EFFECT OF ROW SPACING AND VARIETIES ON GROWTH AND YIELD OF LINSEED

(*Linum usitatissimum* L.)

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IN

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BY

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ABSTRACT

EFFECT OF ROW SPACING AND VARIETIES ON GROWTH AND YIELD OF LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of 2021-22 on "Effect of row spacing and varieties on growth and yield of linseed (*Linum usitatissimum* L.)". The soil of the experimental plot was loamy sand in texture, low in available nitrogen (138.56 kg/ha), medium in available phosphorus (44.42 kg/ha) and high in available potassium (281 kg/ha) with slightly alkaline soil with pH of 7.50. There were nine treatment combinations comprising of three row spacings (22.5 cm, 30 cm and 45 cm) and three varieties (Neelam, T 397 and Pusa 3) were tested in a split plot design.

Significantly the highest plant population (44.33 and 43.70) was recorded at 30 DAS and at harvest with the row spacing of 22.5 cm (S_1). Among spacing treatments, significantly the highest plant height (22.69, 39.65 and 56.64 cm, respectively) at 30, 60 DAS and at harvest was recorded under the row spacing of 22.5 cm (S_1). Significantly the highest numbers of branches per plant (7.68), number of capsules per plant (53.44) and test weight (7.07 g) were observed under the row spacing of 45 cm (S_3). Linseed sown at narrow row spacing of 22.5 cm (S_1) produced significantly the highest seed (1307 kg/ha) and stover yield (2214 kg/ha). The maximum net realization (₹ 43713/ha) and benefit cost ratio (2.01) were recoded under the row spacing of 22.5 cm.

Pusa 3 variety recorded significantly the highest plant height of 22.65, 39.66 and 55.52 cm at 30, 60 DAS and at harvest, respectively. Significantly higher number of branches per plant (7.55), number of pods per plant (52.12) and test weight (7.08 g) were recorded with Pusa 3 variety but it was remained at par with T 397 variety. Significantly higher seed yield (1291 kg/ha) was recorded under Pusa 3 variety however it was found at par with variety T 397 (1188 kg/ha). The variety Pusa 3 recorded significantly the highest stover yield (2335 kg/ha). The maximum net realization (₹ 44604/ha) and benefit cost ratio (2.08) were accured with the Pusa 3 variety.

Based on the results of one year experimentation, it is concluded that linseed crop should be sown at row spacing of 22.5 cm for securing higher seed yield and net realization on loamy sand. Linseed varieties Pusa 3 and T 397 performed better over Neelam.

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CERTIFICATE – I

Date:12/11/2022

This is to certify that the thesis entitled, "**EFFECT OF ROW SPACING AND VARIETIES ON GROWTH AND YIELD OF LINSEED (*Linum usitatissimum* L.)**" submitted for the degree of **MASTER OF SCIENCE** in the subject of **AGRONOMY** is a record of bonafide research work carried out by **PRAJAPATI DARSHANKUMAR KANTIBHAI** under my guidance and supervision and that no part of this thesis has been submitted for any other degree, diploma, associateship, fellowship or other similar titles. The assistance and help received during the course of investigation have been fully acknowledged.

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This is to certify that **PRAJAPATI DARSHANKUMAR KANTIBHAI,** Department of **AGRONOMY**, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar has made all corrections/modifications in the thesis entitled, **"EFFECT OF ROW SPACING AND VARIETIES ON GROWTH AND YIELD OF LINSEED (*Linum usitatissimum* L.)"** as suggested by the External Examiner and the Advisory Committee in the oral examination held on **12th OCTOBER, 2022.**

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SYMBOLS AND ABBREVIATIONS USED

&	:	And
@	:	At the rate of
/	:	Per
%	:	Per cent
+	:	Plus
₹	:	Rupees
ANOVA	:	Analysis of variance
BCR	:	Benefit : Cost Ratio
C.D.	:	Critical Difference
cm	:	Centimetre
C.V.	:	Coefficient of Variation
DAP	:	Diammonium phosphate
DAS	:	Day after sowing
dS/m	:	Deci Simens per metre
d.f.	:	Degree of Freedom
EC	:	Electrical Conductivity
et al.	:	And others
etc.	:	Et citeras
Even.	:	Evening
g	:	Gram
ha	:	Hectare
hrs./day	:	Hours per day
i.e.	:	That is
K_2O	:	Potassium oxide
kg/ha	:	Kilogram per hectare
M.W.	:	Metereological Week
Max.	:	Maximum
Min.	:	Minimum
mm	:	Milimetre
Morn.	:	Morning
N	:	North
No.	:	Number
NS	:	Non Significant
^oC	:	Degree Celsius
P_2O_5	:	Phosphorus penta oxide
PB	:	Pair of Bullock
pH	:	Potenial of hydrogen ion
R.H.	:	Relative Humidity
S.Em.±	:	Standard error of mean
SDAU	:	Sardarkrushinagar Dantiwada Agricultural University
SPD	:	Split plot Design
sq. m	:	Square metre
Sr.	:	Serial
t/ha	:	Tonnes per hectare
viz.	:	Namely

INTRODUCTION

I. INTRODUCTION

Linseed (*Linum usitatissimum* L.) commonly known as *alsi* or flax belonging to the family Linaceae. It is grown mainly for seed and used for extracting oil. The oil content of the seed varies from 33-47 per cent. Linseed oil is an excellent drying oil used in manufacturing paints and varnishes, oilcloth, waterproof fabrics and linoleum. Linseed-cake is a very good manure and animal feed. Linseed is also used in making paper and plastics. Linseed (*Linum usitatissimum* L.) is a self-pollinated crop widely adapted to temperate climate of the world. It is an erect annual herb having the blue or white flowers arranged in erect terminal panicles. The fruit is a globose capsule with shiny, flattened, brown seeds with a short blunt beak.

Flax is considered as a ‘‘founder crops’’ that has been providing raw materials for medicine, food and textiles for more than 8000 years and is of great importance to the human welfare due to the presence of higher concentration of health promoting omega-3 fatty acids (alpha-linolenic acid) which lowers cholesterol level and imparts cardio vascular benefits, many linseed based recipes have been standardized. The crushed seeds/flour is used for value addition and for making various nutritious food preparations. But the linseed oil is not edible due to the laxative properties of the mucilage in the seed coat and presence of higher level of linolenic acid which causes rancidity and emits pungent flavors on oxidation. So on a very small scale, it is used for edible purpose as flax seed breads, bagels and fried food stuff by a small segment of people. In Karnataka and parts of Maharashtra, linseed is used as a traditional food adjunct-chutney powder. It is also used as a medium of frying certain foods in Himachal Pradesh (Dash *et al.*, 2017).

Flax fibre is one of the most natural and eco-friendly fibres among all the textile fibres. The characteristic features of flax fibres are their strength, fineness and durability. They are lustrous, stronger, less stretchy, more durable and more resistant to environmental fluctuation than cotton and jute. This fibre blends very well with wool, silk, cotton *etc.* Bundles of fibres look like blonde hair. The threads are very strong and so are used for shoe making, manufacturing of fishing lines and nets *etc.* The fibre is extensively used in the manufacturing of canvas, twine, carpets, blankets and mats. Rough and coarser grade fibres are used in the manufacturing of strong ropes, shipping cord, twines and cordage, which are very indispensable for

aeronautical and defense purposes. Flax fibre textiles which are called "lilen or linso-fabrics" in which best grades of flax fibres are used for manufacturing suiting, shirting, bed sheets, cloth laces, damasks, curtains *etc*. Flax-jute (Linju) and Flax-cotton (Linco) blended fabrics show better quality than cent-percent jute or cotton fabrics (Dash *et al.*, 2017).

In world, linseed crop cultivated area of 3.26 million ha and seed production is 3.18 million tonnes. Madhya Pradesh, Karnataka, Jharkhand, Bihar, Uttar Pradesh and Chhattisgarh are the leading states in linseed production in India (Anonymous, 2019a).

India is largest linseed growing country in the world and production wise it is on third rank in the world after Canada and China. Among *rabi* oilseed crops in India, linseed occupy the second position *i.e.* next to rapeseed-mustard in importance from the view point of area as well as production. Linseed is good source of calcium and phosphorus with their contents as 170 and 370 mg/100 g respectively (Kasana *et al.*, 2018).

In India linseed is cultivated on around 3.2 lakh ha land with a production of 1.74 lakh tonnes (Anonymous, 2019b). About 20 per cent of the total linseed oil produced in India is used by farmers and rest about 80 per cent goes to industries for the manufacture of paints, varnish, oilcloth, linoleum and printing ink *etc.* Fibres obtained from the stem are known for their length and strength and are two to three times as strong as those of cotton. The fibre is lustrous and blends very well with wool, silk and cotton *etc*. Linseed has an important position in Indian economy due to its wide industrial utility. But the national average productivity of linseed seed is quite low as compared to other countries. In India, linseed is grown mostly under rainfed (63%), *utera* (25%), irrigated (17%) and in input starved conditions in major linseed producing states *i.e.* Madhya Pradesh, Chhattisgarh, Maharashtra, Jharkhand, Uttar Pradesh and Odisha.

The area under cultivation of linseed crop in North Gujarat is increasing recently but least research work in agronomic aspect of linseed has been done. Yield variation in the crop is mostly bought by different agro-climatic location specific various agronomic practices. Among these variety and spacing are important factors contributing for higher production. Now a days various varieties of linseed are released by ICAR and State Agriculture Universities for getting higher productivity. It is necessary to find out the agronomic requirements of newly released varieties, to

exploit their yield potential. Selection of appropriate variety is most important factor for secure higher yield in particular climate. In North Gujarat, There is not any recommended variety for this particular climate. Therefore need to identify an appropriate variety for particular climate.

Row spacing plays an important role in increasing production per unit area. There is a direct effect of row spacing on number of capsule per plant, number of seeds per capsule, weight of seeds and seed yield per plant in linseed for particular variety and climate. Therefore, it is necessary to find out the optimum plant population for getting higher yield. Row spacing is dependent upon the expected growth of a particular crop and variety in a given Agro-climatic condition. Therefore, optimum row spacing is one of the most important factors in increasing the yield per hectare (Ganvit *et al.*, 2019).

Considering the above facts, the present research entitled **'Effect of row spacing and varieties on growth and yield of linseed'** was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of 2021-22 with the following objectives,

Objectives:

1. To find out the appropriate row spacing for better growth and yield of linseed
2. To study the performance of different varieties of linseed
3. To study the interaction effect of row spacing and varieties
4. To work out the economics of different treatments

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

An attempt has been made to review the available literature on "Effect of row spacing and varieties on growth and yield of linseed" The work out on the respects is very limited. Hence, an attempt has been made to review the work carried out in India and abroad of the related crops. The reviews of work are discussed under following headings.

2.1 Effect of row spacing

2.2 Effect of varieties

2.3 Interaction effect of row spacing and varieties

2.4 Economics

2.1 Effect of row spacing

2.1.1 Effect of row spacing on growth parameters

Gabiana *et al.* (2005) conducted a field experiment at Lincoln University, Canterbury during December 2003 to April 2004. They indicate that density 238 plant per m^2 gave significantly higher plant height, stem diameter and branches per plant of linseed over 379, 583 and 769 plants per m^2 density.

A field experiment was carried out on growth and yield comparison of different linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing during 2002-03 at the Agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan. From this study it was found that linseed planting at row spacing 45 cm recorded higher plant density (249.5/m^2), plant height (79.16 cm) at maturity and number of branches per plant (3.66) as compared to 30 cm row spacing (246.7/m^2, 74.36 cm and 3.53, respectively.) (Khan *et al.*, 2005).

Kushwaha *et al.* (2006) conducted a field experiment to study impact of row spacings and nitrogen doses on yield attributes and yields of linseed (*Linum usitatissimum* L.) varieties under irrigated conditions at bundelkhand, Uttar Pradesh during 2003-04. The results showed that significantly the highest capsules per plant and seeds per capsule recorded under row spacing of 30 cm (33.34 and 8.58, respectively) as compared to rest of spacing 20 cm (27.18 and 7.65, respectively) and 25 cm (31.91 and 8.01, respectively).

Saoji *et al.* (2007) carried out a field experiment at Gondia (Maharashtra) during *rabi* season to examine the effect of row spacing (22.5 and 30 cm) of linseed. They

found that row spacing of 22.5 cm recorded higher plant count, plant height, days to 50% flowering and days to maturity than the wider row spacing of 30 cm.

During the *rabi* seasons of 2000-01 and 2001-02, Chaudhary (2009) conducted a field experiment at the Oilseeds Research Farm Kalyanpur, Kanpur (UP). They found that row spacing of 25 cm improved linseed growth and growth attribute substantially more than row spacing of 20 and 30 cm.

Dias *et al.* (2014) conducted a field trial with three spacing of flaxseed (15, 30 and 45 cm) at Western Parana State University in Brazil during the summer. In comparison to the larger row spacing, they found that the narrow row spacing of 30 cm gave higher plant height.

Andruszczak *et al.* (2015) conducted a field experiment on rendzina soil in the years 2010-12 at Bezek Experimental Farm. The seeds of two linseed cultivars (Szafir and Oliwin) were sown at row spacing of 15 cm and 25 cm. They reported that higher number of branches per plant found in 25 cm (8.65) followed by 15 cm (7.77).

Kumar and Tripathi (2015) carried out a field experiment at School of Forestry and Environment of Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad during *rabi* season of 2013-14. They indicated that row spacing of 20 cm of linseed gave significantly higher plant height while number of branches per plant recorded higher at 30 cm spacing over other row spacing.

Field experiment was conducted at Koont Research Farm, PMAS Arid Agriculture University, Rawalpindi to find the effect of agro management practices on linola, during *rabi* 2008-09 and they observed that significantly higher plant height (82.05 cm) was observed in T_9 (15 cm x 30 cm), but it was found statistically at par with T_1 (5 cm x 10 cm), T_5 (10 cm x 20 cm) and T_6 (10 cm x 30 cm). Significantly higher number of basal branches per plant (6.567) was produced by the crop grown at T_9 (15 cm x 30 cm), however which was statistically at par with T_6 (10 cm x 30 cm), T_8 (15 cm x 20 cm) and T_3 (5 cm x 30 cm). (Ali *et al.,* 2016).

During the seasons 2015-16 and 2016-17, Barakat and alaeldin (2018) conducted a field experiment at Hudeiba Research Station Farm, River Nile State. They discovered that spacing of 30 cm resulted in much higher plant height (60.3 cm) and number of branches per plant (20.9) of linseed than spacing of 10 cm, 20 cm and 40 cm.

Gaikwad *et al.* (2019) conducted a field experiment during *rabi* season of 2016-17 on vertisol at oilseed research station, Latur to assess the response of linseed

varieties to different spacing and fertilizer levels. The result showed that the spacing of 30 cm × 10 cm produced significantly higher number of branches per plant and total dry matter (5.88 and 12.63 kg/ha, respectively) whereas, significantly lower number of branches per plant and total dry matter were noticed in spacings 45 cm × 5 cm and 30 cm × 5 cm (5.31, 11.64 kg/ha and 4.54, 10.91 kg/ha, respectively).

The results of an experiment conducted by Ganvit *et al.* (2019) during *rabi* 2016-17 at College Farm, Navsari Agriculture University, Navsari, Gujarat on effect of sowing dates and crop spacing on growth, yield and quality of linseed under south Gujarat condition. They showed that significantly the highest plant height recorded under spacing of 20 cm × 5 cm (59.73 cm). Significantly higher number of branches per plant was observed under spacing 40 cm x 5 cm (9.76) but it was found at par with spacing 30 cm x 5 cm (9.63).

