EFFECTS OF EXTENDED SOWING DATES ON VARIETIES OF LINSEED (*Linum usitatissimum* L.)

by

Miss. Adagale Jayshri Vitthal
(Reg. No. 12/021)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

In partial fulfilment of the requirements for the degree
of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

DIVISION OF AGRONOMY,
COLLEGE OF AGRICULTURE, PUNE-411 005,
MAHARASHTRA, INDIA

[2014]

EFFECTS OF EXTENDED SOWING DATES ON VARIETIES OF LINSEED (*Linum usitatissimum* L.)

by

Miss. Adagale Jayshri Vitthal
(Reg. No.12/021)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

In partial fulfilment of the requirements for the degree
of

MASTER OF SCIENCE (AGRICULTURE)
in
AGRONOMY

Approved by

Dr. P.U. Raundal
Chairman and Research Guide
Associate Prof. of Agronomy
Agriculture Research Station
Gadhinglaj, Dist-Kolhapur

Dr.D.W.Thawal
Committee Member and
Head,
Department of Agronomy
MPKV, Rahuri

Dr.D.V. Dahat
Committee Member and
Asso. Prof. of Agril. Botany
College of Agriculture, Pune

Prof.S.B.Deshmukh
Committee member and
Assistant Prof. of Agronomy
College of Agriculture, Pune

DIVISION OF AGRONOMY
COLLEGE OF AGRICULTURE, PUNE-411005
MAHARASHTRA, INDIA [2014]

CANDIDATE'S DECLARATION

I hereby declare that this thesis entitled "**Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)"** or part there of has not been submitted by me or any other person to any university or institute for Degree or Diploma.

Place : Pune
Date : / /2014

[**J.V.Adagale]**

Dr. P. U. Raundal
Chairman and Research Guide
Associate Professor of Agronomy,
Agriculture Research Station,
Gadhinglaj, Dist- Kolhapur.

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECTS OF EXTENDED SOWING DATES ON VARIETIES OF LINSEED (*Linum usitatissimum* L.)"**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of a *bonafide* research work carried out by **MISS. ADAGALE JAYSHRI VITTHAL,** under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma in any other form.

Place: Pune **(P.U. Raundal)**
Date: / /2014

Dr. A.R. Karale
Associate Dean,
College of Agriculture, Pune-411005,
Maharashtra (INDIA).

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECTS OF EXTENDED SOWING DATES ON VARIETIES OF LINSEED (*Linum usitatissimum* L.)"**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of a *bonafide* research work carried out by **MISS. ADAGALE JAYSHRI VITTHAL ,** under the guidance and supervision of **Dr. P.U.Raundal** Associate Prof. of Agronomy, Agriculture Research Station, Gadhinglaj, Dist- Kolhapur and that no part of the thesis has been submitted for any other Degree or Diploma.

Place: Pune **(A.R. Karale)**

Date: / /2014.

ACKNOWLEDGEMENT

*I avail this opportunity to express my gratefulness with deep sense of gratitude and indebtedness to my honourable research guide and chairman of advisory committee **Dr.P.U.Raundal** , Associate Prof. of Agronomy, Agriculture Research Station, Gadhinglaj, Dist. Kolhapur for his keen interest, dynamic guidance, construction criticism and constant encouragement throughout the period of investigation. I am fortunate that I got an opportunity to work under his guidance where in I developed insight as how to carry out scientific research work, due to his technical and critical methodological approach towards research work.*

*I convey the depth of feeling and gratitude to the members of advisory committee, **Dr.D.W.Thawal** ,Head Department of Agronomy, **Dr.D.V.Dahat**, Associate Prof. of Botany and **Prof. S.B. Deshmukh**, Assistant Prof. of Agronomy for their encouragement during the research work and criticism reviewing of manuscript.*

*I would like grateful thanks to **Dr.A.R.Karale**, Associate Dean, College of Agriculture, Pune for giving permission and providing necessary facilities for the research work, I wish to express co-ordinal thanks and deep sense of gratitude to **Dr.D.A. Sonwane**, Professor of Agronomy, College of Agriculture, Pune for their various kinds of help during completion of my course and research work.*

I also take opportunity to express my deep sense of gratitude and indebtedness to Prof. T.S.Bhondave ,Farm superitendent and Associate Prof.of Aronomy for this valuable guidance, construction criticism and kind co-operation for the conduct of present investigation.

*I owe my special thanks to Prof.**A.A.Shaikh**, Associate. Prof. of Agronomy, Prof.**S.G.Kumbhr,**Prof.**A.G.Jadhav**,Prof.**N.T.Kunjir**,**Dr.R.L.Bhilare**, Prof.**Mrs.S.V.Bagade** and Prof. **Dr. R.H.shinde**, Asst.Prof. of Agronomy, College of Agriculture, Pune for their timely help and co-operation during course of manuscript.*

*I am equally grateful to **Prof. Nikam sir**, College of Agriculture, Nagpur and AICRP on oilseeds, Nagpur for their kind co-operation for providing good quality seeds of linseed for research work.*

*I wish to acknowledge the timely help renderd during the period of research by **Mr.R. Ghorpade**, Agril.Assistant, Division of Agronomy, for their kind cooperation in the laboratory and experimental work.*

*I am equally thankful to **Mr. M. Wavhal, Shri.D.S.Ladkhat, Shri. Mote**, **Shri.R.M.Danve, Phadake** and **Gore** maushi for their kind cooperation in the field of work.*

*It is my ethereal pleasure to convey my heartfelt reverence to my beloved, respected and adorable father **Shri. Vitthal Hariba Adagale**, mother **Smt. Sangita Vitthal Adagale**, who have been an enexhaustible source of inspiration throughout my life. I express my deep sense of appreciation towards my brother **Amol** and my sisters **Rajshri, Bhagyashri** for their never ending love, constant encouragement, blessings and eternal moral support which have brought my educational carrier to this stage.*

*I would like to express my sincere appreciation to my seniors, juniors, colleagues and friends **Sonal, Manisha, Deepali, Nilam,Mahadev, Janardan, Niketan, Nilesh**, **Kanaram** whose excellent company affection and co-operation helped me in carrying out my study with joy and happiness. My sincere thanks to all those who have directly and indirectly helped me in this research work and those names do not appear in this acknowledgement, I ever rest thanks to all of them. Finally, I thanks God for bestowing me with divine spirit to reach this goal amidst several hurdles and struggles.*

Any omissions in this acknowledgement dose not mean lack of gratitude.

Place: Pune

Date : / / 2014 *(**J.V. Adagale**)*

CONTENTS

Chapter		Page No.
CANDIDATE'S DECLARATION		iii
CERTIFICATES		
1.	Research Guide	iv
2.	Associate Dean	v
ACKNOWLEDGEMENTS		vi
LIST OF TABLE		x
LIST OF FIGURES		xii
LIST OF PLATES		xiii
LIST OF ABBREVIATIONS		xiv
ABSTRACT		xv
1.	**INTRODUCTION**	**1**
2.	**REVIEW OF LITERATURE**	**4**
2.1	Effect of sowing times on growth attributes	4
2.2	Effect of sowing times on yield and yield attributes	6
2.3	Effect of varieties on growth, yield and yield attributes	12
2.4	Meteorological study	20
2.5	Economic study	23
3.	**MATERIAL AND METHODS**	**25**
3.1	Details of the experimental Material	25
3.2	Details of the experimental Methods	30
3.3	Cultural operations	35
3.4	Biometric observations	36
3.5	Growth analysis	37
3.6	Post harvest observations	38
3.7	Yield observations	38

3.8	Quality observations	39
3.9	Chemical observations	39
3.10	Meteorological observations	41
3.11	Economic evaluation	41
3.12	Statistical analysis and interpretation of data	42
4.	**RESULTS AND DISCUSSION**	**44**
4.1	Plant count	44
4.2	Growth attributes	46
4.3	Post harvest observations	58
4.4	Yield observations	64
4.5	Quality studies	69
4.6	Chemical observations	72
4.7	Climatic attributes	78
4.8	Economic studies	85
5.	**SUMMARY AND CONCLUSIONS**	**88**
6.	**LITERATURE CITED**	**93**
7.	**APPENDIX**	**104**
8.	**VITA**	**106**

LIST OF TABLES

No.	Title	Page
1.	Analytical methods used for soil and plant analysis	27
2.	Physical and chemical properties of experimental field	28
3.	Weekly meteorological data recorded during the experimental period (November 2012 to March 2013)	29
4.	Cropping history of the experimental field	30
5.	Details of treatment with their symbols	31
6.	Schedule of field operations carried out in experimental field during *rabi*, 2012-13	33
7.	Schedule of biometric observations recorded during period of investigations	40
8.	Mean initial and final count ha^{-1} influenced periodically by different treatments	45
9.	Mean plant height (cm) as influenced periodically by different treatments	48
10.	Mean number of branches $plant^{-1}$ as influenced periodically by different treatments	50
11.	Mean plant spread (cm) as influenced periodically by different treatments	52
12.	Mean dry matter $plant^{-1}$ (g) as influenced periodically by different treatments	54
13.	Mean dry matter $plant^{-1}$(g) as influenced by interaction between sowing times and varieties 75 DAS	55
14.	Mean dry matter $plant^{-1}$(g) as influenced by interaction between sowing times and varieties 90 DAS	55
15.	Mean dry matter $plant^{-1}$ (g) as influenced by interaction between sowing times and varieties at harvest	56
16.	Mean number of capsules $plant^{-1}$, number of seeds $capsules^{-1}$, seed weight $plant^{-1}$ and thousand grain weight (g) as influenced by different treatments	59
17.	Number of capsules $plant^{-1}$ as influenced by interaction of sowing dates and varieties	60
18.	Number of seeds $capsules^{-1}$ as influenced by interaction of sowing dates and varieties	60

List of tables contd…

No.	Title	Page
19.	Seed weight plant^{-1} (g) as influenced by interaction of sowing dates and varieties	61
20.	Mean seed and straw yields (q ha^{-1}) as influenced periodically by different treatments	66
21.	Seed yield (q ha^{-1}) as influenced by interaction of sowing dates and varieties	67
22.	Straw yield (q ha^{-1}) as influenced by interaction of sowing dates and varieties	67
23.	Mean oil content (%) and oil yield (kg ha^{-1}) as affected by different treatments	70
24.	Total N, P, K content in seed and straw (%) as influenced periodically by different treatments	73
25.	Total N,P,K uptake (kg ha^{-1}) by seed, straw and crop as influenced periodically by different treatments	75
26.	Available N,P,K (kg ha^{-1}) in soil after harvest as influenced periodically by different treatments	77
27.	Cumulative growing degree days (heat units) at different critical growth stages as influenced by different treatments	79
28.	Cumulative hydrothermal units at different critical growth stages as influenced by different treatments	82
29.	Cumulative photothermal units at different critical growth stages as influenced by different treatments	84
30.	Mean gross and net monetary returns, cost of cultivation (Rs. ha^{-1}) and B:C ratio as influenced by different treatments	86

