieties to different sowing windows” was carried out during *kharif* 2021 at Agronomy farm, College of Agriculture, Nagpur, Dr. P.D.K.V. Akola.

Summary

The field experiment was laid out in a Split Plot Design with three replications. There were twelve treatment combinations comprising of four sowing windows (26^{th}, 27^{th}, 28^{th} and 29^{th} MW) as main plot treatments and three varieties (AKT-64, NT-11 and Local varieties) as sub plot treatments. The aim of experiment was to study the effect of weather parameters on growth and yield of sesame varieties, suitable sesame variety under different sowing windows and economics in relation to yield of sesame. The gross and net plot size were 4.8 m x 3.6 m and 4.2 m x 2.7 m, respectively. A spacing of 30 cm x 10 cm was adopted by using 5 kg seed ha^{-1}.

A recommended dose of fertilizers (40:25:00 kg N, P and K ha^{-1}) was applied uniformly to all the treatments. Nitrogen was supplied through urea, phosphorus through single super phosphate. 50 per cent nitrogen was applied as basal dose and remaining 50 per cent at 30 days after sowing. The sowing was done by drilling method as per treatments. The crop was harvested after physiological maturity.

Two hand weeding were given to keep the plots weed free. As per the requirement of the crop plant protection measures was applied. No irrigation was given. The various ancillary observations on growth and yield contributing characters were recorded in the experiment at an interval of 20 days and post-harvest studies were carried out to evaluate the treatment effects on sesame crop.

The salient findings recorded during the course of investigation are summarized.

5.1 Pre - harvest studies

5.1.1 Plant stand

Plant stands after emergence and at harvest had shown non-significant effects in different sowing windows, varieties and interaction between sowing windows and varieties.

5.1.2 Crop growth studies

In the present experiment, the pre-harvest observations *viz*., plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} were recorded. A plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} were significantly highest when sesame was sown during 27th MW and it was at par with D_1 - 26th MW in some stages of observations and found superior over 28th and 29th MW respectively.

However, pre-harvest observations recorded under influence of different varieties, variety V_1 - AKT-64 recorded highest above parameters than other varieties. The interaction effect of crop growth studies between sowing windows and varieties was non-significant for all stages of observations.

5.2 Post - harvest studies

The yield contributing characters *viz.*, number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield plant^{-1} (g), straw yield plant^{-1} (g) and test weight (g) was influenced by sowing windows and varieties recorded at harvest. Crop sown during 27th MW recorded significantly highest all ancillary observations. Early and subsequent delay in sowing resulted reduction in all stages of observation.

Variety AKT-64 has performed well in overall all ancillary observations followed by NT-11 than local variety.

The interaction effect between sowing windows and varieties was non-significant in respect of yield contributing characters.

5.3 Yield observations

The yield observations i.e. seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) were influenced by sowing windows and varieties recorded after harvest. Crop sown during 27^{th} MW found significantly higher in all yield observations. Early and subsequent delay in sowing resulted reductions in all yield observations.

Variety AKT-64 have contributed overall higher seed and straw yield as well as harvest index followed by variety NT-11 as per observations.

The interaction effect between sowing windows and varieties was non-significant in case of yield observations.

5.4 Agro-meteorological observation

The temperature requirement was reduced as the sowing is delayed. Sowing on 27^{th} MW recorded highest temperature requirement and sowing on 29^{th} MW recorded lowest thermal requirement**.** The different varieties recorded different temperature requirement. Variety AKT-64 recorded highest temperature requirement followed by variety NT-11.

As regard effect of sowing windows on relative humidity requirement of crop, the average variation in morning and evening relative humidity during 27^{th} MW was slightly greater than other three sowing windows. The different varieties were not influenced due to relative humidity on the growth and development during crop period.

5.5 Economic study

The economic studies in relation to gross monetary return (Rs. ha^{-1}), net monetary returns (Rs. ha^{-1}) and benefit cost ratio were influenced by sowing windows and varieties crop sown during 27th MW recorded highest gross and net monetary returns as well as benefit cost ratio as compare to other three sowing windows.

Variety AKT-64 recorded higher gross and net monetary returns as well as benefit cost ratio followed by NT-11 and local variety.

The interaction effect of sowing dates and different was found to be non-significant in respect of gross and net monetary returns.

CONCLUSIONS

Based on observations of present investigation the following conclusions are drawn.

1. Sowing of sesame during 27th MW recorded highest growth and yield components as compare to its early and delayed sowing.

2. Among the three different varieties of sesame, AKT-64 recorded highest growth and yield components that resulted in increased seed yield as compared to NT-11 and Local varieties.

3. Sowing of sesame during 27th MW and variety AKT-64 obtained significantly higher seed yield with the highest gross and net monetary returns and benefit cost ratio.

4. The temperature and relative humidity requirement of sesame varieties sown during 27th MW was highest. Among Varieties NT-11 reported highest thermal requirement.

IMPLICATION

1. Sesame has to be tested for its response to various sowing windows in changing climate scenario.

2. There is a need to study the effect of sowing windows on growth and yield components of sesame and to study the newly released varietal response of sesame to weather elements for better productivity of sesame.

Chapter VI

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Place: Nagpur

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Signature of Student

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APPENDIX - I

Common cost of cultivation (Rs. ha^{-1}) of sesame (2021-2022)

Sr. No.	Particulars	Frequency	M	F	B. P.	Input cost	Total (Rs. ha^{-1})
I	**Preparatory Tillage**						
1	Ploughing (Tractor)	1	-	-	-	-	2000
2	Harrowing (Tractor)	2	-	-	-	-	2500
3	Levelling	1	2	-	1	-	1150
II	**Seed and Sowing**						
1	Cost of seed @ Rs.150 kg^{-1} (seed rate 5 kg ha^{-1})	-	-	-	-	-	750
3	Sowing operation	1	2	4	1	-	2250
III	**InterculturalOperation**						
1	Gap filling / Thinning	1	-	3	-	-	825
2	Hoeing	1	2	-	1	-	1150
3	Weeding	1	-	10	-	-	2750
IV	**Fertilizer application**						
1	Fertilizer operation (40:25:00 NPK kg ha^{-1})	1	1	4	-	2995	4370
V	**Harvesting Operation**						
1	Harvesting	1	3	10	**-**	**-**	3575
2	Threshing	1	2	8	-	-	2750
3	Market and Transport	1	1	-	-	300	550
	Total						**24620**

APPENDIX – II

Treatment wise cost of cultivation (Rs. ha^{-1})

(Additional Expenditure)

Treat. No.	Particulars	Male	Female	Bullock pair	Input cost	Total Rs.
D_1	Sowing on 26th MW	-	-	-	-	-
D_2	Sowing on 27th MW	-	-	-	-	-
D_3	Sowing on 28th MW	-	-	-	-	-
D_4	Sowing on 29th MW	-	-	-	-	-
V_1	Variety- AKT-64	-	-	-	-	-
V_2	Variety- NT-11	-	-	-	-	-
V_3	Variety- Local	-	-	-	-	-

APPENDIX - III

Prevalent rates of various operational inputs and materials (Rs.)

Sr. No.	Particulars	Rates (Rs.)
(A) Input charges		
1	SSP	16.6 Kg^{-1}
2	Urea	6.66 Kg^{-1}
3	Sesame seed	150 Kg^{-1}
(B) Labour charge		
1	Male	275/day
2	Female	275/day
3	Bullock pair	600/day
4	Tractor (Ploughing)	500/hour