An experiment was conducted during 2017-18 *rabi* season at the farmer field of Dabat district with the objective of evaluating the effects of seed rate and row spacing on the yield and yield components of linseed and they revealed that significantly higher plant height found in row spacing of 25 cm (78.27 cm) as compared to rest of the treatments. Significantly higher primary branches was obtained at 30 cm, whereas, the lowest number of primary branches was recorded at 20 cm. (Teshome *et al.,* 2020).

2.1.2 Effect of row spacing on yield and yield attributes

Gabiana *et al.* (2005) conducted a field experiment at Lincoln University, Canterbury during December 2003 to April 2004. They indicated that density of 238 plant per m^2 gave significantly higher number of capsules per plant, number of seed per capsule, test weight and seed yield of linseed over 379, 583 and 769 plants per m^2.

Hassan *et al.* (2005) carried out a field experiment at Department of agronomy, university of arid agriculture, Rawalpindi, Pakistan during *rabi* season to examine the effect of row spacing (12, 15 and 20 cm). They observed that the row spacing of 12 cm gave significantly higher yield and harvest index over 15 cm and 20 cm row spacing.

Khan *et al.* (2005) conducted a field experiment during 2002-03 at the Agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan to assess the growth and yield comparison of different linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing. They reported

that linseed gave the maximum number of seeds per capsule (8.86) and 1000-seed weight (5.66 g) with row spacing of 45 cm and the maximum seed yield (1.06 t/ha) and harvest index recorded (26.58 %) with 30 cm row spacing.

At Bundelkhand, Uttar Pradesh Kushwaha *et al.* (2006) conducted a field experiment during 2003-04 and they studied impact of row spacings and nitrogen doses on yield attributes and yields of linseed (*Linum usitatissimum* L.) varieties under irrigated conditions and they noticed that significantly the highest seed yield recorded under row spacing of 20 cm (16.80 q/ha) followed by 25 cm (15.77 q/ha).

Saoji *et al.* (2007) carried out a field experiment at Gondia (Maharashtra) during *rabi* season to examine the effect of row spacing (22.5 and 30 cm). They observed that the wider row spacing of 30 cm recorded numerically higher capsules per plant, test weight and seed yield as compared to row spacing of 22.5 cm.

Darja *et al.* (2008) conducted a field experiment at University of Ljubljana Biotechnical Faculty, Slovania during summer season to study the row spacing (8.5, 17 and 34 cm) on the yield of flax. They reported that the row spacing of 17 cm gave significantly higher seed yield over 34 cm row spacing.

Chaudhary (2009) conducted a field experiment at Oilseeds Research Farm Kalyanpur, Kanpur (Uttar Pradesh) during *rabi* seasons of 2000-01 and 2001-02. They indicated that row spacing of 25 cm significantly increased higher yield.

Dias *et al*. (2014) carried out a field experiment at Western Parana State University, Brazil during summer season with three spacing (15, 30 and 45 cm) of flaxseed. They reported that the row spacing of 30 cm recorded the maximum seed yield as compared to row spacing 15 and 45 cm.

The results of an experiment on yield and quality traits of two linseed (*Linum usitatissimum* L.) cultivars as affected by some agronomic factors conducted by Andruszczak *et al.* (2015) during 2010-12 at Bezek Experimental Farm and they showed that significantly the highest seed yield (2.34 t/ha) recorded under row spacing of 15 cm.

Kumar and Tripathi (2015) carried out a field experiment at School of Forestry and Environment of Sam Higginbottom Institute of Agriculture Technology and Sciences Allahabad during *rabi* season of 2013-14. They indicated that row spacing of 20 cm of linseed gave significantly higher seed yield (15.26 q/ha) over 25 cm and 30 cm spacing whereas number of capsules per plant (27.74) and test weight recorded higher (7.35 g) at 30 cm spacing.

Ali *et al.* (2016) conducted a field experiment at Koont Research Farm, PMAS Arid Agriculture University, Rawalpindi, to find the effect of agro management practices on Linola, during *rabi* 2008-09 and they reported that significantly higher seed yield (1104.05 kg/ha) was observed under T_8 (15 cm x 20 cm) but it was found at par with T_6 (10 cm x 30 cm), T_5 (10 cm x 20 cm) and T_7 (15 cm x 10 cm) and higher value for biological yield (4058 kg/ha) was observed under T_8 (15 cm x 20 cm), however it was found at par with T_9 (15 cm x 30 cm).

Gohil *et al*. (2016) carried out a field experiment at Navsari during *rabi* season of 2013-14 to study the row spacing of 30 and 45 cm on linseed. They reported that spacing of 30 cm gave significantly increased seed yield (832 kg/ha) and stover yield (2743 kg/ha) than 45 cm row spacing.

Gaikwad *et al.* (2019) conducted a field experiment during *rabi* season of 2016-2017 on vertisol at oilseed research station, Latur to assess the response of linseed varieties to different spacing and fertilizer levels and they reported that spacing of 30 cm × 5 cm produced significantly higher seed yield (1021 kg/ha) and oil yield (393 kg/ha) over the spacings of 30 cm × 10 cm and 45 cm × 5 cm. The spacing of 30 cm × 5 cm recorded significantly higher straw yield (1554 kg/ha) over other row spacing but it was found at par with 45 cm × 5 cm (1410 kg/ha) and significantly superior over 30 cm × 10 cm (1360 kg/ha).

Ganvit *et al.* (2019) conducted a field experiment at College Farm, Navsari Agriculture University, Navsari, Gujarat in *rabi* season 2016-17 to study the effect of sowing dates and crop spacing on growth, yield and quality of linseed under south Gujarat condition. The results revealed that significantly higher seed and stover yield were recorded under spacing of 20 cm × 5 cm (1262 kg/ha) and (2976 kg/ha) but it was at par with spacing of 30 cm x 5 cm (1227 kg/ha and 2678 kg/ha seed and stover yield, respectively).

An experiment was conducted during 2017-18 *rabi* season at the farmer field of Dabat district with the objective of evaluating the effects of seed rate and row spacing on the yield and yield components of linseed and they observed that significantly higher 1000 seed weight (4.96 g), biomass yield (3789.3 kg/ha) and harvest index (37.88 %) were found in row spacing of 25 cm as compared to rest of the treatments (Teshome *et al.,* 2020).

2.2 Effect of varieties

2.2.1 Effect of varieties on growth parameters

An experiment was conducted to study the performance of Sweta and T 397 cultivars of linseed under land configuration with and without FYM application in salt affected soils under rainfed situation during *rabi* season of 2000-01 at different farmers fields in Kanpur, Uttar Pradesh, India and they showed that higher plant stand, greater plant height and higher germination were recorded under variety Sweta than T 397 (Verma *et al.,* 2004).

A field investigation was carried by Dubey *et al.* (2005) to determine influence of climatic condition during crop season on oil and its quality components of linseed. The linseed varieties Mukta, Hira, T 397, Shubhra and Garima were evaluated for yield and quality under different soil pH (7.0-7.2, 7.5-8.3 and 8.5-9.1) in Kanpur, Uttar Pradesh. They observed that Mukta exhibited the maximum germination percentage under pH range of 7.5-8.3 as well as 8.5-9.1.

A field experiment was carried out on growth and yield comparison of different linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing during 2002-03 at the Agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan the results showed that higher plant height (83.22 cm) under genotype randkat and higher number of branches per plant (4.11) under genotype Carlos-80 as compared to rest of the genotypes (Khan *et al.*, 2005).

Kushwaha *et al.* (2006) conducted a field experiment during 2003- 04 to study the effect of row spacings and nitrogen doses on yield attributes and yields of linseed (*Linum usitatissimum* L.) varieties under irrigated conditions of Bundelkhand and they reported that variety Padmini produced significantly higher number of branches per plant during both the years. On pooled basis it produced 13.64 branches per plant which was 24.8 and 11.6 percent higher than T 397 and Laxmi 27, respectively.

Bozkurt *et al.* (2007) conducted a field experiment on effects of sowing time on quantitative growth of linseed cultivars (Antares and Sar 85). They noted that significantly higher plant height, total plant dry weight, net assimilation rate, root weight ratio and stem weight ratio recorded under variety Antares than Sar 85 in all characters.

A field trial was carried out by Chauhan *et al.* (2008) to examine effect of sowing dates, varieties and number of irrigations on yield attributes, yield and quality of linseed (*Linum usitatissimum* L.) under Bundelkhand condition of Uttar Pradesh.

They reported that final height of main shoot was found significantly higher in Neelam followed by Subhra might be due the genetic constitution and favourable environmental conditions prevailed during the trial.

The results of an experiment conducted by Singh *et al.* (2013) to evaluate influence of N, P, K, S and variety on growth, yield and quality of irrigated linseed during winter *rabi* season of 2009-10 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. They revealed that among the two linseed varieties Shekhar produced significantly higher plant height, primary and secondary branches per plant and dry matter accumulation per plant over Garima.

Andruszczak *et al.* (2015) conducted a field experiment on rendzina soil in the years 2010–2012 at Bezek Experimental Farm. The seeds of two linseed cultivars (Szafir and Oliwin) were sown at row spacing of 15 cm and 25 cm and reported that variety Szafir produced significantly the highest number of branches per plant (8.90).

The experiment was conducted during *rabi* season of 2011-12 to study the impact of different sowing times on growth, yield and quality of linseed cultivars. The results showed that significantly the highest plant height was recorded under variety Garima (58.67 cm). Significantly higher branches per plant observed under treatment V_2 (Shekhar) than other varieties but it was found at par with treatment V_4 (Garima) (Ganga *et al.,* 2015).

An experiment on effect of extended sowing dates on different linseed varieties was conducted at, Agronomy Farm, College of Agriculture, Pune during the year of 2012- 2013 in *rabi* season. The result showed that the highest plant height (64.32 cm), plant spread (16.93 cm) and number of branches/plant (4.87) of linseed was observed in PKVNL 260 but it was found significantly superior over rest of the linseed varieties (Adagale *et al.*, 2016).

Gaikwad *et al.* (2019) conducted a field experiment during *rabi* season of 2016 on vertisol at oilseed research station, Latur to assess the response of linseed varieties to different plant spacing and fertilizer levels. They revealed that significantly the highest plant height recorded under variety NL 260 (55.19 cm) and significantly the highest number of branches was recorded under variety LSL 93 (5.40 cm).

2.2.2 Effect of varieties on yield and yield attributes

Patil and Tripathi (2000) studied performance of linseed varieties under varying sowing and fertilizer management in rainfed condition and they observed that linseed variety 'Kiran' gave the maximum seed yield (1230 kg/ha) followed by R 552 (1050 kg/ha) and RLC 29 (995 kg/ha).

Bastia and Mohanty (2001) conducted a field experiment on response of linseed varieties to fertility levels under rainfed condition. They revealed that variety Laxmy 27 gave better yield (588.19 kg/ha) as compared to Pusa 3 (550.59 kg/ha) and Kiran (524.19 kg/ha).

Margaret *et al.* (2004) conducted experiment used three cultivar he recorded variation in yield in between different cultivar that is Bethune (1764 kg/ha), Hanley (2001 kg/ha) and Norlin (1775 kg/ha).

The experiment was conducted to study performance of Sweta and T 397 cultivars of linseed under land configuration with and without FYM application in salt affected soils under rainfed situation during *rabi* season 2000-01 at different farmers' fields in Kanpur, Uttar Pradesh, India. The results showed that significantly higher straw yield, number of seeds and seed weight per plant, 1000-seed weight and seed yield than T 397 (Verma *et al.,* 2004).

The performance of 8 cultivars/advance lines of linseed *viz.,* Neelam, K2, LCK 9814, LCK 2012, Garima, Sweta, Rashmi and LNK 9933 and 3 controls (Mukta, Hira and T 397) were evaluated on salt sick soils in Kanpur, Uttar Pradesh, during 2001-02 and 2002-03. Among all the cultivars, Garima, performed best in respect of seed yield (607 kg/ha) (Dubey *et al.,* 2005).

Khan *et al.* (2005) conducted a field experiment during 2002-03 at the Agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University, Multan to assess the growth and yield comparison of different Linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing. They observed that higher seed yield (1.09 t/ha) and harvest index (27.64%) recorded under genotype Carlos-80 as compared to rest of the genotypes.

Kushwaha *et al.* (2006) conducted field experiment during 2003-04 to study the effect of row spacings and nitrogen doses on yield attributes and yields of linseed (*Linum usitatissimum* L.) varieties under irrigated conditions of Bundelkhand. They reported that significantly the highest seed yield recorded under variety Padmini 16.88 q/ha as compared to rest of the treatments.

Townshend and Boleyn (2006) conducted a field experiment at New Zealand and revealed that variety Bilton recorded the maximum seed yield (2996 kg/ha) than Biltstar (2770 kg/ha).

A field trial was carried out by Chauhan *et al.* (2008) to examine effect of sowing dates, varieties and number of irrigations on yield attributes, yield and quality of linseed *(Linum usitatissimum* L.) under Bundelkhand condition of Uttar Pradesh and they observed that seed and stover yield differences among varieties were found significant in pooled data of two years. These parameters were found significantly higher in Neelam and Laxmi 27 as compared to other varieties.

The results of an experiment conducted by Singh *et al.* (2013) to evaluate influence of N, P, K, S and variety on growth, yield and quality of irrigated linseed during winter *rabi* season of 2009-10 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh they revealed that significantly higher number of capsules per plant, seeds per capsule and 1000-seeds weight were observed in Shekhar than Garima variety resulted in lucidly higher seed and stover yield in Shekhar by 18.9 and 13.0 per cent, respectively than Garima.

The results of an experiment on yield and quality traits of two linseed (*Linum usitatissimum* L.) cultivars as affected by some agronomic factors conducted by Andruszczak *et al.* (2015) during 2010–12 at Bezek Experimental Farm and they showed that significantly the highest seed yield (2.38 t/ha) was recorded under variety Szafir.

A study was conducted by Ganga *et al.* (2015) during *rabi* season of 2011-12 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi with a view to study the effect of different sowing dates and varieties on growth, yield and quality of linseed and they revealed that variety Shekhar recorded significantly higher seed yield (15.4 q/ha), harvest index (34.58%), number of capsules per plant (53.89) followed by Neelam, T 397 and Garima.

Kumar and Tripathi (2015) studied the varietal performance of linseed (*Linum usitatissimum* L.) planted at different spacing. Among different varieties Padmini was observed to be superior and gave higher seed yield over variety T 397.

An experiment on effects of extended sowing dates on different linseed varieties was conducted at, Agronomy Farm, College of Agriculture, Pune during the year of 2012 - 13 in *rabi* season and they revealed that seed and straw yields were recorded

significantly the highest under variety PKVNL 260 (18.12 q/ha and 28.69 q/ha, respectively) (Adagale *et al.*, 2016).

Maurya *et al.* (2017) conducted field experiment at Agricultural research farm, Institute of Agricultural Sciences, Varanasi, Uttar Pradesh, India in *rabi* season 2011-12 to study the effect of date of sowing on yield attributes and yield of linseed (*Linum usitatissimum* L.) varieties under dryland condition in Eastern Uttar Pradesh and they observed that significantly the highest seed yield (14.19 q/ha) and straw yield (28.64 q/ha) recorded under variety Shekhar.