LIST OF FIGURES

No.	Title	Between Page
1.	Weekly meteorological data recorded during the experimental period (November 2012 to March 2013)	29-30
2.	Plan of layout	31-33
3.	Mean plant height (cm) as influenced periodically by different treatments	48-49
4.	Mean number of branches plant^{-1} as influenced periodically by different treatments	50-51
5.	Mean plant spread (cm) as influenced periodically by different treatments	52-53
6.	Mean dry matter plant^{-1} (g) as influenced periodically by different treatments	54-55
7.	Mean number of capsules plant^{-1}, number of seeds capsules^{-1}, seed weight plant^{-1} and thousand grain weight (g) as influenced by different treatments	59-60
8.	Mean seed and straw yields (q ha^{-1}) as influenced by different treatments	66-67
9.	Total N, P, K uptake (kg ha^{-1}) by seed, straw and crop as influenced by different treatments	75-76
10.	Cumulative growing degree days (heat units) at different critical growth stages as influenced by different treatments	79-80
11.	Cumulative hydrothermal units at different critical growth stages as influenced by different treatments	82-83
12.	Cumulative photothermal units at different critical growth stages as influenced by different treatments	84-85
13.	Mean gross and net monetary returns, cost of cultivation (Rs. ha^{-1}) and B:C ratio as influenced by different treatments	86-87

LIST OF PLATES

Plate No.	Caption	Between Page No.
1.	General view of the experimental plot	47-48
2.	PKVNL-260 variety along with 45 MW (2nd week of November)	56-57
3.	Experimental linseed field plot with 47 MW (4th week of November) sowing date	56-57

LIST OF ABBREVIATIONS

^0C	:	Degree Celsius
C.D.	:	Critical difference
Cm	:	Centimeter(s)
DAS	:	Days after sowing
dm^2	:	Square decimeter (s)
et al.	:	At alli (and others)
EC	:	Electrical conductivity
etc.	:	Et cetra (and so on)
Fig.	:	Figure
RDF	:	Recommended dose of fertilizer
G	:	Gram(s)
GDD	:	Growing degree days
Ha	:	Hectare
Hr	:	Hour
i.e.	:	Id est (that is)
K	:	Potassium
Kg	:	Kilogram(s)
kg ha^{-1}	:	Kilogram per hectare
LAI	:	Leaf area index
M	:	Meter
max.	:	Maximum
min.	:	Minimum
MJ	:	Mega Joule
mm	:	Millimetres
N.S.	:	Non-significant
No.	:	Number
P	:	Phosphorus
T	:	Tonne (s)
RH	:	Relative Humidity
q ha^{-1}	:	Quintal per hectare
S.E.s	:	Standard error
Sr.	:	Serial
viz.,	:	Videlicet (namely)
%	:	Per cent
/	:	Per
@	:	At the rate of

ABSTRACT

EFFECTS OF EXTENDED SOWING DATES ON VARIETIES OF LINSEED (*Linum usitatissimum* L.)

By

Miss. Jayshri Vitthal Adagale

A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
in
AGRONOMY

MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413722
2014

Research Guide	:	Dr. P. U. Raundal
Department	:	Agronomy

The present investigation on " Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)" was conducted during *rabi* season of 2012-13 at Agronomy Farm, College of Agriculture, Pune.

The experiment was laid out in split plot design with three replications and twelve treatment combinations. The treatment consists of four sowing dates *viz.*,S_1 : 44 MW (1st week of November), S_2 : 45 MW (2nd week of November), S_3 : 46 MW (3rd week of November), S_4 : 47 MW (4th week of November) and three varieties *viz.*, V_1 : PKVNL-260, V_2 : NL-97, V_3 : Padmini. The gross plot size was 3.60 m X 2.40 m and net plot size was 2.40 m X 1.80m.

The soil of experimental plot was clay loam in texture, low in available nitrogen (178.48 kg ha^{-1})), medium available phosphorous (19.34 kg ha^{-1})), high available potassium (475.00 kg ha^{-1}) and low in organic carbon content (0.16 %) and electrical conductivity of soil (0.21dSm^{-1}) with p^{H} 7.8.

Among all the sowing dates, sowing of linseed at 45 MW (2^{nd} week of November) was significantly superior for growth attributes namely *viz*., plant height (69.56 cm), number of branches $plant^{-1}$ (4.23), dry matter $plant^{-1}$ (9.87g) and yield attributes *viz*., number of capsule $plant^{-1}$ (59), number of seed $capsule^{-1}$ (10.17), seed weight $plant^{-1}$ (2.71g), test weight $plant^{-1}$ (8.53g), seed yield (18.43 q ha^{-1}) and straw yield (29.76 q ha^{-1}).

The sowing of linseed in different metrological weeks did not influence significantly the oil content in flax seed. Among the sowing dates 45 MW (2^{nd} week of November) recorded significantly maximum uptake of total nitrogen, phosphorous and potassium. Meteorological attributes were significant at all critical growth stages of crop for different sowing dates. The gross monetary returns (81,092 Rs. ha^{-1}), net monetary returns (37,334 Rs. ha^{-1}) and B:C ratio (1.85) were maximum in 45MW (2^{nd} week of November)

The plant height, dry matter accumulation $plant^{-1}$ and the yield contributing characters *viz*., number of capsule $plant^{-1}$ (62), number of seed $capsule^{-1}$ (10.02), seed weight $plant^{-1}$ (3.14g), test weight $plant^{-1}$ (8.43g), seed yield (18.12 q ha^{-1}) and straw yield (28.69 q ha^{-1}) were significantly superior in PKVNL-260.

PKVNL-260 variety was significantly superior over NL-97 and Padmini for growth characters, yield attributes, seed and straw yield.

Meteorological attributes were non significant at all critical growth stages of crop for different linseed varieties. The gross monetary returns (79,728 Rs. ha^{-1}), net monetary returns (36,026 Rs. ha^{-1}), B:C ratio (1.82) and cost of cultivation (43,702 Rs. ha^{-1}) were maximum in PKVNL-260 linseed variety.

The sowing date 45 MW (2nd week of November) with PKVNL-260 combination recorded maximum seed yield (19.20 q ha^{-1}) and straw yield (29.80 q ha^{-1}) than rest of treatment combination.

From this investigations, it is concluded that sowing of linseed variety PKVNL-260 at 45 MW (2nd week of November) recorded maximum production of seed and straw yield. Also reveals that combination of sowing date 45 MW (2nd week of November) and variety PKVNL-260 was found better for maximum seed yield.

Pages 1 to 107

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.) is one of the oldest oilseed crop cultivated for its seed and fiber. According to Vavilov linseed was probably a native of South-West Asia consisting of India, Afganistan and Turkey. Linseed is self pollinated crop. It belongs to the genus *Linum* of family linaceae. The somatic chromosome number of the cultivated species is 2n=30. The chromosome number of different species of the genus linum reported to vary from 16 to 86. The genus *Linum* has 290 species spread over the Temperate Zone of the northern hemispheres most abundantly in Europe and Asia

Linseed (*Linum usitatissimum* L.) is one of the oldest, conventional and important *rabi* oilseed crop of India. It is sixth largest oilseed crop in the World and is one of the oldest cultivated plants. It is herbaceous annual plant, which attains the height of 30-120 cm depending up on the type of cultivar. It is an industrial crop cultivated for its seeds, fibres and oil purpose. All parts of the plant have extensive and varied uses. The oil content of seed varies from 32 to 46 per cent and has an industrial value, it is also used as proteinaceous feed for livestock. The linseed cake is also used as organic manure, which contains about 5 per cent N, 1.4 per cent P_2O_5 and 1.8 per cent K_2O.

Linseed oil is found to be comprised of 5 major fatty acids, *viz*., palmitic, stearic, oleic, linoleic and linolenic. Among the saturated fatty acids palmitic acid is found to vary significantly from 4.08-8.69 per cent, while stearic acid varied from 2.02-7.75 per cent. Among the unsaturated fatty acids, oleic acid varied from 18.44-37.32 per cent. Linoleic and linolenic acids are the essential fatty acids and both varied widely from 9.45-20.27 per cent and 33.22-63.43 per cent, respectively (Kamlesh, *et al*.,2002).

The linseed oil primarily goes to industries for manufacture of paints, varnish, linoleum and pad ink. Linseed oil possesses a very healthy fatty acid profile, particularly, Omega-3 (Alpha Linolenic Acid), the richest source only in linseed (58 per cent), ALPHA provides beneficial effects in numerous clinical conditions such as cardiovascular disease, inflammatory disorders, immune function and cancer etc.

In India, present production of oilseed is not sufficient to meet the demand for consumption and also for industrial use. At present, oilseeds are cultivated on 26.54 million hectares of land in India with production of 23.28 million tonnes (Anonymous, 2013). According to available estimates, the country requires 26 million tonnes of oilseed , which comes to 71 lakh tonnes of vegetable oils by the turn of this century. In India, during 2012-13 it is grown on an area of about 1.9 million hectares, which produced 4.98 lakh tonnes and its cultivation is mostly in Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Maharashtra. Madhya Pradesh ranks first in both area and production among the linseed growing states in India.

In Maharashtra , the total area under various oilseed crops were 28.45 lakh hectares with production of 23.46 lakh tonnes in the year 2012-13. Out of which, linseed crop was on 1.46 lakh hectares with 0.41 lakh tonnes production. Average yield of this crop in Maharashtra state is 2.79 q ha^{-1} (Anonymous, 2013) and it was extensively grown in Vidarbha region.

An impact of changed climate on crop production is expected for various latitude limits for all the crop seasons and the linseed crop is most affected during winter season. Linseed crop require cool climate and moderate temperature (not exceeds above $32^{o}C$). Increase in temperature affects on flowering and causes low yield. It has been observed that increase in temperature reduced potential seed yields at most places. A net reduction in linseed production is anticipated due to reduction in growth period as a result of increased temperature.

Hence, the present investigation was undertaken to study the effect of extended sowing dates and varieties on phonological development, growth and productivity of linseed under mild and short winter condition.

In recent years, high yielding and disease resistant varieties of linseed crop were developed. Substantial increase in seed yield of linseed variety can be achieved by optimum sowing time. Sowing time is the most important factor determining the yield and quality of linseed crop.

Amongst various agronomic practices, the time of sowing plays an important role in influencing the quality and yield of linseed. Normal sowing have longer growth period which consequently provide an opportunity to accumulate more biomass as compared to late sowing hence manifested in higher seed and biological yield (Dixit *et al*. 1992).

The present study was therefore undertaken to evaluate the performance and adaptability of newly released varieties of linseed with different dates of sowing. With this considerations in view, the present investigation entitled "Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)" was carried out at Agronomy Farm, College of Agriculture, Pune during *rabi* 2012-13 with following objectives.

i. To find out suitable sowing time for linseed
ii. To find out suitable variety of linseed under extended sowing time
iii. To study the interaction effects of extended sowing times and linseed varieties.

2. REVIEW OF LITERATURE

The research work in effects of extended sowing dates on varieties of linseed carried out by different workers at various places in India and abroad is summarized in this chapter under appropriate headings.