Gaikwad *et al.* (2019) conducted a field experiment during *rab*i season of 2016 on vertisol at oilseed research station, Latur to assess the response of linseed varieties to different plant spacing and fertilizer levels. They showed that significantly higher total dry matter recorded under variety LSL 93 but it was found at par with NL 260 while significantly the highest number of capsules per plant recorded under variety LSL 93 (56.81).

2.3 Interaction effect of row spacing and varieties

Khan *et al.* (2005) conducted a field experiment during 2002-03 at the Agronomic Research Area, College of Agriculture, Bahauddin Zakariya University, Multan to assess the growth and yield comparison of different linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing. They observed that seed yield was affected significantly by row spacings, varieties and their interaction. The variety Carlos 80 sown at 30 cm row spacing produced the highest mean seed yield 1.35 t/ha and the genotype LS 30 sown at 45 cm row spacing produced the lowest seed yield 0.73 t/ha.

Andruszczak *et al.* (2015) conducted a field experiment on rendzina soil in the years 2010–2012 at Bezek Experimental Farm. The seeds of two linseed cultivars (Szafir and Oliwin) were sown at row spacing of 15 cm and 25 cm and reported that higher number of branches per plant (9.29) found in Szafir × 25 cm as compared to other treatments. While higher seed yield (2.52 t/ha) recorded under Szafir × 15 cm.

Kumar *et al.* (2015) carried out a field experiment at School of Forestry and Environment of Sam Higginbottom Institute of Agriculture Technology and Sciences Allahabad in the *rabi* season during year 2013-14 and they studied varietal performance of linseed planted at different spacing under teak-based agroforestry system. The results showed that interaction effect was recorded significantly the highest seed yield in variety Padmini with row spacing-20 cm (16.91 q/ha).

2.4 Economics

Khare *et al.* (1999) conducted a field experiment at Sagar (M. P.) during *rabi* season and reported that the maximum monetary returns and profitability was recorded in regular sowing of linseed with spacing 30 cm apart.

Singh *et al.* (2013) accomplished a field investigation on influence of N, P, K, S and variety on growth, yield and quality of irrigated linseed during winter *rabi* season of 2009-10 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh and they reported that Shekhar variety which exhibited the maximum net returns (₹ 18570/ha) and output input ratio (2.04).

A field experiment was carried out by Ganga *et al.* (2015) at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi with a view to study the effect of different sowing dates and varieties on growth, yield and quality of linseed and they revealed that the highest net return (₹ 34219/ha) and B : C ratio (1.77) were obtained in Shekhar variety followed by Neelam, Garima and T 397.

An experiment on effects of extended sowing dates on different linseed varieties was conducted at, Agronomy Farm, College of Agriculture, Pune during the year of 2012- 2013 in *rabi* season and they observed that the maximum gross return (₹ 79728 /ha), net returns (₹ 36026/ha) and B : C ratio (1.82) were observed in linseed variety PKVNL 260. (Adagale *et al.*, 2016).

Maurya *et al.* (2017) conducted field a experiment at Agricultural research farm, Institute of Agricultural Sciences, Varanasi, Uttar Pradesh, India in *rabi* season 2011-12 to study the effect of date of sowing on yield attributes and yield of linseed (*Linum usitatissimum* L.) varieties under dryland condition in Eastern Uttar Pradesh and reported that the highest net return and benefit cost ratio were ₹ 33624.9/ha and 1.92, respectively in Shekhar variety followed by Neelam (₹ 30980.57/ha and 1.77) and T 397 (₹ 27574.57/ha and 1.57).

The results of an experiment conducted by Gaikwad *et al.* (2019) during *rabi* season of 2016-2017 on vertisol at oilseed research station, Latur to assess the response of linseed varieties to different spacing and fertilizer levels revealed that the spacing of 30 cm × 5 cm recorded significantly higher gross returns (₹ 50626/ha) over rest of the spacings. The highest net returns (₹ 28645/ha) was also observed with spacing of 30 cm × 5 cm which was significantly superior over 45 cm × 5 cm and it

was found at par with spacing of 30 cm × 10 cm. The highest B : C ratio (2.32) was observed with the spacing of 30 cm × 5 cm over 30 cm × 10 cm and 45 cm × 10 cm.

The results of an experiment on effect of sowing dates and crop spacing on growth, yield and quality of linseed under south Gujarat condition conducted by Ganvit *et al.* (2019) during *rabi* 2016-17 at College Farm, Navsari Agriculture University, Navsari, Gujarat and they observed that the highest net returns (₹ 72565/ha) was recorded under the treatments S_1 : (20 cm x 5 cm) with 4.43 BCR as compared to other two treatment S_2 : 30 cm × 5 cm (₹ 70056/ha and 4.28 BCR), S_3 : 40 cm × 5 cm (₹ 65082/ha and 3.98 BCR).

MATERIAL AND METHODS

III. MATERIAL AND METHODS

This chapter deals with the details of materials used during the course of investigation and methods adopted in conducting the present investigation entitled *"*Effect of row spacing and varieties on growth and yield of linseed*"*.

3.1 Experimental site

A field experiment was conducted during the *rabi* season of the year 2021-22 on Block - B, plot No. 7 of the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat.

3.2 Climate and weather

Geographically, Sardarkrushinagar is situated at 24°19' N latitude and 72°19' E longitude, with an elevation of 154.52 m above the mean sea level. The climate of Sardarkrushinagar is arid and semi-arid. In this area, monsoon commences by the third week of June and retreats by the middle of September. Uncertain and uneven distribution of rainfall occur during the monsoon in Banaskantha district. Partial failure of rains once in three or four years is very common. July and August are the months of heavy precipitation. There is no rainfall in winter and summer almost in all parts of Gujarat. Temperature during most part of rainy season ranges from 20 °C to 35 °C, however, in the month of October; it rises to as high as 37 °C. It continues to drop from the beginning of November, while winter season sets in and continues till the middle of February; December and January are the coldest months. The average minimum temperature during the winter ranges from 5°C to 18 °C, while the average maximum temperature varied from 24 °C to 38 °C.

The standard week-wise meteorological data for the period of investigation recorded at the Agricultural Meteorology Observatory located at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, District- Banaskantha are presented in Table 3.1 and depicted graphically in Figure. 3.1.

The data indicated that mean maximum temperature ranged between 21.9 to 39.2°C, while mean minimum temperature ranged between 6.0 to 18.7°C during the period of experimentation. The mean relative humidity ranged from 57 to 77 per cent. The bright sunshine ranged between 5.4 to 9.8 hours/day during crop period.

Table 3.1: Standard week-wise meteorological data recorded during crop season of *rabi* 2021-22

Standard meteorological weeks	Temperature °C		Bright sunshine (hours)	Rain fall (mm)	Wind speed (km/hrs)	Relative humidity (%)	
	Max.	Min.				Morn.	Even.
November, 2021							
46	32.4	13.6	8.2	0.0	2.7	71	51
47	28.9	17.5	5.4	0.0	2.6	77	55
48	31.6	15.4	8.0	0.0	2.6	74	47
December, 2021							
49	28.1	13.6	7.5	0.0	2.9	70	35
50	26.5	10.6	8.0	0.0	2.7	70	32
51	25.2	7.6	8.9	0.0	3.3	70	30
52	27.1	11.7	6.8	0.0	2.8	76	41
January, 2022							
1	25.9	12.7	6.4	0.0	2.4	76	53
2	21.9	7.0	8.9	0.0	4.4	67	45
3	24.9	8.5	8.9	0.0	2.8	68	39
4	25.0	6.0	7.9	0.0	4.1	57	35
5	27.6	8.8	9.2	0.0	3.2	65	33
February, 2022							
6	27.9	9.5	9.0	0.0	3.2	64	31
7	30.3	10.0	9.5	0.0	2.7	65	29
8	32.4	12.6	9.4	0.0	3.8	69	26
9	32.9	15.4	9.8	0.0	5.2	69	23
March, 2022							
10	35.0	16.1	9.0	0.0	4.2	69	22
11	39.2	17.7	9.5	0.0	3.4	71	20
12	38.9	18.7	9.3	0.0	4.6	70	23

All over climatological data indicated that the weather conditions were fairly cool and dry during the investigation period and more or less quite favourable for the satisfactory growth and development of the linseed crop during *rabi* season of 2021-22.

3.3 Cropping history of the experimental site

The cropping history of the experimental plot block-B, No. 7, for preceding years is illustrated in Table 3.2.

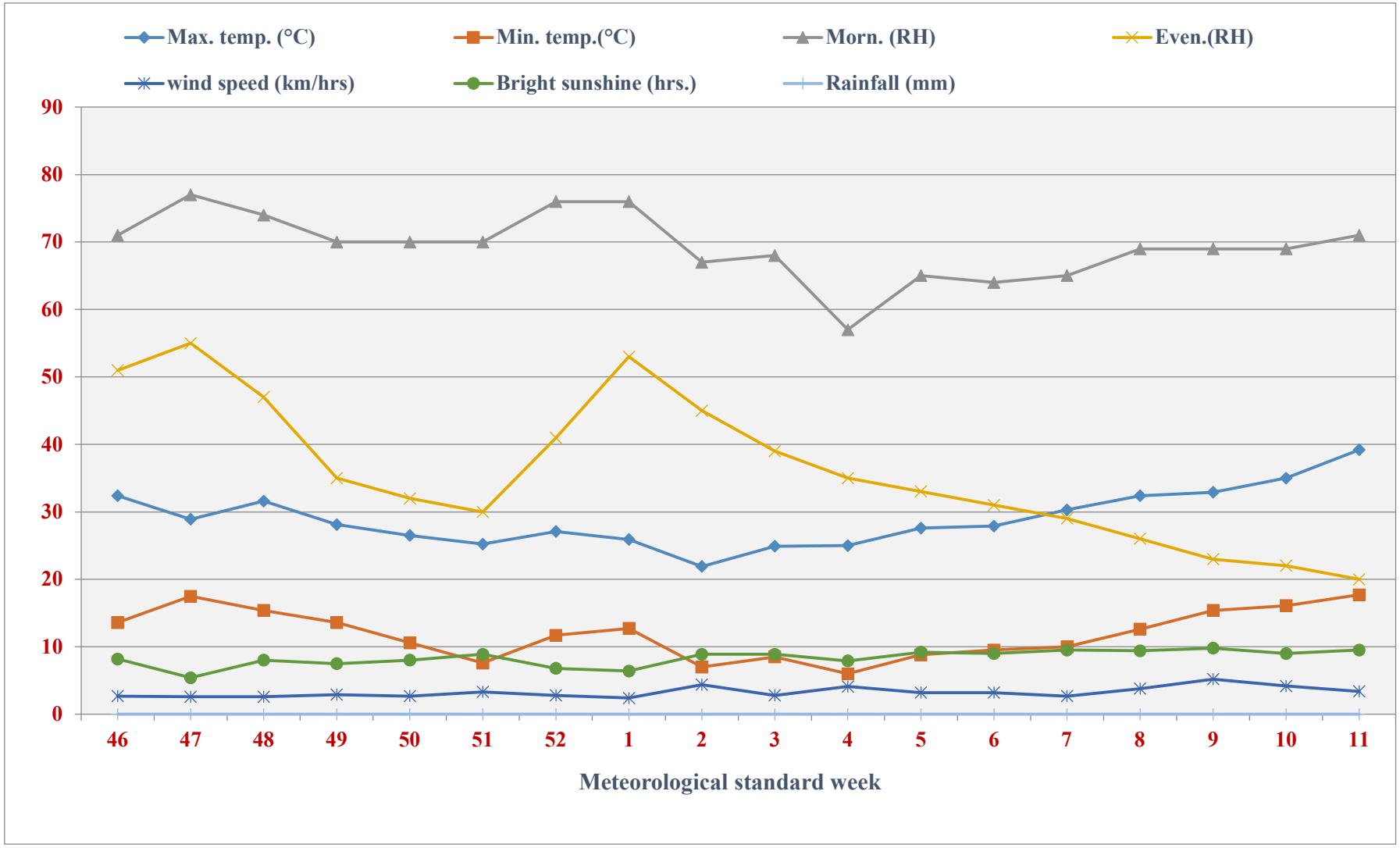

Figure 3.1: Mean weekly meteorological data for crop season during 2021-22

Table 3.2: Cropping history of the experimental site

Year	Season	Crop	Fertilizer (kg/ha)		
			N	P_2O_5	K_2O
2018-19	*Kharif*	Groundnut	12.5	25	00
	Rabi	Chickpea	20	40	00
	Summer	Fallow	-	-	-
2019-20	*Kharif*	Cowpea	20	40	00
	Rabi	Cumin	40	15	00
	Summer	Fallow	-	-	-
2020-21	*Kharif*	Groundnut	12.5	25	00
	Rabi	Gram	20	40	-
	Summer	Fallow	-	-	-
2021-22	*Kharif*	Bajara	80	40	00
	Rabi	Linseed (Present experiment)	60	40	00

3.4 Physico-chemical properties of soil

Table 3.3: Physico-chemical properties of experimental plot

Sr. No.	Properties	Soil depth 0-15 (cm)	Methods employed
[A] Mechanical properties			
(a)	Sand (%)	84.32	International Pipette method (Piper, 1966).
(b)	Silt (%)	8.06	
(c)	Clay (%)	7.62	
(d)	Textural class	Loamy sand	
[B] Chemical properties			
(a)	Soil pH (1.0:2.5, Soil: Water ratio)	7.50	Potentiometric method (Jackson, 1973).
(b)	Electrical conductivity (dS/m) (1.0:2.5, Soil: Water ratio)	0.11	Schofield method (Jackson, 1973).
(c)	Organic carbon (%)	0.29	Walkley and Black's rapid titration method (Jackson, 1973)
(d)	Available N (kg/ha)	138.56	Alkaline permanganate method (Subbiah and Asija, 1956)
(e)	Available P_2O_5 (kg/ha)	44.42	Olsen's method (Olsen *et al*. 1954).
(f)	Available K_2O (kg/ha)	281	Flame photometric method (Jackson, 1973)

The texture of the soil was loamy sand. The composite soil samples were collected from the experimental plots to a depth of 0-15 cm before sowing of the crop

and they were analyzed for determining the physical properties as well as chemical parameters of the soil, details of which are given in Table 3.3. It is alluvial in origin, light brown in colour, well drained, fairly retentive of moisture and low in available nitrogen, while medium in available phosphorus and higher in available potassium. It is suitable for a variety of crops of arid and semi-arid origins.

Table 3.4: Selection of crop and variety

Characteristics	**Neelam**	**T 397**	**Pusa 3**
Year of release	1980	1960	1985
Days to maturity	125 - 150	125 - 145	130 - 150
Yield (kg/ha)	1400 – 1600	1000 – 1800	1500 - 1900
Seed oil contain (%)	43	44	45
Flower colour	White	Blue	Blue

3.5 Experimental details

A field experiment entitled **"**Effect of row spacing and varieties on growth and yield of linseed*"* was laid out in split plot design with four replications during the *rabi* season of 2021-22.

3.5.1 Treatment details

The details of experimental treatments are illustrated in Table 3.4.

[A] Main plot (S) row spacing

S_1: 22.5 cm

S_2: 30 cm

S_3: 45 cm

[B] Sub plot (V) variety

V_1 : Neelam

V_2 : T 397

V_3 : Pusa 3

3.5.2 Experimental design and layout

The experiment was laid out in a split plot design with four replications. The layout of experiment was depicted in Figure 3.2. The details of the experiment are presented in Table 3.5.

Table 3.5: Treatment combinations

Treatment	Treatment combinations		Row spacing(S)	Variety (V)
T_1	S_1V_1	:	22.5 cm spacing	Neelam
T_2	S_1V_2	:	22.5 cm spacing	T 397
T_3	S_1V_3	:	22.5 cm spacing	Pusa 3
T_4	S_2V_1	:	30 cm spacing	Neelam
T_5	S_2V_2	:	30 cm spacing	T 397
T_6	S_2V_3	:	30 cm spacing	Pusa 3
T_7	S_3V_1	:	45 cm spacing	Neelam
T_8	S_3V_2	:	45 cm spacing	T 397
T_9	S_3V_3	:	45 cm spacing	Pusa 3

Table 3.6: Experimental details

Experimental design		:	Split plot Design
Number of replications		:	4
Number of treatments		:	9
Number of plots		:	36
Crop		:	Linseed
Variety		:	V_1= Neelam, V_2= T 397, V_3= Pusa 3
Plot size	Gross	:	6.0 m x 4.5 m
	Net	:	S_1= 4.6 m x 3.6 m S_2= 4.6 m x 3.9 m S_3= 4.6 m x 3.6 m
Spacing		:	S_1= 22.5 cm, S_2= 30 cm, S_3= 45 cm
Seed rate		:	S_1= 30 kg/ha, S_2= 20 kg/ha, S_3= 15 kg/ha

3.6 Cultural operations

The schedule of field operations performed during the period of investigation are described and also furnished in Table 3.6.

3.6.1 Land preparation

The experimental field was prepared by tractor drawn implements. The field was cultivated by cultivator in both the directions and it was followed by harrowing and planking for leveling and preparation of fine seedbed.

3.6.2 Experimental layout

The experiment was laid out in split plot design with four replications. The treatment consist of three row spacing and three varieties. The experimental layout was prepared by manually then the treatments were allotted randomly in each replication as shown in Figure. 3.2.

3.6.3 Fertilizer application

The shallow furrows were opened in each plot as per treatments in dry condition. The entire quantity of phosphorous (40 kg P_2O_5 per ha) in the form of DAP and 50 percent dose of nitrogen (30 kg N per ha) in the form of DAP and urea were manually applied uniformly in previously opened furrows before sowing of linseed crop. Remaining 50 per cent nitrogen (30 kg N per ha) in the form of urea was applied at 40 days after sowing as top dressing when irrigation was applied.

3.6.4 Sowing

Seeds of linseed varieties Neelam, T 397 and Pusa 3 were used for sowing on 16th November 2021. The seeds were sown manually at a depth of 3 cm in the spaced at 22.5 cm, 30 cm and 45 cm where fertilizer applied and lightly covered with the soil. The plots were irrigated immediately after sowing to ensure uniform germination.

3.6.5 Irrigation

The first irrigation was applied immediately after sowing to ensure good and even seed germination. Second light irrigation was given after four to six days after first irrigation for quick germination and establishment of seedling. Remaining seven irrigation were given according to moisture condition of soil and when required to crop.

3.6.6 Interculturing and hand weeding

Two interculturing followed by hand weeding was carried out at 40 and 55 DAS to keep the plots free from weeds and better soil aeration.

3.6.7 Harvesting and threshing

The crop was harvested on attaining physiological maturity. Five randomly selected plants (Previously tagged) from each plot were harvested separately for recording necessary biometric observations and their produces were added to the respective net plot yield later on. The border lines were harvested first and were removed from experimental area. Then the net area was harvested simultaneously.

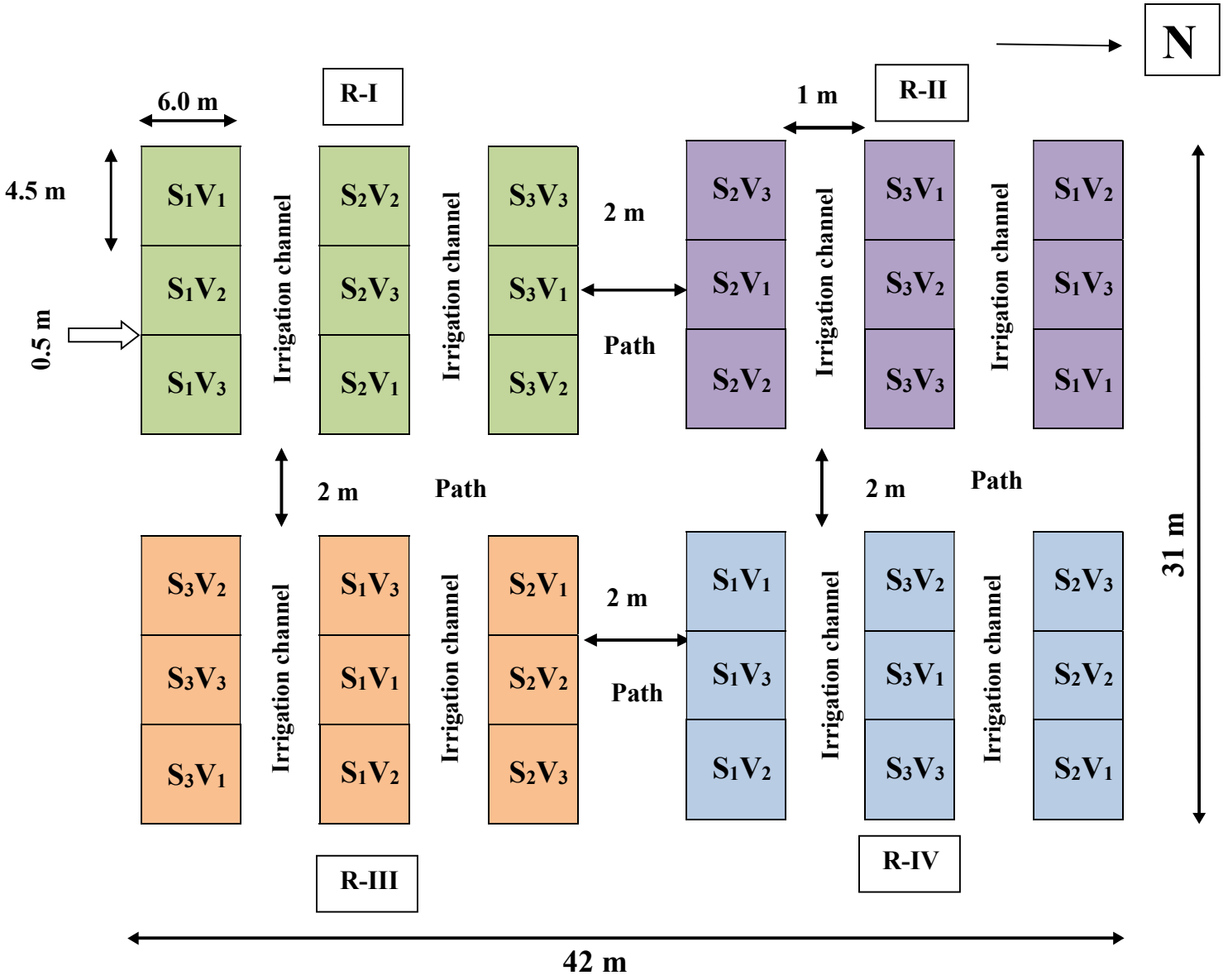

Fig. 3.2: Layout of field experiment

Design : Split plot design

Gross Plot size : 6.0 m x 4.5 m

Net plot size : S_1 = 4.6 m x 3.6 m

S_2 = 4.6 m x 3.9 m

S_3 = 4.6 m x 3.6 m

Replication : 4

Total Area : 1302 m^2

Table 3.7: Calendar of cultural operations followed during the course of investigation

Sr. No.	Name of operation		Frequency	Date
[A]	**Pre-sowing operations:**			
	(1)	Tillage by tractor drawn cultivator followed by harrowing and planking	1	14-11-2021
	(2)	Lay-out of experiment	1	15-11-2021
	(3)	Opening of furrows for fertilizer application	1	15-11-2021
	(4)	Application of fertilizer (basal)	1	16-11-2021
[B]	**Sowing and Post-sowing operations:**			
	(1)	Sowing	1	16-11-2021
	(2)	Top dressing	1	24-12-2021
	(3)	Irrigations:		
		1^{st} 2^{nd} 3^{rd} 4^{th} 5^{th} 6^{th} 7^{th} 8^{th} 9^{th}	9	16-11-2021 20-11-2021 07-12-2021 24-12-2021 08-01-2022 23-01-2022 07-02-2022 20-02-2022 03-03-2022
	(4)	Hand weeding	2	25-12-2021 09-01-2022
	(5)	Interculturing	2	25-12-2021 09-01-2022
	(6)	Harvesting	1	20-03-2022
	(7)	Threshing and cleaning	1	26-03-2022

and the produce was tied into bundles and was allowed to sun dry in respective plots for 6 to 7 days. Dried bundles were weighed separately for each plot and threshed. After cleaning, the grain weight was recorded and stover yield was recorded by subtraction of grain yield from the total biological yield**.**

3.7 Biometric observations

The biometric observations were recorded from plant present in one m^2 and five randomly selected tagged plants within each net plot. The details of various plant population growth characters, yield attributes and economics studied during the course of investigation are given in Table 3.7 along with the size of samples and time of recording. Details of the techniques employed for recording observations are described below.

3.7.1 Plant population

The number of plants per sq. m from each net plot were counted at 30 DAS and at harvest.

3.7.2 Growth attributes

3.7.2.1 Plant height (cm)

The height of five earlier randomly selected and tagged plants were measured from the base of the plant to the tip of main shoot at 30, 60 DAS and at harvest of the crop. The mean plant height was calculated and expressed in centimetre.

3.7.2.2 Number of branches per plant

Periodical number of branches per plant were counted from the selected five tagged plants from each net plot. The average values for each plot at each stage were computed and recorded.

3.7.2.3 Days to 50% flowering

The numbers of days required from the date of sowing to date at which 50 per cent plants have come to flowering were recorded as days to 50 per cent flowering for each treatment.

3.8 Yield attributes and yield

3.8.1 Number of capsules per plant

Total number of capsules collected from five tagged plants were counted for respective treatments and mean values were recorded as capsules per plant.

3.8.2 Number of seeds per capsule

The total number of seeds obtained from the capsules of the five selected plants was counted. The value obtained was divided by the number of capsules in order to get the average number of seeds per capsule.

3.8.3 Test weight (g)

A representative seed samples were collected randomly from the bulk produce of each net plot and 1000 seeds were counted from the sample and then weight in gram was noted as test weight of each treatment.

3.8.4 Seed yield (kg/ha)

The produce of each net plot area was threshed separately, cleaned and the grain yield was recorded per plot and then computed on hectare basis for each treatment.

Table 3.8: Parameters studied during the field investigation

Sr. No.	Parameters		Sample size	Time of observation
[A]	Plant population per sq. m		Plants count per sq. m	30 DAS and at harvest
[B]	**Growth parameter**			
	1	Plant height (cm)	Five plants per net plot	30 DAS, 60 DAS and at harvest
	2	Number of branches per plant	Five plants per net plot	At harvest
	3	Days to 50 % flowering	Net plot	At 50 % flowering
[C]	**Yield attributes and yield**			
	1	Numbers of capsule per plant	Five plants per net plot	At harvest
	2	Number of seeds per capsule	Five plant per net plot	At harvest
	3	Test weight (g)	1000 seed weight	At harvest
	4	Seed yield (kg/ha)	Net plot	At harvest
	5	Stover yield (kg/ha)	Net plot	At harvest
	6	Harvest index (%)	As per formula	After harvest
[D]	**Quality parameter**			
	1	Oil content in seed	As per procedure	After harvest
	2	Protein content in seed	As per procedure	After harvest
[E]	**Economics**			
	1	Net realization (₹/ha)	As per formula	After harvest
	2	BCR	As per formula	After harvest

3.8.5 Stover yield (kg/ha)

Stover yield was obtained by subtracting the grain yield from the weight of the total produce of each net plot and recorded. Finally, it was converted on hectare basis.

3.8.6 Harvest index (%)

The harvest index is the ratio of economic yield to the biological yield. The harvest index for each treatment was worked out by using the formula (Donald and Hamblin, 1976).

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

3.9 Quality parameters

3.9.1 Oil content (%)

A sample of 20 g seeds was drawn from each net plot produce for oil content study. The oil content of seed was determined by Nuclear Magnetic Resonance (NMR) as per the method suggested by Tiwari *et al.* (1974).

3.9.2 Protein content (%)

The estimation of nitrogen in seed was done by adopting the micro Kjeldahl's method as described by Jackson (1973). The protein content in grain was calculated by multiplying nitrogen content of the seed (per cent) with the factor 6.25 as reported by Gupta *et al.* (1988) and was expressed as percentage on dry weight basis for each treatment.

3.10 Statistical analysis

The statistical analysis of data of various characters studied in the investigation was done using analysis of variance techniques as suggested by Panse and Sukhatme (1985).

The critical differences for comparing treatment means were worked out at 5 per cent level of significance. To elucidate effects summary table along with critical difference at 5 per cent were prepared and are given in chapter "Results and Discussion" and their analysis of variances are given in the appendices at the end.

3.11 Economics

To evaluate the most effective and remunerative treatment, the relative economics of each treatment was worked out in terms of gross, net realization and benefit : cost ratio.

3.11.1 Gross realization (₹/ha)

The gross realization in term of rupees per hectare was calculated from the income received from forage yield of each treatment with the prevailing, market price. The cost of cultivation was worked out considering the cost of all the operations right from the preparation of land to harvesting of the crop. Details of cost of cultivation is outlined in the Appendices-A.

3.11.2 Net return (₹/ha)

The net realization was worked out by deducting the total cost of cultivation from the gross realization per hectare for each treatment and recorded accordingly.

3.11.3 Benefit: cost ratio (BCR)

The benefit cost ratio (BCR) was calculated as follows.

$$\text{Benefit : Cost Ratio (BCR)} = \frac{\text{Gross realization (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Plate I: General view of experimental field of linseed

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

The results obtained from the present investigation entitled "Effect of row spacing and varieties on growth and yield of linseed (*Linum usitatissimum* L.)" laid out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District-Banaskantha (Gujarat) during *rabi* season of 2021-22 are presented in this chapter.

The data pertaining to the effect of different row spacing and varieties on growth, yield attributes and yield as well as quality parameters were subjected to statistical analysis in order to test significance of results. Analysis of variance for all these data have been presented in appendices at the end (appendices C-G). For the sake of convenience, the entire chapter has been divided under following sub heads.

4.1 Plant population

4.2 Growth parameters

4.3 Yield attributes and yield

4.4 Quality parameters

4.5 Economics

4.1 Plant population

4.1.1 Plant population at 30 DAS and at harvest

The data on plant population per square metre area at 30 DAS and at harvest of linseed were recorded and presented in Table 4.1 and graphically depicted in Figure 4.1.

4.1.1.1 Effect of row spacing

The data showed that plant population per square metre area at 30 DAS and at harvest were significantly influenced by different row spacing. Significantly the highest plants population (44.33 and 43.70) were recorded at 30 DAS and at harvest with the row spacing of 22.5 cm (S_1), respectively. The lowest plant population (21.38 and 20.70) were recorded at 30 DAS and at harvest with row spacing of 45 cm (S_3), respectively. This might be due to wider row spacing resulted in lower row per unit area reflected in lower plant population. Similar results were also observed by Gabiana *et al*. (2005), Khan *et al*. (2005) and Saoji *et al*. (2007).

4.1.1.2 Effect of varieties

A perusal of data presented in Table 4.1 were showed that plant population per square metre area at 30 DAS and at harvest did not differ significantly in different varieties.