2.1 Effect of sowing dates on growth attributes

Singh (1966) carried out a field experiment at Varanasi and reported that the appropriate time of sowing for proper vegetative and reproductive growth of linseed was third week of October i.e. 21st October than 4th November.

Singh and Singh (1978) carried out a field experiment at Rajasthan and found that mustard crop sown at 10th and 25th October attained maximum number of branches and plant height followed by late sowing dates.

Chaudhary *et al*. (1991) conducted a field experiment at Pusa, Bihar and reported that the mustard crop sown at 22nd September gave maximum development in growth characters like number of branches, plant height and plant spread than the crop sown at 9th and 15th September.

Kumar and Shaktawat (1991) performed a field experiment at Udaipur and observed that the crop mustard sown at 15th October had maximum development in growth characters as higher number of total branches plant^{-1} and number of seeds plant^{-1} than the delayed sowing of 25th October, 5th and 15th November.

Abd EL-Dayem *et al*. (1998) performed a field experiment at Cario, Egypt on flex and concluded that there were significant differences in plant height, plant spread technical length of top branching zone and stem diameter due to sowing date (15th and 30th October, 15th and 30th November).

Naik and Satapathy (2000) carried out a field experiment at Jashipur, Orissa and reported that there was improvement in the growth characters of linseed as plant height, days to 50% flowering, number of primary branches plant^{-1} and days to maturity when linseed sown at extended sowing date.

Saeidi (2000) conducted field experiment at Iran and concluded that the crop sown at 16th November there was reduction in emergence because of low temperature. Delayed in sowing resulted in reduction in emergence, number of branches plant^{-1}, plant height and all growth characters.

Singh *et al*. (2002) conducted experiment at Uttar Pradesh, India and concluded that there was significant improvement in growth characters like number of branches, plant height, dry matter plant^{-1} of linseed under 30th October sowing as compared to 18th October and 11th November.

Yadav *et al*. (2002) at Uttar Pradesh, India conducted a field experiment and observed that crop sown at 1st-8th November resulted in the greatest plant height (79.7, 65.6 and 67.4 cm), number of primary branches plant^{-1} (4.1, 4.3, 4.5). The linseed sown at extended sowing date observed development in growth characters.

Singh *et al*. (2003) carried a field experiment at Ludhiana and observed that under late sown condition the genotype of mustard PC 5-17 gave higher leaf area index, secondary branches plant^{-1}, dry matter plant^{-1} more than the genotype PC 5.

Moahapatra *et al*. (2007) carried out a field experiment at Calcutta on linseed, resulted that except primary branches plant^{-1} and plant height all other growth characters were more at 30th October sowing.

2.2 Effect of sowing dates on yield and yield attributes

Bhatt (1965) conducted field experiment to study the appropriate sowing time on linseed, in M.P. He observed that the crop sown at 9th and 20th October gave significantly higher yield over the late sown crop at 29th October and 8th

November. On an average, the net gain by sowing the crop during the first fortnight of October was over 125 kg ha^{-1} higher than the latest sown crop. (8^{th} Nov.)

Singh (1966) carried out a field experiment on linseed at Varanasi and concluded that early sowing of 21^{st} October showed an increase in yield of 50.012 % over late planting of 4^{th} November. There was increase in number of capsules $plant^{-1}$, number of seeds $capsules^{-1}$. So that there was increase in yield over late planting.

Bishnoi and Singh (1976) conducted a field experiment at Hissar and observed that raya crop sown at 10^{th} October gave highest seed yield than the 30^{th} October and 30^{th} November. The linseed sown at extended date, which, was give low yield than the normal sowing date.

Mathur *et al.* (1984) conducted field experiment on effect of date of sowing on the incidence of *Dasineuralini* Branes (Diptera : cecidomyidae) and yield of linseed and it was found that maximum yield (1.387 kg $plot^{-1}$) was obtained with the sowing of crop at 18^{th} October to 5^{th} November . Lowest yield (0.607 kg $plot^{-1}$) was recorded when the crop was sown on 15^{th} November.

Rajput and Gautam (1993) performed a field experiment at Madhya Pradesh and reported that the optimum sowing date was 10^{th} November. The seed oil content was decreased and protein content was increased as the sowing was delayed after 10^{th} October. But the yield of linseed sowing at 10^{th} November was significantly increased than the other sowing date.

Chaudhary *et al*. (1991) conducted a field experiment at Pusa, Bihar and noticed that the mustard crop sown at 22^{nd} September gave higher seed yield and straw yield than the crop sown on 9^{th} and 15^{th} September. The mustard crop sown at extended sowing dates gave high yield.

Kumar and Shaktawat (1991) performed a field experiment at Udaipur and reported that the crop mustard sown at 15th October gave highest seed yield than the delayed sowing of 25th October, 5th and 15th November.

Dixit *et al*. (1992) carried out a field experiment at Madhya Pradesh and revealed that the maximum yield of linseed (11.73-15.50 q ha^{-1}) was recorded when the crop was sown at 25th October than 15th December sowing. The yield attributes was more developed when the crop sown at 25th October, so the yield was maximum on this sowing date.

Rajput and Gautam (1993) studied the response of sowing date and nitrogen levels on growth, yield and quality of linseed during winter season and revealed that early sown crop (10th November) recorded 58.4 and 62.1 per cent higher seed yield over late sown crop (10th December) during first and second years, respectively. The highest seed yield of 1150 kg ha^{-1} was recorded in 10th November sown crop but it was at par with 25th October (1060 kg ha^{-1}) and 25th November (1040 kg ha^{-1}) sown crop during first year.

Ciriciofolo and Bonciarelli (1994) carried out a field experiment at Apollinare, Italy and observed that linseed crop sown in October or March, autumn sowing gave greater yields than spring sowing with lower plant densities. Because crop sown in October or March, autumn sowing had maximum development in yield attributes which is gave greater yield.

Dudhade *et al*. (1994) conducted a field experiment at Rahuri, Maharashtra and reported that the mustard crop sown on 1st October gave the highest seed yield than the 15th and 30th October, 15th and 30th November respectively. The number of capsules plant^{-1}, number of seeds capsules^{-1} and seed weight plant^{-1} was increased so the yield was increased on 1st October.

Mastro (1994) at Italy conducted a field experiment on linseed and reported that autumn sowing, in the second half of October, resulted in higher yield than spring sowing. All the yield attributes were developed in the second half of October.

Dixit *et al*. (1997) conducted a field experiment at Madhya Pradesh and studied that crops sown at 5^{th}-11^{th} November, 22^{nd}-28^{th} October and 15^{th}-21^{st} October respectively with temperature 25.2^{o}c gave the highest seed yield.

Shahidullah *et al*. (1997) performed a field experiment at Bangladesh and noticed that the greatest seed yield was obtained by sowing on 3^{rd} November and it decreased gradually with delay in sowing. The number of capsules plant^{-1}, number of seeds capsules^{-1} and seed weight plant^{-1} was increased when the crop was sown on 3^{rd} November.

Abdul EL-Dayem *et al*. (1998) performed a field experiment at Caria, Egypt and concluded that sowing at 15^{th} November gave higher values compared to 15^{th} October sowing, where the increments were 39.89, 42.28, 64, 40, 64.53, 76.66, 25.31 and 1.91 % for seed yield plant^{-1}, seed yield for feddan, straw yield plant^{-1}, straw yield feddan^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1} and 1000 seed weight, respectively. There was also gradual increase in oil percentage with the delay in sowing date until 15^{th} November.

Murthy *et al*. (1998) conducted a field experiment at Hyderabad and reported that the seed yield of soybean was high during winter season when sown on 15^{th} October but seed yield decreased with delay in the time of seeding soybean genotypes.

Kalita *et al*. (1999) conducted a field experiment at Assam, India and mentioned that linseed sown at 10th November recorded significantly higher seed yield and total N, P and K uptake in both the years than the 21st November.

Giri (2000) at New Delhi, conducted a field experiment and revealed that sunflower sown in the third week of October produced higher dry matter plant^{-1} than the crop sown in November third week, but the higher yield of sunflower was in third week of November.

Naik and Satapathy (2000) carried out a field experiment at Jashipur, Orissa and reported that there was highest yield, number of capsules plant^{-1}, number of seeds capsule^{-1} under late sown condition of linseed.

Saeidi (2000) at Iran, conducted a field experiment and concluded that the number of capsules plant^{-1}, seed yield were highest for different cultivars at 17th October. The average seed yield was highest in 17th October sowing than the 16th November sowing of linseed.

Zubal (2000) conducted a field experiment at Slovakia and observed that there was increase in the yield at late sowing of linseed.

Singh *et al*. (2001) condutced a field experiment at Jodhpur, Rajasthan and reported that the delay in sowing, i.e. in fourth week of October and first week of November, reduced the seed yield of Indian mustard by 14.4 and 24.7% in comparison with sowing of third week of October respectively.

Singh *et al*. (2002) conducted experiment at Uttar Pradesh, India and concluded that there was significant improvement in yield attributes, seed yield of linseed under 30th October sowing as compared to 18th October and 11th November.

Yadav *et al*. (2002) at Uttar Pradesh, India conducted a field experiment and found that crop sown at 1st-8th November resulted in the greatest seed yield (2164, 1949 and 2053 kg ha^{-1}), number of capsules plant^{-1} (76.1, 74.3 and 68.4), number of grains capsule^{-1} (8.2, 7.7 and 7.6).

Impact of sowing time cum newly released cultivars of linseed was studied at Palampur and it was observed that seed yield (988 kg ha^{-1}) and gross monetary return (Rs.19767 ha^{-1}) were significantly superior when crop was sown during November 1st week. But the crop sown during October last week was at par in these regards. The reduction in the seed yield was by 26.21 % in November last week sown crop as compared to November 1st week sown crop. (Anonymous, 2006a).

Impact of sowing time cum newly released cultivars of linseed was studied at Nagpur and it was revealed that the linseed crop sown during October last week to November 1st week produced significantly higher seed yield (1070 kg ha^{-1}) November 2nd and last week and net monetary return (Rs.14980 ha^{-1}) as compared to late sown crop (Anonymous, 2006b).

Awasthi *et al*. (2007) performed a field experiment at Kanpur, Uttar Pradesh and reported that sowing of mustard on 15th October achieved higher seed yield compared to sowing on 30th October.

Moahapatra *et al*. (2007) carried out a field experiment at Calcutta, on rape seed resulted that late sowing on 30th October with Laxmi-27 out yielded (8.39 q ha^{-1}) among four varieties, Laxmi-27, Jawahar-23, Neelum and T-397. The capsules plant^{-1}, seeds capsule^{-1}, seed yield plant^{-1} and 1000 seed weight were more at 30th October sowing. Also the higher oil percentage on October sowing than that of November sowing was observed.

Turhan *et al*. (2007) conducted a field experiment at Turkey and resulted that a significant differences were obtained among four sowing dates; 10th October, 20th October, 30th October, 10th November. The highest average seed yield

(2437.50 kg ha^{-1}) was obtained from earliest sowing time, whereas the lowest seed yield (1027.40 kg ha^{-1}) was obtained from the latest sowing time. Seed yield significantly decreased as sowing time was delayed.

Shaikh *et al*. (2008) at Latur, Maharashtra , conducted a field experiment and they resulted that highest seed yield (889 kg ha^{-1}) and harvest index (30 %) were recorded for linseed crop sown in 40th MW as compared to 40th, 41th, 42th, 43th, 44th, 45th MW. Significant reductions in seed yield and harvest index were observed with successive delay in sowing.

Husain *et al*. (2009) carried out field experiment at Kanpur and found that crop sown in last week of October and mid November gave higher seed and fiber yields. All yield attributes was observed more in last week of October and mid November than delayed sowing which gave high yield.

Seadh *et al*. (2012) conducted a field trial in Egypt and revealed that safflower sown at 1st October gave the highest value of seed yield, while crop sown at 1st September gave the lowest yield of safflower.

2.3 Effect of varieties on growth, yield attributes and yield

Singh (1968) studied the effect of varying levels of nitrogen and date of sowing on yield and quality of linseed (*Linum usitatissimum L*.) and revealed that the plant spread, number of capsule plant^{-1}, number of seed capsule^{-1}, diameter capsule^{-1}, weight capsule^{-1} and test weight of thousand seeds were adversely affected due to delay in planting. Early sowing (21st October) reported an increase in yield to the tune of 50.01 per cent over late planting (4th November.)

Bishnoi and Singh (1976) conducted a field experiment at Hissar and observed that raya crop sown at 10th October with variety RH-29 gave highest seed yield as compared to other varieties as RH-30, RL-18.

Singh and Singh (1978) carried out a field experiment at Rajsthan and found that mustard crop sown under late condition cultivar Pusa Kalyani gave highest yield (20.2q ha^{-1}) and proved superior to other varieties as Durgamani, RL18.

While studying the performance of high yield and disease resistant varieties from different agro climatic situation under Jabalpur (M.P.) condition, Vyas and Prasad (1980) observed that SPS-49-2 and SPS-30-5 which were bold seed type gave higher grain yield of 1275 and 1150 kg ha^{-1}, respectively.

Reddy (1983) conducted a field experiment on response of linseed cultivars to varying fertility levels under irrigation and observed that oil yields were higher in T-126, Jawahar-17 and S-36.

Dubey and Srivastava(1986) studied on three new varieties of linseed named Garima, Sweta and Shubhra at the C. S. Azad University of Agriculture and technology, Kanpur and concluded that Garima perform well with mean seed and oil yield of 1491 and 632 kg ha^{-1} respectively under irrigated situation, it out yield the best check Neelum and T-397 in seed and oil yield respectively by margin of over 18 percent.

Patidar and Lal (1991) performed a field experiment at Udaipur and revealed that the maximum seed yield was obtained from the cultivar RL 102-71 which was significantly higher by 10.7 and 13,1% than Chambl and T 397, respectively. The cultivar RL 102-71 withstand at late sown climatic conditions so, it gave more yield than the other varieties of linseed.

Mangal and Lal (1991) carried out a field experiment at Udaipur and studied that under late sown condition on 4^{th} November the variety RL 102-71 which was significantly higher by 10.27 and 16.34% than Chambl and T 397, respectively.

Paikaray and Misra (1991) at Semiliguda, conducted a field experiment and stated that the niger variety IGP76 sown on 10th September gave highest seed yield than the varieties GA10, GA11, UN4, IGP72, GA5, ONS8, N71, ONS7 respectively.

Cremaschi *et al*. (1992) carried out field experiment at Italy and concluded that the variety Lidgate gave the highest yield (3.12 t ha^{-1}) as compared to the Azur, Adin, Amazon, Barbara, Blue chip, BS89C, Buseto Palizzolo, Crystal, Linda, Ocean, Olin.

Dixit *et al*. (1992) carried out a field experiment at Madhya Pradesh and opined that the variety R552 of 119 days gave the highest seed yield (9.26-13.10q ha^{-1}) compared with Jawahar-23 (125 days) and R17 (119 days).

Patidar and Lal (1992) conducted a field experiment on performance of linseed cultivars at different levels of Nitrogen and observed that the maximum seed yield of linseed was with RL-102-71.Which was significantly higher by 10.7 and 13.1 % over Chambal and T-397, respectively

Popescu and Marinescu (1992) conducted a field experiment at Romania and reported that among the present commercial Romanian varieties, the new varieties Raluca, Lulia and Geria had better yield potential and better stability than the older varieties Azur, Iris and Adin.

Singh *et al*. (1993) carried out a field experiment at Hissar and stated that under late sown condition the mustard variety RH30 gave significantly higher seed yield, test weight, harvest index oil content than Varuna.

Sarma and Sarma (1993) conducted a field experiment at Assam and mentioned that the mustard variety Dira 367 gave highest seed yield (1557 kg ha^{-1})

as compared to varieties M 27(829 kg ha^{-1}), TM 2 (1309 kg ha^{-1}), Varuna (1457 kg ha^{-1}) respectively.

Verma and Pathak(1993) studied on response of linseed varieties to different dates of sowing during winter season at Kanpur and showed that Garima yielded significantly higher seed yield than the Neelum and Shubhra. The linseed variety Garima was gave high yield because of their improved genetical characters than the other varieties.

Leto *et al*. (1993) performed a field experiment at Villalba, Caltanissetta and reveales that Ocean and Line Isp II gave the satisfactory and stable yield. Isp II was more suitable to change in climatic condition and have improved genetical make up than the other varieties. So it gave high yield under extended sowing dates.

Rajput *et al*. (1993) performed a field experiment at Madhya Pradesh and reported that the optimum sowing date was 10^{th} November seed oil content decreased and protein content increased as the sowing was delayed after 10^{th} October.

Ciriciofolo and Bonciarelli (1994) carried out a field experiment at Apollinare, Italy and reported that the cultivars Linda, Barbara, Isp IV, Antares and Blue chip were particularly suitable for autumn sowing.

Dudhade *et al*. (1994) conducted a field experiment at Rahuri, Maharashtra and resulted that under late sown condition the mustard variety Seeta gave highest seed yield than Puasa Bold and Puasa Barani.

Mastro (1994) at Italy, conducted a field experiment and reported that autumn sowing, in the second half of October and in spring sowing the cultivar Ocean and Barbara gave best seed yield.

Fontana and Maestrini (1995) conducted a field experiment at Italy and concluded that the cultivar Barbara and Lidgate had highest seed yield above 2.6 t ha^{-1}. The cultivar Barbara and Lidgate have more improved growth and yield attributes, so it gave high yield under extended sowing date.

Shrma *et al.* (1995) studied on performance of linseed cultivars under varying dates of sowing in Kullu valley at Regional Research station Bajaura and concluded that the varities Himalini and Janaki gave significantly higher yield than Jeevan and KL-1 in 1986-1987 but in 1987-1988 no significant difference in yield were obtained between Himalini, Janaki and Jeevan.

Merrien (1996) conducted a field experiment at France, stated that winter and spring oilseed flax varieties produced higher biomass, capsules $plant^{-1}$ and yield. So the flax varieties gave high seed and straw yield under late sown condition.

Singh and Verma (1996) carried out a field experiment at Ghaziapur, Uttar Pradesh and reported that under late sown condition the linseed variety Sweta gave highest seed yield than the local variety.

Lisson and Mendham (1997) conducted a field experiment at Tasmania, Australia and revealed that European flax cultivar yielded significantly more stem and bark fibre, seed yield than Australian flax cultivar. Also there were clear benefits from sown at early November and January and also accommodate higher seeding rate in late sowing.

Ram and Singh (1997) conducted a field experiment at Ranchi, Bihar and revealed that net returns (Rs. 3122 ha^{-1}) and benefit: cost ratio (1.26) as compared to Sweta, Shunhra and BAU 470-B.

Shahidullah *et al*. (1997) carried out a field experiment at Bangladesh and found that Comilla gave the greatest seed yield by sowing at 3rd November than the cultivar Lin-1, P-14-25 and 8125. The variety Comilla have more development in growth characters so resulting in high yield.

Kightley *et al*. (1997) at UK, conducted a field experiment and revealed that the variety Oliver had the best combination of yield, quality and agronomic characteristics. The genetical make up of Oliver variety was improved so it gave high seed yield.

Murthy *et al*. (1998) conducted e field experiment at Hyderabad and reported that the soybean genotype MACS 201 proved superior to all other genotypes in terms of yield components and seed yield.

Dubey (1999) carried out a experiment at Madhya Pradesh, India and concluded that under late sowing date the cultivar RLC-29 (Sheetal) recorded significantly higher values of almost all the growth and yield parameters, grain yield (q ha^{-1}) and economics over other cultivars except plant height (cm), seed $capsule^{-1}$ and harvest index (%). RLC-29 recorded the highest growth and yield attributes including grain yield and was the most economical cultivar for late planting especially after soybean and recorded 57.51, 11.69, 14.44 and 22.53 % more grain yield than SLS-21, SLS-9, SLS-7 and T-397, respectively.

Payasi *et al*. (1999) at Madhya Pradesh, India conducted a field experiment and reported that RIC-4 had the highest yield followed by SPS49-2, Jawahar 23, LMH81-1 and EC22583. R1156, R552, SPS48-5, and LCK8323 showed wide adaptability for seed yield $plant^{-1}$ and seed yield ha^{-1}, so they may be successfully grown in all type of environment. RLC4, EC41484 and ILS164 were highly responsive for capsule $plant^{-1}$, while LHCK5 and EC15888 were responsive for seeds $capsule^{-1}$.

Khare *et al.* (1999) conducted the experiment on relative performance of linseed cultivars under different sowing management in rainfed condition and observed that the Cv. Kiran exceeded all cv. in term of seed yield and profit, mainly due to more branches plant^{-1} and capsules plant^{-1}.

An experiment conducted by Pali and Tripathi (2000) on performance of linseed (*Linum usitatissimum* L. *)* cultivars under varying sowing time and fertilizer management in rainfed condition reported and that Cv. Kiran linseed gave the maximum seed yield followed by R-552, RLC-29 and local branches plant^{-1}, dry matter plant^{-1}, capsule plant^{-1} and seed capsule^{-1} mainly contributed to the seed yield.

Bhushan *et al*. (2000) performed a field experiment at Uttar Pradesh, India and revealed that the cultivar Neelum produced the highest dry matter accumulation (DMA) at flowering as well as seed yield, seeds capsule^{-1} and 1000 seed weight.

Dubey (2000) performed a field experiment at Madhya Pradesh and observed that the variety RLC29 recorded significantly higher values almost all the growth and yield parameters, seed yield (q ha^{-1}) and economics over other varieties except plant height (cm), seeds capsule^{-1} and harvest index (%) as compared to the SLS21, SLS9, SLS7.

Saeidi (2000) at Iran, conducted field experiment and reported that delayed sowing resulted in the reduction in emergence of number of days to maturity, yield and yield components in all edible flax genotypes.