Table 4.1: Plant population of linseed as influenced by different row spacing and varieties

Treatments	Plant population per metre square	
	At 30 DAS	At harvest
Row spacing (S)		
S_1 : 22.5 cm	44.33	43.70
S_2 : 30 cm	32.50	31.95
S_3 : 45 cm	21.38	20.70
S.Em.±	0.71	0.76
C.D. (P=0.05)	2.47	2.64
C.V.%	7.55	8.24
Variety (V)		
V_1 : Neelam	32.38	31.70
V_2 : T 397	32.75	32.28
V_3 : Pusa 3	33.08	32.36
S.Em.±	0.65	0.67
C.D. (P=0.05)	NS	NS
Interaction (S × V)		
S.Em.±	1.13	1.16
C.D. (P=0.05)	NS	NS
C.V.%	6.93	7.23

4.1.1.3 Interaction effect

Plant population at 30 DAS and at harvest were not influenced significantly by interaction effect of different row spacing and varieties.

4.2 Growth parameters

4.2.1 Plant height (cm)

The mean data on periodical plant height were recorded at 30 DAS, 60 DAS and at harvest stage of linseed which are furnished in Table 4.2 and graphically depicted in Figure 4.2. It was observed that plant height increased with advancement in age of crop.

4.2.1.1 Effect of row spacing

Data indicated that the plant height recorded at 30 DAS, 60 DAS and at harvest were significantly influenced by various row spacing. Significantly the highest plant height (22.69, 39.65 and 56.64 cm) were recorded with the row spacing of 22.5 cm

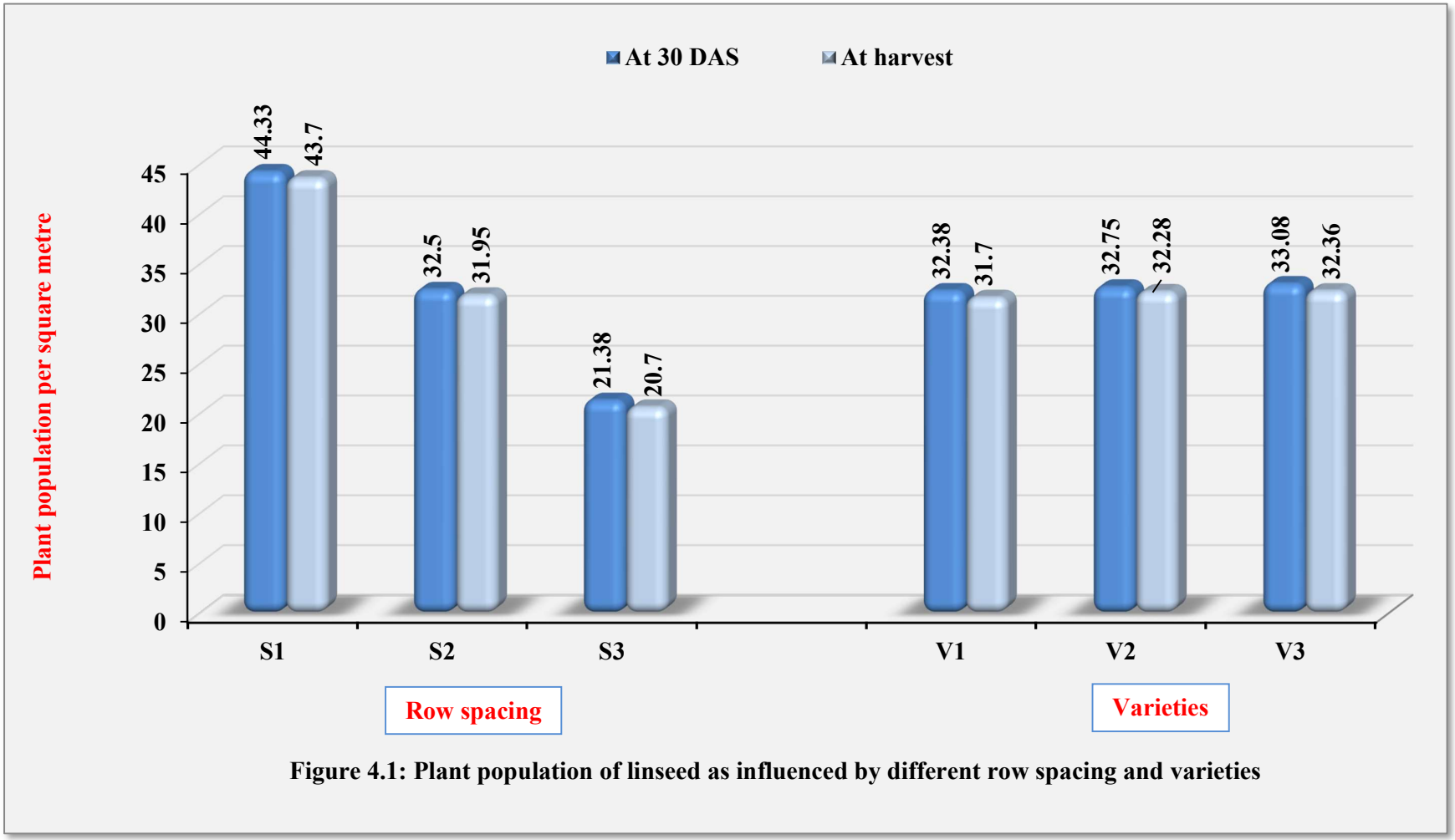

Figure 4.1: Plant population of linseed as influenced by different row spacing and varieties

(S_1) at 30 DAS, 60 DAS and at harvest, respectively. While the minimum plant height (20.41, 36.05 and 49.25 cm) were recorded at 30 DAS, 60 DAS and at harvest under the row spacing of 45 cm (S_3), respectively.

Plant height was remarkably accelerated at row spacing 22.5 cm might be due to unavailability of sufficient space and sunlight which forced the plants to grow vertically rather than horizontally. The present results are in close conformity with those of Darja *et al.* (2008), Kumar and Tripathi (2015), Gohil *et al.* (2016) and Ganvit *et al.* (2019).

4.2.1.2 Effect of varieties

Data furnished in Table 4.2 indicated that the effect of different varieties on plant height of linseed at 30, 60 DAS and at harvest were found significant. Significantly the highest plant height (22.65, 39.66 and 55.52 cm) of linseed was recorded by Pusa 3 variety at 30, 60 DAS and at harvest, respectively. While significantly the lowest plant height of linseed (19.97, 36.02 and 49.93 cm) was recorded by Neelam variety at 30, 60 DAS and at harvest, respectively. The variation in plant height by different varieties due to different varietal character as observed by Andruszczak *et al.* (2015), Adagale *et al.* (2016) and Gaikwad *et al.* (2019).

Table 4.2: Plant height of linseed as influenced by different row spacing and varieties

Treatments	Plant height (cm)		
	At 30 DAS	At 60 DAS	At harvest
Row spacing (S)			
S_1 : 22.5 cm	22.69	39.65	56.64
S_2 : 30 cm	20.75	36.81	51.56
S_3 : 45 cm	20.41	36.05	49.25
S.Em.±	0.50	0.81	1.25
C.D. (P=0.05)	1.72	2.81	4.33
C.V. %	8.08	7.51	8.26
Variety (V)			
V_1 : Neelam	19.97	36.02	49.93
V_2 : T 397	21.23	36.84	52.01
V_3 : Pusa 3	22.65	39.66	55.52
S.Em.±	0.44	0.72	1.13
C.D. (P=0.05)	1.29	2.15	3.34
Interaction (S × V)			
S.Em.±	0.75	1.25	1.95
C.D. (P=0.05)	NS	NS	NS
C.V. %	7.09	6.67	7.43

4.2.1.3 Interaction effect

The interaction effect of different row spacing and varieties failed to show its significant effect on plant height at 30, 60 DAS and at harvest in linseed.

4.2.2 Number of branches per plant

The data pertaining to the number of branches per plant of linseed as influenced by the treatments of different row spacing and varieties were presented in Table 4.3 and graphically depicted in Figure 4.3

4.2.2.1 Effect of row spacing

As appraisal of data in Table 4.3 indicated that the number of branches per plant were significantly influenced by different row spacing. Among different row spacing, significantly the highest numbers of branches per plant (7.68) was observed under the row spacing of 45 cm (S_3). The minimum branches per plant (6.50) was recorded under row spacing of 22.5 cm (S_1).

The maximum number of branches per plant recorded under the wider row spacing might be due to sufficient availability of sunlight and nutrient reflected in increased plant growth and development. The present result is in close conformation with Khan *et al.* (2005), Kushwaha *et al.* (2006), Saoji *et al.* (2007), Andruszczak *et al*. (2015), Kumar and Tripathi (2015) and Ali *et al.* (2016).

4.2.2.2 Effect of varieties

Data furnished in Table 4.3 indicated that the effect of different varieties on number of branches per plant of linseed were found significant. Significantly higher number of branches per plant was recorded under Pusa 3 variety (7.55) but it was remained at par with T 397 variety (7.12). Variation among the varieties in respect of number of branches per plant was due to genetic variation. The results agreed with Andruszczak *et al.* (2015), Ganga *et al.*, (2015), Adagale *et al.* (2016) and Gaikwad *et al.* (2019) in linseed varieties.

4.2.2.3 Interaction effect

The interaction effect of different row spacing and varieties with regard to number of branches per plant at harvest was found to be non-significant.

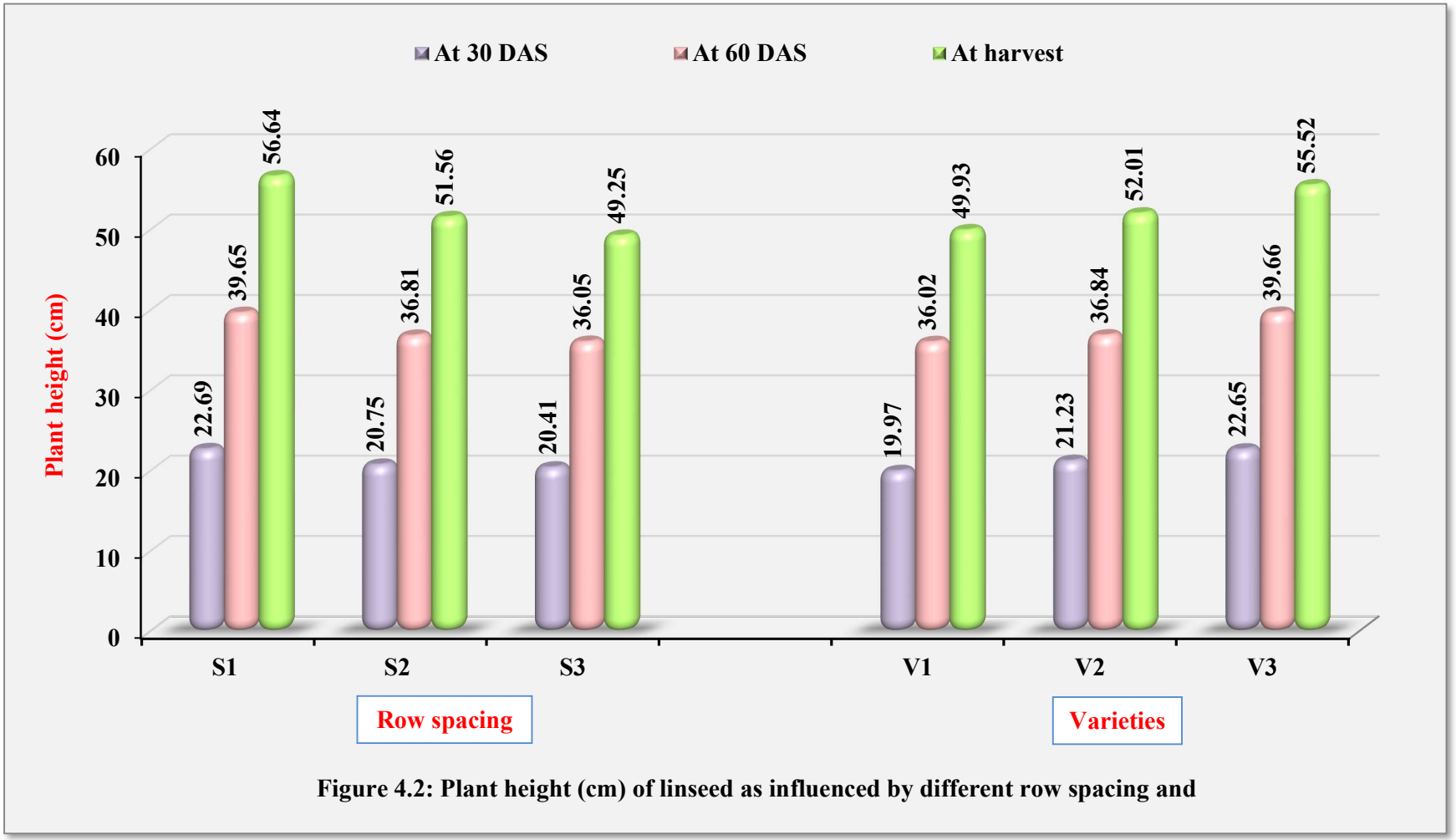

Figure 4.2: Plant height (cm) of linseed as influenced by different row spacing and

Table 4.3: Number of branches per plant of linseed as influenced by different row spacing and varieties

Treatments	Number of branches per plant
Row spacing (S)	
S_1 : 22.5 cm	6.50
S_2 : 30 cm	7.11
S_3 : 45 cm	7.68
S.Em.±	0.15
C.D. (P=0.05)	0.54
C.V. %	7.56
Variety (V)	
V_1 : Neelam	6.63
V_2 : T 397	7.12
V_3 : Pusa 3	7.55
S.Em.±	0.15
C.D. (P=0.05)	0.45
Interaction (S × V)	
S.Em.±	0.26
C.D. (P=0.05)	NS
C.V. %	7.33

4.2.3 Days to 50% flowering

The data pertaining to days to 50% flowering of linseed crop as influenced by the treatments of row spacing and varieties presented in Table 4.4.

Table 4.4: Days to 50% flowering of linseed as influenced by different row spacing and varieties

Treatments	Days to 50% flowering
Row spacing (S)	
S_1 : 22.5 cm	62.62
S_2 : 30 cm	63.64
S_3 : 45 cm	62.44
S.Em.±	1.40
C.D. (P=0.05)	NS
C.V. %	7.71
Variety (V)	
V_1 : Neelam	64.56
V_2 : T 397	63.72
V_3 : Pusa 3	60.43
S.Em.±	1.24
C.D. (P=0.05)	NS
Interaction (S × V)	
S.Em.±	2.14
C.D. (P=0.05)	NS
C.V. %	6.81

4.2.3.1 Effect of row spacing

Data presented in Table 4.4 showed that different row spacing *i.e*. 22.5 cm, 30 cm and 45 cm had no significant effect on days to 50% flowering.

4.2.3.2 Effect of varieties

As appraisal of data in Table 4.4 indicated that the days to 50 % flowering of linseed was not significantly influenced due to different varieties.

4.2.3.3 Interaction effect

The interaction effect of different treatments of row spacing and varieties with regard to days to 50% flowering was found non-significant.

4.3 Yield attributes and yield

4.3.1 Number of capsules per plant

The data pertaining to the number of capsules per plant in linseed at harvest stage as influenced by different row spacing and varieties are presented in Table 4.5 and graphically depicted in Figure 4.4.