Singh *et al*. (2001) conduced a field experiment at Jodhpur, Rajasthan and reported that the varieties of mustard Pusa Bold and T 59 when sown at fourth week of October and first week of November found statistically at par in respect of yield and yield attributes, but significantly superior to local cultivar, accounting of increase in seed yield by 29 and 20.2% respectively.

Singh *et al*. (2003) carried a field experiment at Ludhiyana and studied that under late sown condition the genotype of mustard PC 5-17 gave 5% higher seed yield, leaf area index, secondary branches plant^{-1}, oil yield, net returns more than the genotype PC 5.

Khan *et al*. (2003) performed a field experiment at Multan, Pakistan and revealed that eight linseed genotypes P14-80-79-52, Randkat, PB-180, P16-80-99, Royal-4, LS-30, T-5 and Carlos-80 produced higher seed yield sown in rabi and genotype Carlos-80 had the highest seed yield.

Impact of sowing time-cum-newly released cultivars of linseed was studied at Faizabad and it was concluded that the linseed Cv. Garima exceeded Shubhra, Shekhar and T-397 with regards to seed yield. The magnitude of superiority of Garima over Shubhra, Shekhar and T-397 was found to be significant by a margin of 24.23,12 .07 and 45.07 per cent, respectively (Anonymous, 2006a).

Impact of sowing time-cum-newly released cultivars of linseed was studied at Powarkheda and it was revealed that seed yield produced by Kiran Cultivar was significantly higher over JLS-9, J-23 and Kartika (Anonymous 2006b).

Awasthi *et al*. (2007) performed a field experiment at Kanpur, Uttar Pradesh and reported that sowing of mustard variety Vaibhav on 15th October achieved higher seed yield and net monetary return as compared to sowing on 30th October and variety Urwashi.

Moahapatra *et al*. (2007) carried out a field experiment at Calcutta, India resulted that late sowing on 30th October with Laxmi-27 out yielded (8.39 q ha^{-1}) among four varieties; Laxmi-27, Jawahar-23, Neelum and T-397. All phonological characters, seed oil percentage, seed yield and harvest index showed its best expression in Laxmi-27 variety.

Turhan *et al*. (2007) performed a field experiment at Turkey and noticed that significant differences were obtained among different cultivar H604049, H604038, Viking, Elan, Titan, Lorenz and Trabant sown at different sowing dates. The cultivar H604038 produced the highest seed yield (1988.4 kg ha^{-1}) and it was followed by variety Trabant (1981kg ha^{-1}) and Titan (1963.8 kg ha^{-1}). The highest oil content, 42% was obtained from genotype Lorenz at the first sowing time and from genotype Trabant at the second sowing time.

Rao *et al*. (2007) conducted a experiment on stability behaviour of some linseed (*Linum usitatissimum* L.) genotype under environmental variability and showed that genotype Kiran required 53 day to flower, 105 days to mature, 1000 seed weight $plant^{-1}$ (4.66 g) and 1.34 g seed yield $plant^{-1}$.

El-Refaey *et al*. (2008) conducted a field experiment at, Egypt and found that the flax genotype Sakha-1, Sakha-3 performed the highest fibre yield. Sakha-1 had the superiority for number of capsules $plant^{-1}$, seed yield $plant^{-1}$ and oil yield as compared to other variety as Giza-8, Marlin, Escalina.

Husain *et al*. (2009) carried out field experiment at Kanpur and found that under late sown condition the variety Gaurav gave highest yield than the varieties Shikha, Rashmi, Meera, Parvati, Jeevan, Nagarkot and Pratap Alsi1.

2.4 Meteorological study

Sorlino (1997) at Argentina, conducted a field experiment and observed that thermal duration of flowering was longer following early sowing but vernalisation caused no significant differences. Vernalisation affected total flower number, particularly when sown late, through its effect on vegetative growth.

Casa *et al.* (1999) studied the environmental effects on linseed *(Linum usitatissimum* L.*)* yield and growth of flax at different temperature. Same, from emergence to beginning of flowering calculated using the mean daily temperature, averaged 382 ^{0}Cd (degree days) .The maximum LAI which coincided with full flowering was reached in 1997 and 1998 at about 400 ^{0}Cd which took 16 days lesser, from emergence in 1998. The higher temperature and dry conditions during vegetative development phase caused shortening in the growing cycle as compared to cooler year.

Gourangakar and Chakravarty (1999) conducted field experiment on thermal growth rate, heat and radiation utilization efficiency of Brassica under semiarid environment. They observed that the seed filing and maturity stages of crop growth of late sown crop (2nd week of Nov.) experienced 2.5-3.0^{0}C higher temperature as compared to early sown crop (2nd fortnight of October). Study also revealed that there was significant correlation between GDD and crop growth parameters with correlation coefficient ranging between 0.58 and 0.98 among different cultivars and sowing dates.

Mokashi.(1999) conducted experiment on thermal requirement in sunflower-red gram intercropping in the scarcity zone of Maharashtra state; and revealed that the accumulated heat units and number of days for reaching various growth stages decreased with successive delay in sowing. The variation in accumulated heat unit and number of days required in reaching various growth stages did not indicate any definite trend. The crop sown earlier received maximum thermal energy than late sown crop during all the years of experimentation. The heat unit required to attain the harvesting stage marginally differ within the year under all sowing dates as evident from coefficient of variation.

Agrawal *et al*. (2002) studied on thermal requirement of sunflower plant type, three date of spring planting and observed that GDD was higher in D_1 and D_2

planting than D_3 and its mean value was 3435, 2288 and 2172 ^{0}Cd, respectively. However different genotypes were similar in GDD requirement.

Singh (2002) studied the effect of intercropping on reflected photo synthetically active radiation (RPR) in rainfed crop. They concluded that RPR values increased with increase in crop age up to 42 days and decreased with decreasing crop age (56-70DAS) and again increased at 98th day. In general RPR values were highest during the initial stage of crop growth owing to more exposure of soil due to less LAI.

Naresh Kumar (2005) studied on thermal unit requirement for leaf growth and phonological development in sunflower. He observed that GDD requirement for different phonological stages in different sowing time varied more during seed filling period than the vegetative period.

Vrishali. (2005) conducted a field experiment on relationship of LAI and biomass of soybean with agro climatic indices. They revealed that the GDD and HTU for soybean season reported significant correlation with LAI as well as biomass.

Sorlino *et al*. (2004) carried out a field experiment at Argentina and reported that flowering duration and magnitude were reduced with delayed sowing date then crop loss compensation aptitude, especially with potential stress situation.

Neog and Chakravarty (2005) conducted a experiment on thermal unit and phonological model for Brassica jincea and revealed that decreasing trend in accumulated GDD was observed with successive delay in sowing of crop.

Shaikh *et al*. (2008) at Latur, Maharashtra , conducted a field experiment and they noticed that delay in sowing of cultivars Kiran, Garima and RLC-4 showed differences in number of days required for maturity and growing degree days from sowing to maturity.

2.5 Economic study

Dixit *et al*. (1992) carried out a field experiment at Madhya Pradesh and reported that the maximum net return of linseed up to Rs. 7200-10500 ha^{-1} was obtained when the crop was sown at 25^{th} October while crop sown at 15^{th} November gave less net return Rs. 5280-6700/ha.

Yadav *et al*. (1993) carried out field experiment at Kanpur, Uttar Pradesh and observed that the mustard crop sown at 25^{th} October proved best on the basis of economics net return was Rs. 10500.

Singh and Verma (1996) carried out a field experiment at Ghaziapur, Uttar Pradesh and found that under late sown condition the linseed variety Sweta gave the maximum return of Rs. 2395 ha^{-1} compared to local variety

Raghuwanshi *et al*. (1998) carried out a field experiment at Madhya Pradesh, India and revealed that in *rabi* sowing the highest benefit: cost ratio (9.00) was observed in linseed supplemented with 50% of the recommended NPK. The use of NPK fertilizers increased the net profit by 8 of the additional cost of linseed.

Bastia and Mohanty (1999) at Bhawanipatna, Orissa and opined that the variety Laxmy 27 gave highest yield 588.41 kg ha^{-1} as compared to Pusa 3 (550.59 kg ha^{-1}) and Kiran (524.19 kg ha^{-1}).

Singh *et al*. (2002) conducted experiment at Uttar Pradesh, India and reported that there was significant improvement in net returns, output-input ratio of linseed under 30^{th} October sowing as compared to 18^{th} October and 11^{th} November.

Yadav *et al*. (2002) at Uttar Pradesh, India conducted a field experiment and resulted that crop sown at 1^{st}-8^{th} November resulted in the greatest net returns (29162, 25998 and 29768 Rs. ha^{-1}).

Belayk *et al*. (2004) performed a field experiment at Russia and revealed that the maximum potential and economic yield was obtained with early planting.

Impact of sowing time-cum-newly released varieties of linseed was studied at Palampu and it was observed that seed yield (988 kg ha^{-1}) and gross monetary return (19767 Rs.ha^{-1}) were found to be significantly superior when crop was sown during November 2^{nd} week but the crop sown during October last week was at par in these regards. The reduction in seed yield was observed 26.21 % in November last week sown crop as compared to November 2^{nd} week sown crop (Anonymous, 2006a).

Impact of sowing-cum-newly released varieties of linseed was studied at Nagpur and it was revealed that the linseed crop sown during the last week of October produced significantly higher seed yield (1070 kg ha^{-1}) and net monetary return (14980Rs. ha^{-1}) as compared to latter sowing during November 2^{nd} and last week (Anonymous, 2006b).

3. MATERIAL AND METHODS

The present field investigation was carried out to study "Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)" during *rabi* 2012-13.The details of material used and methods adopted during the period of investigation are presented in this chapter under following heads.

3.1 Details of the experimental material

3.1.1 Experimental site

The experiment was laid out in Plot No. 14 C, Agronomy Farm, College of Agriculture, Pune, during *rabi*, 2012-13.

3.1.2 Soil

The topography of the experimental field was uniform and leveled. The soil of the experimental field was clay loam in texture with depth upto 60 cm.

In order to know the physical and chemical properties of experimental field, representative composite samples were collected from 0 to 30 cm depth at 5 randomly selected spots in zig-zag fashion before sowing of the crop. These samples were mixed together and air dried under shade. A representative soil sample was prepared for determining physical and chemical properties of the experimental field.

The analytical methods used for soil and plant analysis are presented in Table 1. The data in Table 2 reveals that the soil of experimental field was clay loam in texture, normal in reaction (p^H 7.8) with low available nitrogen (178.48 kg ha^{-1}), medium available phosphorus (19.34 kg ha^{-1}), high available potassium (475 kg ha^{-1}), electrical conductivity (0.21dSm^{-1}) and organic carbon (0.16 %).

3.1.3 Climatic conditions during the period of experimentation

3.1.3.1 General

Agroclimatically, Pune comes under the Plain Zone. Geographically, Pune is situated on $18^o2'$ North latitude and $73^o51'$ East longitude. The altitude above mean sea level is about 557.7 meters. The average annual rainfall is 675 mm, out of the total annual rainfall, 75 per cent is received during the period from June to September from South-West monsoon, while the rest is received in October and November from North-East monsoon.