4.3.1.1 Effect of row spacing

As appraisal of data in Table 4.5, indicated that the number of capsules per plant was significantly influenced due to different row spacing treatments. Among different spacing, 45 cm row spacing (S_3) produced significantly the highest number of capsules per plant (53.44) as compared to other spacing treatments. The minimum number of capsules per plant (45.88) was recorded under the treatment 22.5 cm (S_3).

The maximum numbers of capsules per plant were recorded under 45 cm (S_3) as compared to other row spacing. The improvement in number of capsules per plant at wider row spacing might be due to reduction in competition between the plants for light, space, moisture and nutrients and sufficient interception of sunlight which enhanced the photosynthetic activities responsible for better growth and development of plant under wider spaced conditions. While under narrow row spacing having greater plant density lowered down the expression of yield attributes. The reduction in yield attributes with increased plant density might be due to keen competition for moisture, nutrients and sunshine. The wider row spacing improved individual plant yield attributes similar resulted drawn by Kushwaha *et al*. (2006), Saoji *et al*. (2007) and Kumar and Tripathi (2015).

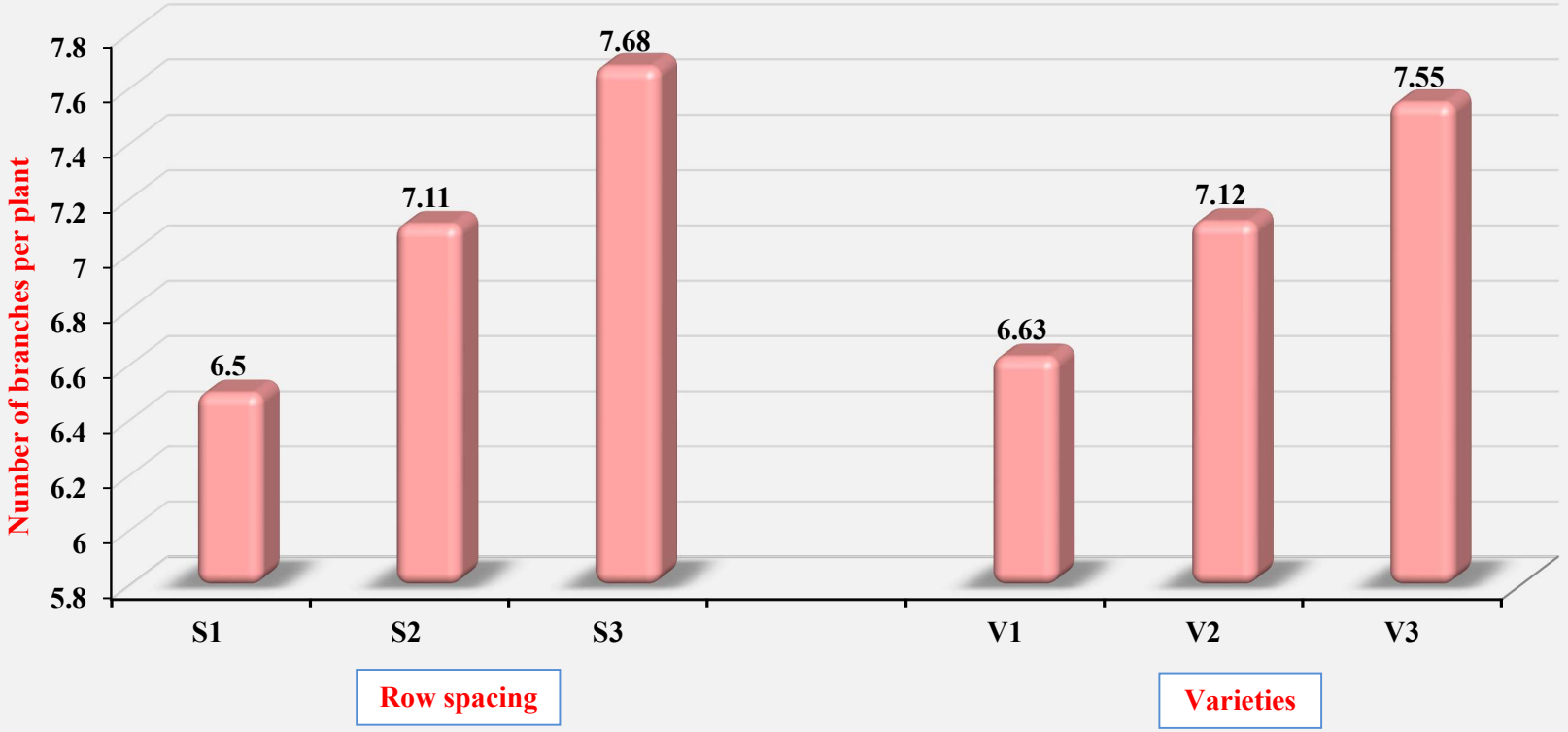

Figure 4.3: Number of branches per plant of linseed as influenced by different row spacing and varieties

4.3.1.2 Effect of varieties

Data furnished in Table 4.5 indicated that the effect of different varieties on number of capsules per plant of linseed was found significant. Significantly higher number of capsules per plant was recorded by Pusa 3 (52.12) variety and it was found at par with T 397 (50.24) variety. Whereas, significantly the lower number of capsules per plant was recorded by Neelam (46.39) variety. This might be due to different genetic potential of the varieties and Pusa 3 variety might be considered the best variety among the three varieties. This variation was found due to the variation of the varietal characteristics in this study. Singh *et al.* (2013), Ganga *et al.* (2015) and Gaikwad *et al.* (2019) found similar results in linseed variety.

Table 4.5: Number of capsules per plant of linseed as influenced by different row spacing and varieties

Treatments	Number of capsules per plant
Row spacing (S)	
S_1 : 22.5 cm	45.88
S_2 : 30 cm	49.43
S_3 : 45 cm	53.44
S.Em.±	1.11
C.D. (P=0.05)	3.83
C.V. %	7.73
Variety (V)	
V_1 : Neelam	46.39
V_2 : T 397	50.24
V_3 : Pusa 3	52.12
S.Em.±	1.03
C.D. (P=0.05)	3.06
Interaction (S × V)	
S.Em.±	1.78
C.D. (P=0.05)	NS
C.V. %	7.20

4.3.1.3 Interaction effect

There was non-significant effect of interaction between different row spacing and varieties observed on the number of capsules per plant during the course of investigation.

4.3.2 Number of seeds per capsule

The data pertaining to number of seeds per capsule recorded in linseed as influenced by different row spacing and varieties are presented in Table 4.6.

4.3.2.1 Effect of row spacing

A perusal of data in Table 4.6 revealed that different row spacing did not exert their significant influence on number of seeds per capsule of linseed.

Table 4.6: Number of seeds per capsule of linseed as influenced by different row spacing and varieties

Treatments	Number of seeds per capsule
Row spacing (S)	
S_1 : 22.5 cm	7.66
S_2 : 30 cm	7.82
S_3 : 45 cm	7.89
S.Em.±	0.18
C.D. (P=0.05)	NS
C.V. %	8.14
Variety (V)	
V_1 : Neelam	7.53
V_2 : T 397	7.88
V_3 : Pusa 3	7.96
S.Em.±	0.16
C.D. (P=0.05)	NS
Interaction (S × V)	
S.Em.±	0.27
C.D. (P=0.05)	NS
C.V. %	7.02

4.3.2.2 Effect of varieties

The data presented in Table 4.6 indicated that different varieties treatments had non-significant effect on the number of seeds per capsule.

4.3.2.3 Interaction effect

It is evident from data (Table 4.6) that combined effect of different treatments of different row spacing and varieties failed to manifest their significant effect on number of capsules per plant during the course of investigation.

4.3.3 Test weight

The data pertaining to test weight of linseed as influenced by different row spacing and varieties are presented in Table 4.7 and graphically depicted in Figure 4.5.

4.3.3.1 Effect of row spacing

Data tabulated in Table 4.7 indicated that the test weight of linseed was significantly influenced due to different row spacing. Among different spacing, row spacing of 45 cm (S_3) produced significantly the highest test weight (7.07 g). The lowest test weight (6.24 g) was recorded under 22.5 cm (S_3) row spacing.

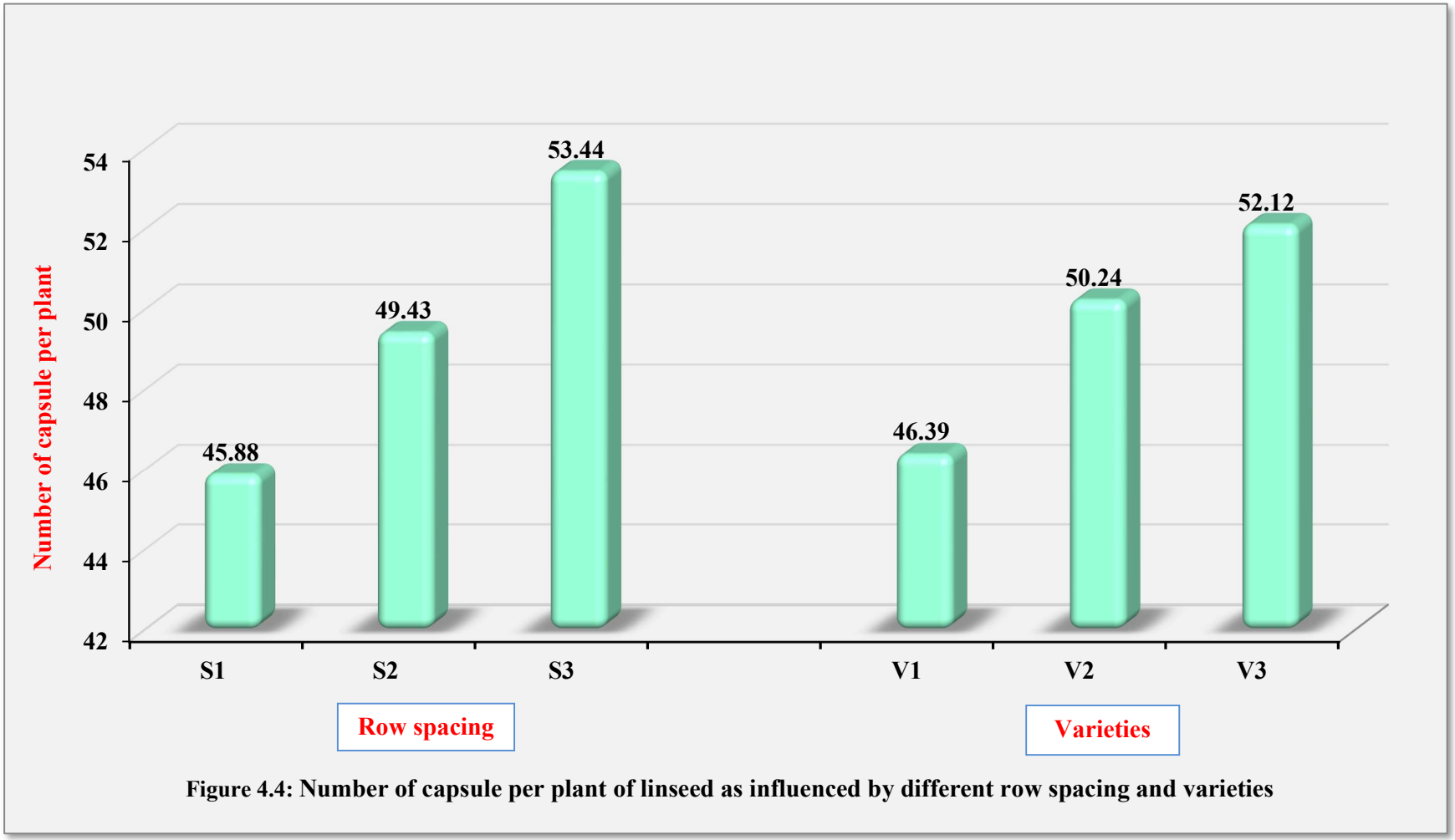

Figure 4.4: Number of capsule per plant of linseed as influenced by different row spacing and varieties

The maximum test weight was recorded under 45 cm (S_3) as compared to other spacing may be explained due to less competition between plants for nutrients, soil moisture, space and solar radiation in wider row spacing than closer spacing. Similar results were reported by Kushwaha *et al.* (2006), Kumar and Tripathi (2015) and Gaikwad *et al.* (2019).

Table 4.7: Test weight of linseed as influenced by different row spacing and varieties

Treatments	Test weight (g)
Row spacing (S)	
S_1 : 22.5 cm	6.24
S_2 : 30 cm	6.58
S_3 : 45 cm	7.07
S.Em.±	0.14
C.D. (P=0.05)	0.47
C.V. %	7.07
Variety (V)	
V_1 : Neelam	6.08
V_2 : T 397	6.74
V_3 : Pusa 3	7.08
S.Em.±	0.13
C.D. (P=0.05)	0.39
Interaction (S × V)	
S.Em.±	0.23
C.D. (P=0.05)	NS
C.V. %	6.94

4.3.3.2 Effect of varieties

An appraisal of data presented in Table 4.7 showed that different varieties had significant effect on the test weight of linseed. Significantly higher test weight was observed under variety Pusa 3 (7.08 g) over other varieties but it was remained at par with variety T 397 (6.74 g). The minimum test weight of linseed was observed under variety Neelam (6.08 g). This variation in test weight can be attributed to genetic makeup of the varieties. Singh *et al.* (2013) found similar results in linseed. They said that the variation in test weight of the varieties of linseed might be due to their different genetic characteristics.

4.3.3.3 Interaction effect

Interaction effect of different treatments of different row spacing and varieties in respect of test weight was found non-significant during the experimentation.

4.3.4 Seed Yield (kg/ha)

Data on seed yield of linseed as effected by different row spacing and varieties are depicted in Table 4.8 and graphically illustrated in Figure 4.6.

4.3.4.1 Effect of row spacing

An appraisal of data in Table 4.8 indicated that differences in linseed seed yield due to row spacing was found significant. Linseed sown at narrow row spacing of 22.5 cm (S_1) produced significantly the highest seed yield (1307 kg/ha). The minimum seed yield (1031 kg/ha) was recorded with the row spacing of 45 cm (S_3).

Higher seed yield under the narrow spacing treatment 22.5 cm (S_1) due to more number of plants occupied per unit area under narrow spacing as compared to wider spacing crop which could led to produce higher seed yield per unit area. Similar results were reported by Khan *et al.* (2005), Kushwaha *et al.* (2006), Saoji *et al.* (2007), Gohil *et al.* (2016) and Ganvit *et al.* (2019).