The annual maximum temperature ranged between 34^oC and 40^oC and annual minimum temperature ranged between 6^oC and 10^oC. The relative humidity during morning and evening ranged between 86 and 70 per cent, respectively.

3.1.3.2 Nature of season during the experimental period

In order to get an idea about climatic conditions prevailed during the crop growth period of present investigation, the mean weekly weather were recorded on the important weather parameters during the crop season is presented in Table 3 and graphically depicted in Fig. 1

From the data presented in Table 3, it was observed that mean maximum and minimum temperature ranged between 29.5^oC and 41.0^oC and 10.4^oC and 16.5^oC, respectively. The mean relative humidity during morning hours ranged between 55 and 95 per cent and during evening hours from 14 and 41 per cent. There was no rainfall during crop growth period. As regards to bright sunshine hours, the maximum sunshine hours (9.9 hrs.

Table 1: Analytical methods used for soil and plant analysis

Sr. No.	**Parameters**	**Method adopted**	**References**
A.	**Soil analysis**		
1.	Particle size analysis	Hydrometer method	Bouyoucos, (1962)
2.	Textural class	Hydrometer method	Bouyoucos, (1962)
3.	pH	Potentiometer	Page *et al*, (1982)
4.	E. C. (dSm^{-1})	Conductometric	Page *et al*, (1982)
5.	Organic carbon	Wet oxidation method	Nelson and Sommers, (1982)
6.	Available Nitrogen	Modified alkaline permanganate method	Sahrawat and Burford, (1982)
7.	Available Phosphorus	Olsen's method	Olsen and Sommers, (1982)
8.	Available Potassium	Neutral normal ammonium acetate extraction method	Jackson, (1973)
B.	**Plant analysis**		
1.	Nitrogen	Micro-Kjeldhal method	A.O. A. C., (1980)
2.	Phosphorous	Vando-molybdate yellow colour method in nitric acid system	Jackson, (1973)
3.	Potassium	Flame photometric method	Jackson, (1973)

Table 2: Physical and chemical properties of soil from the experimental field (0-30 cm)

Sr. No.	Characters	Content
A.	**Physical properties**	
1.	Sand (%)	34.83
2.	Silt (%)	24.65
3.	Clay (%)	40.52
4.	Texture	Clay loam
B.	**Chemical properties**	
1.	Available nitrogen (kg ha^{-1})	178.48
2.	Available Phosphorus (kg ha^{-1})	19.34
3.	Available Potassium (kg ha^{-1})	475.00
4.	pH	7.8
5.	E. C. (dSm^{-1})	0.21
6.	Organic carbon (%)	0.16

Table 3: Weekly meteorological data recorded during the experimental period (Nov. 2012 to March 2013)

Month and year	MW	Mean Temp. (^{0}C)		Relativehumidity (%)		Rain-fall (mm)	Rainy days	Bright sunshine (hrs day^{-1})
		Max.	Min.	Morning	Evening			
Oct. 2012	44	30.0	16.5	89	42	0	0	6.6
Nov. 2012	45	32.1	16.2	88	36	0	0	9.0
	46	30.2	13.4	90	33	0	0	8.9
	47	30.0	12.3	91	36	0	0	8.8
	48	31.6	14.3	92	37	0	0	8.0
Dec. 2012	49	31.2	16.1	89	41	0	0	8.5
	50	31.6	12.8	93	33	0	0	9.1
	51	29.7	11.7	92	34	0	0	7.8
	52	29.5	10.7	95	36	0	0	8.6
Jan. 2013	1	32.0	15.1	93	27	0	0	8.9
	2	30.1	10.4	94	32	0	0	8.6
	3	30.1	10.4	94	32	0	0	8.6
	4	31.1	11.4	94	27	0	0	8.5
Feb. 2013	5	31.7	14.7	82	33	0	0	7.0
	6	31.4	14.7	90	36	0	0	8.0
	7	32.4	11.4	90	22	0	0	9.8
	8	33.5	12.6	85	22	0	0	9.9
March 2013	9	34.1	12.2	71	14	0	0	8.5
	10	41.0	15.4	63	17	0	0	8.3
	11	35.4	16.1	64	17	0	0	7.4
	12	36.1	18.3	55	15	0	0	7.0

day^{-1}) were observed in 9th meteorological week and minimum bright sunshine hours (6.6 hrs day^{-1}) were observed in 44th meteorological week.

Table 4: Cropping history of the experimental field

The cropping history of the experimental field for previous three years is presented in Table 4.

Sr. No.	Year	Crop		
		Kharif	***Rabi***	***Summer***
1.	2009-10	Soybean	Chilli	Fallow
2.	2010-11	Soybean	Wheat	Fallow
3.	2011-12	Sannhemp	Wheat	Fallow
4.	2012-13	Soybean	Present investigation	-

3.2 Details of experimental methods

3.2.1 Experimental details

The experiment was laid out in split-plot design with twelve treatment combinations. The treatment comprising four sowing dates *viz.*,., S_1 : 44 MW (1st week of November), S_2 : 45 MW (2nd week of November), S_3 : 46 MW (3rd week of November), S_4 : 47 MW (4th week of November) and three varieties *viz.*, V_1 : PKVNL-260, V_2 : NL-97, V_3 : Padmini. The gross plot size was 3.60m x 2.40m and net plot size 2.40m x 1.80m. The details of the treatment with symbols used are presented in Table 5. and plan of field layout along with allocation of treatments shown in Fig. 2

Table 5: Details of treatments along with their symbols

Sr. No.	Details of the treatment	Symbol used
A.	**Main plot: Sowing dates**	**S**
1	44 MW (1st week of November)	S_1
2	45 MW (2nd week of November)	S_2
3	46 MW (3rd week of November)	S_3
4	47 MW (4th week of November)	S_4
B.	**Sub plot : Linseed varieties**	**V**
1	PKVNL-260	V_1
2	NL-97	V_2
3	Padmini	V_3

3.2.2 Preparation of field of layout

The plan of layout and other details are given below:

a) Crop : Linseed

b) Sowing time : 4

b) Varieties : 3

c) Season : *Rabi*, 2012-13

d) Design : Split plot

e) Replications : 3

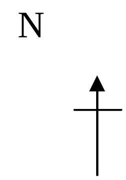
f)Treatment combinations : 12 (4 x 3)

g) Spacing : 30 cm x 5 cm

h) Plot size : Gross: 3.60 x 2.40 m^2

Net: 2.40 x 1.80 m^2

Fig.2 Plan of layout



R-I

T_{11} S_4V_2	T_9 S_3V_3	T_2 S_1V_2	T_4 S_2V_1
T_{10} S_4V_1	T_8 S_3V_2	T_1 S_1V_1	T_6 S_2V_3
T_{12} S_4V_3	T_7 S_3V_1	T_3 S_1V_3	T_5 S_2V_2

R-II

T_7 S_3V_1	T_3 S_1V_3	T_5 S_2V_2	T_{12} S_4V_3
T_9 S_3V_3	T_2 S_1V_2	T_4 S_2V_1	T_{11} S_4V_2
T_8 S_3V_2	T_1 S_1V_1	T_6 S_2V_3	T_{10} S_4V_1

R-III

T_1 S_1V_1	T_5 S_2V_2	T_{12} S_4V_3	T_7 S_3V_1
T_3 S_1V_3	T_4 S_2V_1	T_{11} S_4V_2	T_9 S_3V_3
T_2 S_1V_2	T_6 S_2V_3	T_{10} S_4V_1	T_8 S_3V_2

Table 6: Schedule of field operations carried out in experimental field During *rabi* 2012-13

Sr. No.	Cultural operations	Frequency	Date
A.	**Preparatory tillage**		
1	Ploughing	1	20-10-12
2	Harrowing and clod crushing	1	23-10-12
3	Collection of stubbles	1	25-10-12
4	Preparation of layout	1	28-10-12
B.	**Sowing**		
1	Sowing	1(S_1) 1(S_2) 1(S_3) 1(S_4)	01-11-12 08-11-12 13-11-12 21-11-12
C.	**Fertilizer application**		
1	Application of urea, single super phosphate	1(S_1) 1(S_2) 1(S_3) 1(S_4)	01-11-12 08-11-12 13-11-12 23-11-12
2	Top dressing of urea	1(S_1) 1(S_2) 1(S_3) 1(S_4)	30-11-12 08-12-12 12-12-12 23-12-12
D.	**Post sowing operation**		
1	Gap filling	1(S_1) 1(S_2) 1(S_3) 1(S_4)	13-11-12 18-11-12 23-11-12 03-12-12
2	Thinning	1(S_1) 1(S_2) 1(S_3) 1(S_4)	23-11-12 28-11-12 03-12-12 13-12-12
3	Irrigation	4(S_1) 4(S_2)	01-11-12, 30-12-12, 20-1-13, 15-1-13 08-11-12, 08-12-12, 27-12-12,

			10-01-13
		3(S_3)	13-11-12, 12-12-12, 08-01-13
		3(S_4)	23-11-12, 23-12-12, 07-01-13
4	Weeding	1(S_1)	08-12-12
		1(S_2)	13-12-12
		1(S_3)	18-12-12
		1(S_4)	30-12-12
E.	**Harvesting**	1(S_1)	27-02-13
		1(S_2)	03-03-13
		1(S_3)	06-03-13
		1(S_4)	08-03-13
F.	**Threshing and winnowing**		14-03-13 to 16-03-13

3.3 Cultural operations

The various cultural operations carried out in the experimental field are given in Table 6.

3.3.1 Land preparation

Preparatory tillage operations were done by various implements mounted on tractor. Ploughing was done upto 30 cm depth by using mould board plough. Clod crushing was done with the help of disk harrow. Cross harrowing was done by tractor and thus, plain seed bed was achieved.

3.3.2 Seeds and sowing

The seeds of linseed varieties were obtained from the AICRP oilseeds, College of Agriculture, Nagpur. The seeds were sown by line sowing in shallow furrows opened by marker at 30 cm row spacing and 5 cm plant to plant spacing with depth up to 3-4 cm.

3.3.3 Fertilizer application

The half dose of nitrogen through urea and full dose of P_2O_5 through single super phosphate were applied at sowing time to all plots. The remaining half dose of nitrogen was top dressed through urea at 45 DAS.

3.3.4 Irrigation

The first irrigation was applied immediately after sowing for better germination and subsequent irrigations were given as per the growth stages of the crop.

3.3.5 Gap filling and thinning

The desired plant population per plot i.e. one plant each spot was maintained. Gap filling and thinning were done to maintain average 5 cm intra plant spacing.

3.3.6 Weeding

The weeding operation were carried out by giving hand weeding at 20, 50, 70 DAS.

3.3.7 Harvesting and threshing

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

3.4 Biometric observations

The details of the biometric observations recorded are mentioned in Table 7.

3.4.1 Sampling techniques

For recording observations, five plants were selected randomly in each net plot. The selected plants were labelled and were marked by fixing pegs near them. All the observations on growth and yield attributes were recorded on these plants.