Table 4.8: Seed yield of linseed as influenced by different row spacing and varieties

Treatments	Seed yield (kg/ha)
Row spacing (S)	
S_1 : 22.5 cm	1307
S_2 : 30 cm	1138
S_3 : 45 cm	1031
S.Em.±	41.57
C.D. (P=0.05)	143.87
C.V. %	12.43
Variety (V)	
V_1 : Neelam	995
V_2 : T 397	1188
V_3 : Pusa 3	1291
S.Em.±	38.51
C.D. (P=0.05)	114.43
Interaction (S × V)	
S.Em.±	66.71
C.D. (P=0.05)	NS
C.V. %	11.52

4.3.4.2 Effect of varieties

A perusal of data presented in Table 4.8 revealed that the effect of different varieties on seed yield of linseed was found significant. Significantly higher seed yield (1291 kg/ha) was recorded under Pusa 3 variety it was found at par with variety T 397 (1188 kg/ha). Significantly lower seed yield (995 kg/ha) was recorded by

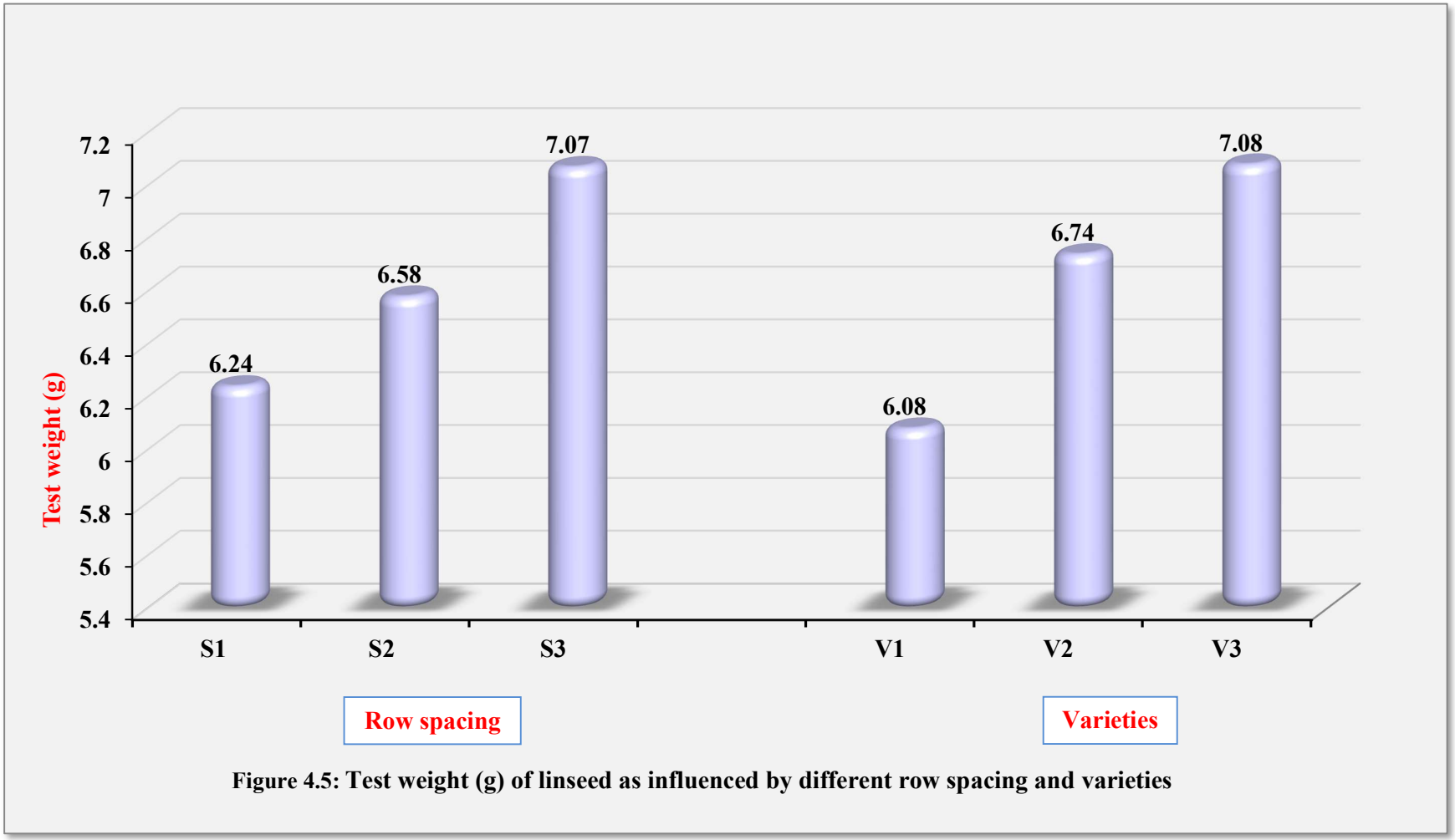

Figure 4.5: Test weight (g) of linseed as influenced by different row spacing and varieties

Neelam variety. The highest seed yield of Pusa 3 variety might be due to higher value of number of branches per plant, number of capsules per plant and test weight as compared to other varieties. The results are agreed with Adagale *et al.*, (2016) and Maurya *et al.* (2017).

4.3.4.3 Interaction effect

Interaction effect of row spacing and varieties with regards to seed yield (kg/ha) was found non-significant.

4.3.5 Stover yield (kg/ha)

The data on stover yield of linseed influenced by different row spacing and varieties are presented in Table 4.9 and graphically illustrated in Figure 4.6.

4.3.5.1 Effect of row spacing

The results indicated that various row spacing influenced significantly on stover yield recorded after the harvest. Significantly the highest stover yield (2214 kg/ha) was registered under row spacing of 22.5 cm (S_1). The minimum stover yield (1893 kg/ha) was recorded with row spacing of 45 cm (S_3).

The remarkable increase in stover yield under narrow spacing (22.5 cm) was mainly due to more plants per unit area as well as taller plant which ultimately led to produce higher dry matter per unit area. Similar results were reported by Gohil *et al*. (2016) and Ganvit *et al.* (2019).

4.3.5.2 Effect of varieties

The data reported in Table 4.9 revealed that the stover yield of linseed was significantly affected due to the different varieties during the course of investigation. The variety Pusa 3 recorded significantly the highest stover yield (2335 kg/ha). The lowest stover yield (1745 kg/ha) was recorded with the variety Neelam. The highest stover yield of Pusa 3 variety might be due to higher value of plant height, number of branches per plant, number of capsules per plant and test weight per plant as compared to other two varieties. The results agreed with Adagale *et al.*, (2016), Maurya *et al*., (2017) and Gaikwad *et al.* (2019).

4.3.5.3 Interaction effect

Interaction effect of different row spacing and varieties with respect to stover yield was found non-significant.

Table 4.9: Stover yield of linseed as influenced by different row spacing and varieties

Treatments	Stover yield (kg/ha)
Row spacing (S)	
S_1 : 22.5 cm	2214
S_2 : 30 cm	1925
S_3 : 45 cm	1893
S.Em.±	54.88
C.D. (P=0.05)	189.91
C.V. %	9.46
Variety (V)	
V_1 : Neelam	1745
V_2 : T 397	1951
V_3 : Pusa 3	2335
S.Em.±	51.88
C.D. (P=0.05)	154.15
Interaction (S × V)	
S.Em.±	89.86
C.D. (P=0.05)	NS
C.V. %	8.94

4.3.6 Harvest index (%)

The data on harvest index (%) on linseed as influenced by different row spacing and varieties treatments are furnished in Table 4.10.

Table 4.10: Harvest index of linseed as influenced by different row spacing and varieties

Treatments	Harvest index (%)
Row spacing (S)	
S_1 : 22.5 cm	36.90
S_2 : 30 cm	37.51
S_3 : 45 cm	35.25
S.Em.±	1.22
C.D. (P=0.05)	NS
C.V. %	11.55
Variety (V)	
V_1 : Neelam	36.29
V_2 : T 397	37.88
V_3 : Pusa 3	35.49
S.Em.±	1.17
C.D. (P=0.05)	NS
Interaction (S × V)	
S.Em.±	2.02
C.D. (P=0.05)	NS
C.V. %	11.04

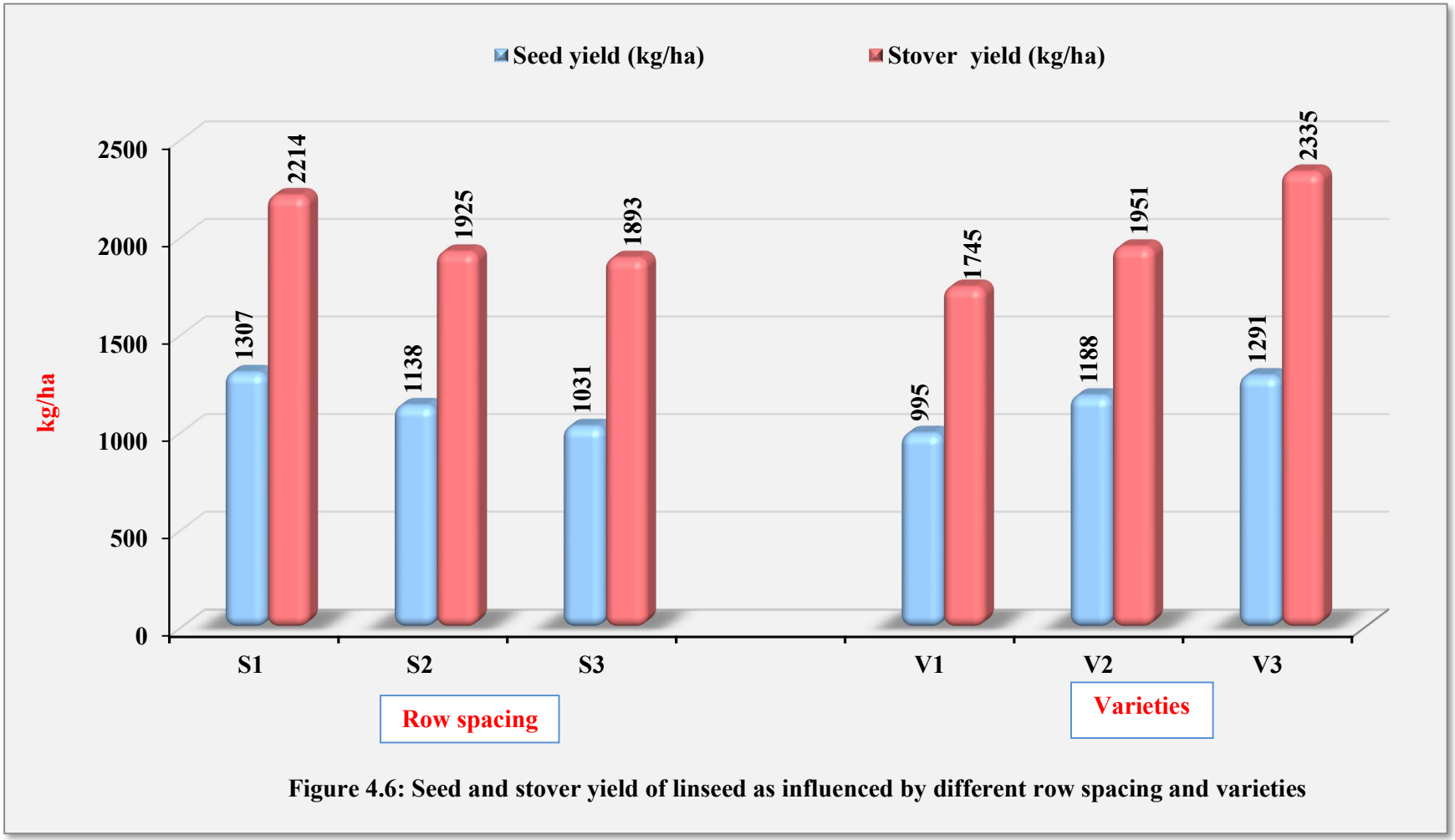

Figure 4.6: Seed and stover yield of linseed as influenced by different row spacing and varieties

4.3.6.1 Effect of row spacing

The data showed in Table 4.10 revealed that various treatments of row spacing not exert their significant effect on harvest index.

4.3.6.2 Effect of varieties

An appraisal of data presented in Table 4.10 indicated non-significant difference in harvest index due to different varieties.

4.3.6.3 Interaction effect

Interaction effect of different row spacing and varieties was found to be non-significant with respect to harvest index.

4.4 Quality parameters

4.4.1 Oil content (%)

The mean data of oil content (%) in seeds of linseed as influenced by different row spacing and varieties treatments are presented in Table 4.11.

4.4.1.1 Effect of row spacing

The data in Table 4.11 also revealed that various treatments of row spacing did not exert their significant effect on oil content of linseed.

Table 4.11: Oil content of linseed as influenced by different row spacing and varieties

Treatments	Oil content (%)
Row spacing (S)	
S_1 : 22.5 cm	31.73
S_2 : 30 cm	32.01
S_3 : 45 cm	32.14
S.Em.±	0.67
C.D. (P=0.05)	NS
C.V. %	7.24
Variety (V)	
V_1 : Neelam	32.14
V_2 : T 397	31.94
V_3 : Pusa 3	31.79
S.Em.±	0.66
C.D. (P=0.05)	NS
Interaction (S × V)	
S.Em.±	1.14
C.D. (P=0.05)	NS
C.V. %	7.13

4.4.1.2 Effect of varieties

It is clear from the data presented in Table 4.11 that the oil content in seeds of linseed was not influenced significantly due to different varieties however, numerically higher value was observed with variety Neelam.

4.4.1.3 Interaction effect

Interaction effect of different row spacing and varieties was also found non-significant with respect to oil content and it is furnished in Table 4.11.

4.4.2 Protein content (%)

The mean data of protein content in seeds of linseed as influenced by different row spacing and varieties are presented in Table 4.12.

4.4.2.1 Effect of row spacing

The data in Table 4.12 also revealed that various treatments of row spacing did not exert their significant effect on protein content of linseed.

4.4.2.2 Effect of varieties

It is clear from the data presented in Table 4.12 that the protein content in seeds of linseed was not influenced significantly due to different varieties however, numerically higher value was observed with variety Neelam.

Table 4.12: Protein content of linseed as influenced by different row spacing and varieties

Treatments	Protein content (%)
Row spacing (S)	
S_1 : 22.5 cm	20.88
S_2 : 30 cm	21.05
S_3 : 45 cm	21.48
S.Em.±	0.48
C.D. (P=0.05)	NS
C.V. %	7.79
Variety (V)	
V_1 : Neelam	21.34
V_2 : T 397	21.19
V_3 : Pusa 3	20.86
S.Em.±	NS
C.D. (P=0.05)	1.39
Interaction (S × V)	
S.Em.±	0.81
C.D. (P=0.05)	NS
C.V. %	7.67

4.4.2.3 Interaction effect

Interaction effect of row spacing and varieties was also found non-significant with respect to protein content and it is furnished in Table 4.12.

4.5 Economics

Data pertaining to economics of crop as influence by different row spacing and varieties are furnished in Table 4.13 and graphically depicted in Figure 4.7. The cost of cultivation per hectare also worked out and prevailing market prices of produce are given in appendix A.

4.5.1 Effect of row spacing

It is apparent from Table 4.13 that row spacing of 22.5 cm registered the highest net realization (₹ 43713/ha) and benefit cost ratio (2.01). The lowest net realization (₹ 28930/ha) and the benefit cost ratio (1.72) was obtained under the row spacing of 45 cm. This increase in profitability was mainly due to higher seed yield. These results are in conformity with the results reported Gohil *et al.* (2016) and Ganvit *et al.* (2019).

4.5.2 Effect of varieties

The result presented in Table 4.13 indicated that the highest net realization (₹ 44604/ha) and benefit cost ratio (2.08) was accrued with the Pusa 3 variety. The lowest net realization (₹ 24774/ha) and benefit cost ratio (1.60) was realized with the Neelam variety. These results are in conformity with the results reported by Ganga *et al.* (2015), Adagale *et al.*, (2016) and Maurya *et al.* (2017).