3.4.2 Plant count

The initial and final plant count were recorded at 20^{th} days after sowing and at harvest, by counting all plants from each net plot and expressed on hectare basis.

3.5 Growth analysis

3.5.1 Plant height (cm)

The height of plant generally indicates the growth of the crop. The height of the plant was recorded on 30th, 45th, 60th, 75th, 90th DAS and at harvest. It was measured from the base of main stem to apical growing point.

3.5.2 Number of branches plant^{-1}

Numbers of branches excluding the main stem were recorded at an interval of 15 days from 30th, 45th, 60th, 75th, 90th DAS and at harvest.

3.5.3 Plant spread (cm)

Plant spread was recorded at an interval of 15 days from 30th, 45th, 60th, 75th, 90th DAS and at harvest. Plant spread was the measured by maximum horizontal space occupied by the plant between tips of two extreme leaves either side from the observational plant.

3.5.4 Dry matter per plant (g)

From each treatment one plant was cut off at random from the ground level and was used for determining the dry weight of plants. Observations for dry matter plant^{-1} were recorded at30th, 45th, 60th, 75th, 90th DAS and at harvest. The material was chaffed and was first air dried in sun and then inoven at about 60^{o}C till they showed constant weight. After weighing material, the dry matter of plant was recorded.

3.6 Post harvest observations

3.6.1 Number of capsules plant^{-1}

The number of capsules plant^{-1} at harvest was recorded from the five plants under observation.

3.6.2 Number of seeds capsule^{-1}

The number of seeds capsule^{-1} of the five plants under observation was counted and from this, the mean number of seeds per capsule^{-1} was calculated at harvest.

3.6.3 Seed weight plant^{-1}

The weight of seeds (g) plant^{-1} was calculated after weighing seed separated from the capsules of all five observational plants.

3.6.4 Test weight (g)

A weight of 1000 seeds was taken from net plot of each treatment.

3.7 Yield observations

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

The seed yield (kg) net plot^{-1} was recorded after threshing all plants from the net plot^{-1}. Seed weight net plot^{-1} was multiplied by hector factor to express as seed yield hectare^{-1}.

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

Yield of straw (kg) net plot^{-1} was obtained by subtracting the yield of seeds plot^{-1} from the yield of total dry produce net plot^{-1} and then converted to hectare basis.

3.8 Quality observations

3.8.1 Oil content

Oil content of seed from each treatment plot was determined by the “Soxhlet Apparatus” using petroleum ether.

3.9 Chemical studies

3.9.1 Soil analysis

The composite soil sample from 0-30 cm layer collected before sowing from the experimental area. After harvesting, the soil samples from each of the treatment for assessment of chemical properties of soil were collected. The appropriate methods for estimation were used (Table 1.) and the concentration of nutrients in the soil samples were worked out.

3.9.2 Plant analysis

The observational plants collected at harvest were used for chemical analysis. The dried samples of seeds and straw were ground and passed through Willey mill (20 mesh) and about 20 g of representative samples from each powdered material was stored in plastic bag, suitably labeled and used for estimation of nitrogen, phosphorus and potassium separately. The different methods utilized were given in Table 1.

3.9.3 N, P and K uptake by crop

The uptake of nitrogen, phosphorus and potassium by seed and straw were calculated by multiplying per cent N, P and K in seed and straw with their respective yields. Total uptake was recorded by summing up the respective uptake by seed and straw.

Table 7: Schedule of biometric observations recorded during period of investigations

Sr. No.	Particulars	Frequency	Observation recorded days after sowing (DAS)	Number of plants for observation
A)	**Biometric observation**			
1.	i)Initial plant count	1	20 DAS	All plant
	ii)Final plant count	1	At harvest	All plant
2.	Plant height (cm)	6	30,45,60,75,90, at harvest	5 plant
3.	Number of branches $plant^{-1}$	6	30,45,60,75,90, at harvest	5 plant
4.	Plant spread (cm)	6	30,45,60,75,90, at harvest	5 plant
5.	Dry matter (g)	6	30,45,60,75,90, at harvest	1 plant
B)	**Post harvest observation**			
1.	Number of capsules $plant^{-1}$	1	At harvest	5 plant
2.	Number of seeds $capsule^{-1}$	1	At harvest	5 plant
3.	Seed weight $plant^{-1}$(g)	1	At harvest	5 plant
4.	Test weight (g)	1	At harvest	5 plant
5.	Seed yield (q ha^{-1})	1	At harvest	Net plot
6.	Stover yield (q ha^{-1})	1	At harvest	Net plot
C)	**Quality studies**			
1.	Oil content (%)	1	At harvest	Net plot
D)	**Chemical analysis**			
1.	Initial and final soil analysis	1	Before sowing and after harvesting	
2.	N, P, K,uptake(kg ha^{-1})	1	At harvest	Net plot
E)	**Meteorological observation**			
1.	GDD (Growing degree days)		At critical growth stage	Net plot
2.	Photothermal unit		At critical growth stage	Net plot
3.	Hydrothermal unit		At critical growth stage	Net plot

3.10 Meteorological observations

3.10.1 Growing degree days (GDD)

The GDD requirement for emergence, branching, flowering ,capsule development and at physiological maturity were recorded during period of above growth stages by following formula (Mali *et al*., 2000)

GDD = (Maximum temperature + Minimum temperature) / 2 – Base temperature

Base temperature for linseed = 4.4^{o}C

3.10.2 Photothermal unit

The photothermal unit was calculated by multiplying GDD into day length at critical growth stages of crop.

Photothermal unit = GDD X Day length

3.10.3Hydrothermal unit

The hydrothermal unit was calculated by multiplying GDD into relative humidity at critical growth stages of crop.

Hydrothermal unit = GDD X Relative humidity

3.11 Economic evaluation

The economics hectare^{-1} was worked out by considering prevailing market prices of commodity and charges of various items for crop production and mentioned in Appendix I were considered.

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

Wage rates of hired laborers, irrigation charges, cost of seed, market rate of fertilizer, hired charges of machinery with implements and interest on working capitalwere considered. The cost of cultivation oflinseed crop in different treatments was given in Appendix II.

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

The gross monetary returns (Rs. ha^{-1}) were worked out by considering seed yield and straw yield from different treatments and prevailing market price of commodities.

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

The net monetary returns hectare^{-1} was calculated by deducting cost of cultivation of the corresponding treatment from gross monetary returns.

The formula used given below,

Net monetary return = Gross monetary return – Cost of cultivation

3.11.4 Benefit: Cost ratio (B: C Ratio)

B: C Ratio was calculated by following formula,

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

3.12 Statistical analysis and interpretation of the data

The statistical analysis of data was carried out by “Analysis of Variance” (Fisher, 1970) and test of significance was carried out as given by Panse and Sukhatme (1985). The ancillary and yield data of individual crop was analyzed by split plot design for linseed crop. When the treatment differences were significant standard error (S.E.m$\pm$) and critical difference (C.D.) were calculated at 5 per cent probability level and when the treatment differences were not significant, only standard error was worked out. The data were appropriately presented in tables and suitably depicted in graphical illustrations and figures wherever essential.

4. RESULTS AND DISCUSSION

A present investigation was undertaken to study the "Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)" during *rabi* season 2012-13 at Agronomy farm, A.C. Pune. The data obtained from experiment were dully analyzed and discussed in this chapter and attempt has been made to explain the findings with probable and logical reasoning.

4.1 Plant count

Data regarding initial and final plant count of linseed as influenced by various treatments during *rabi* 2012 - 13 are presented in Table 8. The mean initial and final plant count of linseed was 657636 and 655639 ha^{-1}, respectively.

4.1.1 Effect of sowing dates

The initial and final plant count of linseed did not differ significantly due to different sowing dates.

4.1.2 Effect of varieties

The initial and final plant count of linseed did not differ significantly due to different varieties of linseed.

4.1.3 Interaction effect

None of the above interaction effects between sowing dates and linseed varieties were found to be significant in respect of initial and final plant stand.

Table 8: Mean initial and final plant count ha^{-1} as influenced periodically by different treatments.

Treatment	Plant population	
	Initial	Final
A. Sowing times:		
S_1 : 44 MW	657663	655669
S_2 : 45 MW	657641	655648
S_3 : 46 MW	657626	655631
S_4 : 47 MW	657612	655609
S.E. m ±	16.84	14.67
C.D. at 5%	N.S.	N.S.
B. Varieties :		
V_1: PKVNL-260	657652	655659
V_2 : NL-97	657634	655639
V_3 : Padmini	657622	655619
S.E. m ±	15.92	13.56
C.D. at 5%	N.S.	N.S.
C. Interaction		
S.E. m ±	11.84	11.12
C.D. at 5%	N.S.	N.S.
General mean	657636	655639

4.2 Growth attributes

Data on growth attributing characters of linseed were recorded periodically at an interval of 15 days from 30 DAS and presented in the subsequent paragraphs.

4.2.1 Plant height (cm)

The data pertaining to mean plant height as influenced periodically by different treatments are presented in Table 9 and graphically depicted in Fig.3.

The mean plant height of linseed was progressively increased with advancement in the age of crop. The mean plant height at 30, 45, 60, 75, 90 DAS and at harvest was 24.15, 32.60, 44.01, 52.74, 58.80 and 59.75 cm, respectively.

4.2.1.1 Effect of sowing dates

The mean plant height of linseed was influenced significantly due to extended sowing dates at all growth phases of crop.

During all the growth stages of crop, 45 MW recorded significantly higher plant height which was at par with 44 MW and significantly superior over rest of sowing date. These results indicate that sowing of the linseed in 45 MW was most suitable for plant height. This might be associated with the linseed sown in 45 MW was exposed to low temperature, more dew formation, higher coldness and resulted in higher plant height.

The results are in the confirmity with those of Abdul EL-Dayem *et al*. (1998), Naik and Satapathy (2000) and Singh and Singh (1978).

4.2.1.2 Effect of varieties

The plant height differed significantly due to different linseed varieties during all the growth stages of crop. The highest plant height of linseed was observed in PKVNL-260 which was significantly superior over rest of the linseed varieties at all growth stages. At, 60 DAS plant height of variety NL-97 found at par with PKVNL-260. Significantly lower plant height was recorded in the variety Padmini. The increased plant height in linseed is genetically governed phenomenon, hormone balance, nutrient absorption capacity and conversion of radiant energy into chemical energy in presence of chlorophyll.

Similar results were recorded by Fontana and Maestrini (1995), Shahidullah *et al.* (1997), Kightley *et al.* (1997), Dubey (1999), Dubey (2000) and Moahapatra *et al.* (2007)

4.2.1.3 Interaction effect

None of the interaction effects between sowing dates and linseed varieties were found to be significant in respect of plant height.