Table 4.13: Economics of linseed as influenced by different row spacing and varieties

Treatments	Yield (kg/ha)		Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
	Seed	Stover				
Row spacing (S)						
S_1 : 22.5 cm	1307	2214	87169	43456	43713	2.01
S_2 : 30 cm	1138	1925	75895	41503	34392	1.83
S_3 : 45 cm	1031	1893	68908	39978	28930	1.72
Variety (V)						
V_1 : Neelam	995	1745	66420	41646	24774	1.60
V_2 : T 397	1188	1951	79171	41646	37525	1.91
V_3 : Pusa 3	1291	2335	86250	41646	44604	2.08

Selling price of seed = ₹ 65/kg
Selling price of stover = ₹ 1/kg

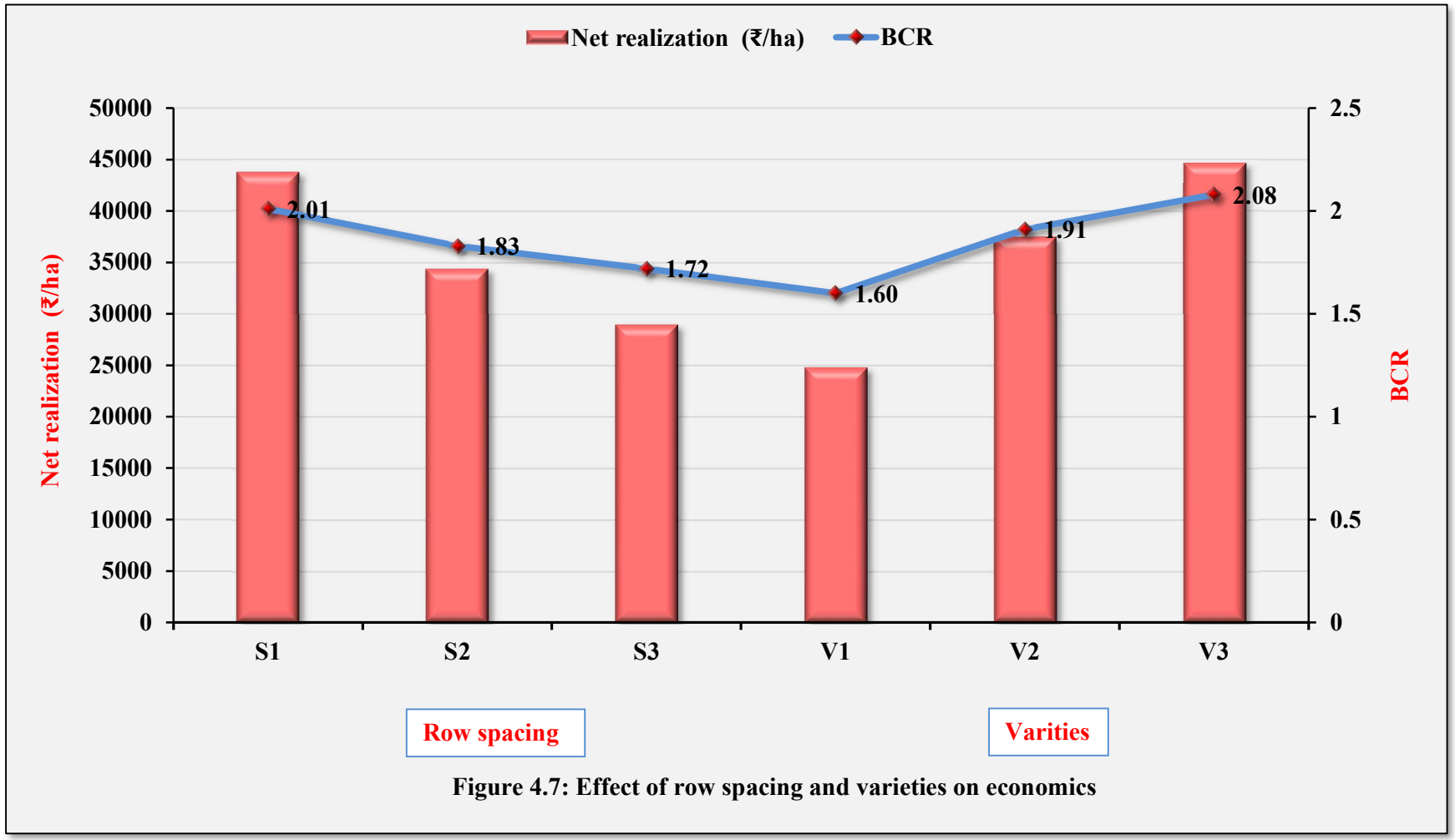

Figure 4.7: Effect of row spacing and varieties on economics

Plate II: S_1V_3 - 22.5 cm row spacing with Pusa 3 variety

Plate III: S_1V_2 - 22.5 cm row spacing with T 397 variety

SUMMARY AND CONCLUSIONS

V. SUMMARY AND CONCLUSION

A field experiment entitled “Effect of row spacing and varieties on growth and yield of linseed” was carried out during *rabi* season of 2021-22 at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Dist. Banaskantha, Gujarat.

There were nine treatment combinations comprising of three row spacings *i.e.* S_1: 22.5 cm, S_2: 30 cm and S_3: 45 cm and three varieties *i.e.* Neelam, T 397 and Pusa 3 were tested in a split plot design with four replications. Growth parameters *viz.,* plant population per square metre, plant height, number of branches per plant and days to 50% flowering were measured at periodical intervals. Likewise, yield and yield attributes *viz.,* number of capsules per plant, number of seeds per capsule, test weight, seed and stover yield as well as harvest index were measured at harvest. Quality parameters, oil content and protein content in seed were obtained after harvest. The data generated on various aspects in this study were analysed through standard statistical methods and logical conclusions were drawn. The experimental findings in details and their discussions have been given in the previous chapters. The salient findings are summarized as under the following sub-heads.

5.1 Effect of row spacing

5.2 Effect of varieties

5.3 Interaction effect

5.4 Conclusion

5.1 Effect of row spacing

5.1.1 Row spacing of 22.5 cm recorded significantly the highest plant population/m^2 at 30 DAS and at harvest of linseed while the minimum plant population per square metre was observed at 30 DAS and at harvest under 45 cm row spacing.

5.1.2 Significantly the highest plant height was recorded at 30, 60 DAS and at harvest under row spacing of 22.5 cm (S_1). The lowest plant height was recorded with row spacing of 45 cm (S_3) at 30, 60 DAS and at harvest.

5.1.3 Row spacing of 45 cm recorded significantly the highest number of branches per plant of linseed whereas 22.5 cm row spacing recorded the lowest number of branches per plant.

5.1.4 Effect of various row spacings in respect of days to 50 % flowering was found non-significant during the course of investigation.

5.1.5 Number of capsules per plant and test weight were found significantly the highest with row spacing of 45 cm (S_3). The lower number of capsules per plant and test weight were recorded with row spacing of 22.5 cm (S_1).

5.1.6 Number of seeds per capsule of linseed crop did not differ significantly due to different row spacing.

5.1.7 Seed and stover yield (kg/ha) were recorded significantly the highest with 22.5 cm (S_1) row spacing while minimum seed and stover yield was observed with S_3 (45 cm) row spacing.

5.1.8 Effect of different row spacings in respect of harvest index (%) was found non-significant during the course of investigation.

5.1.9 Oil and protein content (%) of linseed crop after harvest were found non-significant due to different row spacing.

5.1.10 The maximum net realization and benefit cost ratio was recorded with S_1 (22.5 cm) spacing. Whereas, minimum net realization and benefit cost ratio was observed with S_3 (45 cm).

5.2 Effect of varieties

5.2.1 Plant population per square metre at 30 DAS and at harvest did not influenced significantly due to different varieties.

5.2.2 Significantly the highest plant height of linseed was recorded at 30, 60 DAS and at harvest with variety Pusa 3 (V_3). While the minimum plant height was observed in variety Neelam (V_1).

5.2.3 The number of branches per plant of linseed the significantly higher with variety Pusa 3 (V_3) but it was remained at par with variety T 397 (V_2). The lowest number of branches per plant was recorded by variety Neelam (V_1).

5.2.4 Effect of various varieties on days to 50% flowering was found non-significant during the course of investigation.

5.2.5 Number of capsules per plant and test weight were noted significantly higher with variety Pusa 3 (V_3) but it was found at par with variety T 397 (V_2). The lowest number of capsules per plant and test weight were recorded by variety Neelam (V1).

5.2.6 Number of seeds per capsule of linseed crop did not differ significantly by different varieties.

5.2.7 Seed yield (kg/ha) of linseed was significantly higher with variety Pusa 3 (V_3) but it was found at par with V_2 (T 397) variety. In case of stover yield variety Pusa 3 (V_3) recorded the highest value. The lower seed and stover yield were recorded with variety Neelam (V_1).

5.2.8 Effect of various varieties on harvest index (%) was found non-significant during the course of investigation.

5.2.9 Effect of various varieties with respect to oil and protein content (%) in seeds was found non-significant during the course of investigation.

5.2.10 The maximum net realization and benefit cost ratio were recorded with variety Pusa 3. Whereas, the minimum net realization and benefit cost ratio were observed with variety Neelam.

5.3 Interaction effect

5.3.1 Interaction effect of row spacing and varieties on growth attribute, yield attribute, yield and quality parameters of linseed were found to be non - significant.

5.4 Conclusion

Based on the results of one year experimentation, it is concluded that linseed crop should be sown at row spacing of 22.5 cm for securing higher seed yield and net realization on loamy sand. Linseed varieties Pusa 3 and T 397 performed better over Neelam.

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APPENDICES

APPENDICES

Appendix-A: Cost of cultivation of linseed and other details of cost incurred

[I] Details of common operational cost of linseed crop

Sr. No.	Particulars	PB	Labourer	Frequency	Cost (₹/ha)
(A) Land preparation:					
1	Cultivation by tractor (3 hrs. @ ₹ 600/hr.)	-	-	1	1800
2	Harrowing by tractor (3 hrs. @ ₹ 350/hr.)	-	-	1	1050
3	Planking (3 hrs. @ ₹ 250/hr.)	-	-	1	750
(B) Sowing:					
1.	Preparation of layout and irrigation channel	1	2	1	1130
2.	Opening of furrows by tractor (1 hrs. @ 600 ₹/ha)	-	-	-	600
3.	Sowing and fertilizer application(manually)	-	4	1	1360
4.	Irrigations	-	-	9	9900
5.	Fertilizer cost (60:40:00 NPK/ha)	-	-	1	2757
6.	FYM (5 t/ha)	-	5	-	6700
(C) After care:					
1	Hand weeding	-	4	2	2720
2	Inter culturing (manually)	-	2	2	1360
3	Threshing (3 hrs. @ ₹ 500/hr.) and winnowing	-	5	1	3200
4	Cleaning and bagging	-	2	1	680
Fix cost					**₹ 34007/ha**

(II) Details of cost of row spacing and varieties treatments

Treatments	Seed rate (kg/ha)	Cost of seed (₹/ha)	Labour for harvesting	Harvesting charge (₹/ha)	Variable cost of treatments (₹/ha)
Row spacing and varieties					
S_1 V_1	30.0	2400	12	4080	6480
S_1 V_2	30.0	2400	12	4080	6480
S_1 V_3	30.0	2400	12	4080	6480
S_2 V_1	20.0	1600	9	3060	4660
S_2 V_2	20.0	1600	9	3060	4660
S_2 V_3	20.0	1600	9	3060	4660
S_3 V_1	15.0	1200	6	2040	3240
S_3 V_2	15.0	1200	6	2040	3240
S_3 V_3	15.0	1200	6	2040	3240

(III) Rate of various inputs

Sr. No.	Item/ Input		Rate (₹)
1	Pair of bullock (PB)		₹ 450 per day
2	Irrigation charges (including labour charge)		₹ 1100 per irrigation per ha
3	Cultivation by tractor		₹ 600 per hour
4	Harrowing by tractor		₹ 450 per hour
5	Labour charge		₹ 340 per day
6	Urea (97 kg)		₹ 6 per kg urea
7	DAP (87 kg)		₹ 25 per kg DAP
8	Organic manure (FYM)		₹ 1.0 per kg
9	Cost of seed		₹ 80 per kg
10	Selling price	a) Linseed seed	₹ 65 per kg
		b) Linseed straw	₹ 1 per kg

Appendix – B: Details of treatment combination cost

Treatment	Variable cost (₹/ha)	Fix cost (₹/ha)	Total cost (₹/ha)	Interest @ 12% per annum (4 months)	Supervision charges @ 10% per annum (4 months)	Total cost of cultivation (₹/ha)
S_1 V_1	6480	34007	40487	1619	1350	43456
S_1 V_2	6480	34007	40487	1619	1350	43456
S_1 V_3	6480	34007	40487	1619	1350	43456
S_2 V_1	4660	34007	38667	1547	1289	41503
S_2 V_2	4660	34007	38667	1547	1289	41503
S_2 V_3	4660	34007	38667	1547	1289	41503
S_3 V_1	3240	34007	37247	1490	1242	39978
S_3 V_2	3240	34007	37247	1490	1242	39978
S_3 V_3	3240	34007	37247	1490	1242	39978

Appendix-C: Analysis of variance for plant population and plant height of linseed

Source of variance	Degree of freedom	Mean sum of square				
		Plant population per metre square		Plant height (cm)		
		30 DAS	At harvest	30 DAS	60 DAS	At harvest
Replication	3	5.86	2.97	5.69	37.36	16.67
S	2	1581.76*	1587.25*	18.23*	43.30*	171.39*
Error (A)	6	6.11	7.01	2.95	7.94	18.79
V	2	1.51	1.58	21.58*	43.75*	95.76*
S × V	4	4.16	3.08	2.06	11.23	11.65
Error (B)	18	5.15	5.39	2.28	6.26	15.21

*Significant at 5% level of significance.

Appendix-D: Analysis of variance for days to number of branches per plant and days to 50% flowering of linseed

Source of variance	Degree of freedom	Mean sum of square	
		Number of branches per plant	Days to 50% flowering
Replication	3	0.15	22.05
S	2	4.15*	5.03
Error (A)	6	0.29	23.52
V	2	2.58*	57.17
S × V	4	0.79	9.04
Error (B)	18	0.27	18.35

*Significant at 5% level of significance.

Appendix-E: Analysis of variance for number of capsule per plant, number of seed per capsule and test weight of linseed

Source of variance	Degree of freedom	Mean sum of square		
		Number of capsule per plant	Number of seed per capsule	Test weight (g)
Replication	3	8.80	0.45	0.08
S	2	172.03*	0.18	2.09*
Error (A)	6	14.70	0.40	0.22
V	2	102.42*	0.63	3.10*
S × V	4	36.29	0.31	0.03
Error (B)	18	12.74	0.30	0.21

*Significant at 5% level of significance.

Appendix-F: Analysis of variance for seed yield, stover yield and harvest index of linseed

Source of variance	Degree of freedom	Mean sum of square		
		Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Replication	3	14181.86	32173.48	15.08
S	2	232114.81*	376390.15*	16.49
Error (A)	6	20741.16	36140.15	17.84
V	2	271400.85*	1076656.21*	17.82
S × V	4	46663.18	54050.51	20.34
Error (B)	18	17799.21	35301.59	15.96

*Significant at 5% level of significance.

Appendix-G: Analysis of variance for oil content and protein content of linseed

Source of variance	Degree of freedom	Mean sum of square	
		Oil content (%)	Protein content (%)
Replication	3	0.44	0.74
S	2	0.52	1.18
Error (A)	6	5.38	2.73
V	2	0.38	0.75
S × V	4	0.09	6.69
Error (B)	18	4.76	2.06

CERTIFICATE

This is to certify that, I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference service in a library or documentation centre.

D. K. Prajapati

Place : **SARDARKRUSHINAGAR** **(PRAJAPATI DARSHANKUMAR K.)**
Date : 12, **NOVEMBER, 2022**