Table 9: Mean plant height (cm) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)					
	30	**45**	**60**	**75**	**90**	**At harvest**
A. Sowing times:						
S_1 : 44 MW	24.94	33.38	45.70	53.56	63.47	64.45
S_2 : 45 MW	25.26	33.71	45.76	57.54	68.56	69.51
S_3 : 46 MW	23.52	31.96	42.47	50.86	59.60	60.54
S_4 : 47 MW	22.90	31.34	42.10	48.78	43.57	44.49
S.E. m ±	0.38	0.42	0.47	1.33	1.70	1.71
C.D. at 5%	1.14	1.26	1.41	3.99	5.11	5.16
B. Varieties						
V_1:PKVNL-260	25.45	33.90	45.24	55.65	63.34	64.32
V_2 : NL-97	23.79	32.23	44.08	52.22	57.88	58.83
V_3 : Padmini	23.22	31.65	42.70	50.37	55.18	56.10
S.E. m ±	0.41	0.52	0.67	0.57	0.71	0.70
C.D. at 5%	1.21	1.55	2.00	1.70	2.12	2.10
C. Interaction						
S.E. m ±	0.82	1.04	1.34	1.14	1.43	1.43
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	24.15	32.60	44.01	52.74	58.80	59.75

4.2.2 Number of branches plant^{-1}

The periodical mean number of branches plant^{-1} as influenced periodically by different treatments are presented in the Table 10.

The mean number of branches plant^{-1} at 30, 45, 60, 75, 90 and at harvest were 3.59, 4.03, 4.11, 4.20, 4.20 and 4.20 respectively.

4.2.2.1 Effect of sowing dates

The mean number of branches plant^{-1} were found to be non significant for the sowing dates.

4.2.2.2 Effect of varieties

The mean number of branches plant^{-1} was influenced significantly due to linseed varieties at all growth phases of crop except at 30 DAS. The variety PKVNL-260 recorded significantly highest number of branches plant^{-1} at 45, 60, 75, 90 DAS and at harvest over rest of the varieties. After 75 DAS till harvest there were no increase in number of branches plant^{-1}.

4.2.2.3 Interaction effect

None of the above interaction effects between sowing dates and linseed varieties in the number of branches plant^{-1} were significant.

Table 10: Mean number of branches plant^{-1} as influenced periodically by different treatments

Treatment	Days after sowing (DAS)					
	30	45	60	75	90	At harvest
A. Sowing times:						
S_1 : 44 MW	3.63	4.03	4.12	4.20	4.20	4.20
S_2 : 45 MW	3.78	4.07	4.13	4.23	4.23	4.23
S_3 : 46 MW	3.51	4.02	4.09	4.19	4.19	4.19
S_4 : 47 MW	3.42	4.01	4.08	4.18	4.18	4.18
S.E. m ±	0.04	0.05	0.08	0.06	0.16	0.16
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B. Varieties :						
V_1: PKVNL-260	3.75	4.81	4.87	4.87	4.87	4.87
V_2 : NL-97	3.58	3.68	3.78	3.95	3.95	3.95
V_3 : Padmini	3.43	3.61	3.66	3.78	3.78	3.78
S.E. m ±	0.05	0.16	0.21	0.17	0.17	0.17
C.D. at 5%	N.S.	0.49	0.65	0.54	0.54	0.54
C. Interaction						
S.E. m ±	0.10	0.12	0.04	0.06	0.09	0.09
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	3.59	4.03	4.11	4.20	4.20	4.20

4.2.3 Plant spread (cm)

The data pertaining to mean plant spread recorded periodically as influenced by different treatments are presented in Table 11 and graphically depicted in Fig. 5.

The mean number of plant spread at 30, 45, 60, 75, 90 and at harvest were 4.10, 7.93, 9.60, 14.03, 15.83 and 15.83, respectively.

4.2.2.1 Effect of sowing dates

The sowing of linseed at 45 MW recorded significantly higher plant spread over rest of sowing date at all growth stages except 30 DAS. The 45 MW recorded significantly higher plant spread at 45, 60, 75, 90 DAS and at harvest which was at par with 44 MW at all this growth stages of crop. At, 60 DAS, 46 MW found at par with the sowing date 44 and 45 MW. The 45MW had more plant spread followed by 44, 46 and 47 MW. This might be due to favorable climatic condition during 44 and 45 MW while during 46 and 47 MW the rise in temperature reduced number of branches, leaves and this reflects in plant spread.

This results corroborate to the findings of Chaudhary *et al*. (1991) and Abdul EL-Dayem *et al*. (1998).

4.2.2.2 Effect of varieties

The mean plant spread of linseed was influenced significantly due to linseed varieties at all growth phases of crop except 30 DAS.

Table 11: Mean plant spread plant^{-1} (cm) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)					
	30	45	60	75	90	At harvest
A. Sowing times:						
S_1 : 44 MW	4.09	7.91	9.59	14.14	15.94	15.94
S_2 : 45 MW	4.15	8.05	9.77	14.17	16.97	16.97
S_3 : 46 MW	4.08	7.88	9.56	13.93	15.73	15.73
S_4 : 47 MW	4.06	7.87	9.51	13.91	14.71	14.71
S.E. m ±	0.08	0.05	0.08	0.07	0.37	0.37
C.D. at 5%	N.S.	0.15	0.24	0.21	1.12	1.12
B. Varieties :						
V_1: PKVNL-260	4.12	8.02	9.71	14.13	16.93	16.93
V_2 : NL-97	4.10	7.90	9.68	14.03	15.83	15.83
V_3 : Padmini	4.07	7.80	9.43	13.95	14.75	14.75
S.E. m ±	0.07	0.06	0.06	0.05	0.06	0.06
C.D. at 5%	N.S.	0.19	0.18	0.15	0.18	0.18
C. Interaction						
S.E. m ±	0.06	0.12	0.12	0.10	0.12	0.12
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	4.10	7.93	9.60	14.03	15.83	15.83

The linseed variety PKVNL-260 recorded significantly higher plant spread during all growth stages of crop except 30 DAS. The linseed variety PKVNL-260 recorded significantly higher plant spread at 45, 60, 75, 90 DAS and at harvest. The mean values of plant spread of variety NL-97 at 45, 60, 75 DAS found at par with variety PKVNL-260.

These results are in accordance to the findings of Singh (1968), Merrien (1996) and Kightley *et al*. (1997).

4.2.2.3 Interaction effect

None of the above interaction effects between sowing dates and linseed varieties were found to be significant in respect of the plant spread.

4.2.3 Dry matter plant^{-1} (g)

The data pertaining to mean dry matter accumulation recorded periodically as influenced by different treatments are presented in Table 12 and graphically depicted in Fig. 6.

The mean dry matter of linseed was progressively increased with advancement of age of crop. The mean values of dry matter plant^{-1} were 1.25, 2.03, 2.50, 3.69, 6.24 and 8.28g at 30, 45, 60, 75, 90 and at harvest respectively.

4.2.3.1 Effect of sowing dates

The mean dry matter accumulation plant^{-1} of linseed was significantly influenced due to various sowing dates at all growth sages except 30 DAS.

Table 12: Mean dry matter plant^{-1} (g) as influenced periodically by different treatments

Treatment	Days after sowing (DAS)					
	30	**45**	**60**	**75**	**90**	**At harvest**
A. Sowing times:						
S_1 : 44 MW	1.25	2.00	2.96	3.82	6.36	8.58
S_2 : 45 MW	1.27	2.52	3.56	4.60	7.73	9.87
S_3 : 46 MW	1.25	1.88	1.92	3.54	5.96	7.56
S_4 : 47 MW	1.24	1.74	1.56	2.76	4.91	7.12
S.E. m ±	0.05	0.18	0.37	0.34	0.40	0.05
C.D. at 5%	N.S.	0.58	1.13	1.04	1.25	0.17
B. Varieties :						
V_1: PKVNL-260	1.27	2.23	3.12	4.58	7.41	9.23
V_2 : NL-97	1.25	1.98	2.85	3.78	6.13	8.38
V_3 : Padmini	1.24	1.90	1.54	2.69	5.18	7.25
S.E. m ±	0.06	0.01	0.05	0.06	0.12	0.02
C.D. at 5%	N.S.	0.04	0.14	0.17	0.35	0.07
C. Interaction						
S.E. m ±	0.12	0.02	0.11	0.12	0.24	0.04
C.D. at 5%	N.S.	N.S.	N.S.	0.37	0.48	0.13
General mean	1.25	2.03	2.50	3.69	6.24	8.28

Table 13: Mean dry matter plant^{-1}(g) as influenced by interaction between sowing times and varieties 75 DAS

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	4.60	4.28	2.59	3.82
S_2 45 MW (2nd week of November)	5.42	4.84	3.55	4.60
S_3 46 MW (3rd week of November)	4.39	3.79	2.45	3.54
S_4 47 MW (4th week of November)	3.92	2.20	2.11	2.76
Mean	4.58	3.78	2.69	3.69
S.E. m $\pm$	0.12			
C.D at 5%	0.37			

Table 14: Mean dry matter plant^{-1}(g) as influenced by interaction between sowing times and varieties 90 DAS

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	7.85	6.18	5.04	6.36
S_2 45 MW (2nd week of November)	8.85	7.78	6.55	7.73
S_3 46 MW (3rd week of November)	6.98	5.75	5.15	5.96
S_4 47 MW (4th week of November)	5.96	4.81	3.97	4.91
Mean	7.41	6.13	5.18	6.24
S.E. m $\pm$	0.24			
C.D at 5%	0.48			

Table 15: Mean dry matter plant^{-1} (g) as influenced by interaction between sowing times and varieties at harvest

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	9.78	8.84	7.12	8.58
S_2 45 MW (2nd week of November)	10.02	9.96	9.63	9.87
S_3 46 MW (3rd week of November)	8.67	7.88	6.14	7.56
S_4 47 MW (4th week of November)	8.44	6.84	6.09	7.12
Mean	9.23	8.38	7.25	8.28
S.E. m $\pm$	0.04			
C.D at 5%	0.13			

The sowing of linseed at 45 MW recorded significantly higher dry matter at 45, 60, 75, 90 DAS and at harvest. The dry matter recorded at 45, 60 and 75 DAS for 44 MW found at par with 45 MW and significantly superior over rest of the sowing dates. The 45 MW accumulated significantly more dry matter plant^{-1} at 90 DAS and at harvest over rest of the sowing dates. The vegetative growth and dry matter production were less in extended sowing dates. This was mainly due to rise in temperature which forced to late sown linseed to mature earlier and this enforced maturity resulted in shorting of growing period. This decreased growth period might have reduced dry matter production with late sowing.

These results confirm the findings of Dudhade *et al.* (1994), Kumar and Shaktawat (1991), Ciriciofolo and Bonciarelli (1994), Singh *et al.* (2003) and Singh *et al.* (2002).

4.2.3.2 Effect of varieties

The dry matter plant^{-1} of linseed was influenced significantly due to various varieties at all growth stages except 30 DAS. The significantly higher dry matter of linseed was registered in PKVNL-260 over rest of linseed varieties. The dry matter accumulation is the result of all growth attributes viz., plant height, number of branches plant^{-1}, plant spread and yield attributes. Similar results were obtained by Moahapatra *et al.* (2007) and Pali and Tripathi (2000).

4.2.3.3 Interaction effect

The mean dry matter plant^{-1} of linseed was significantly influenced due to interaction effects between sowing dates and linseed varieties at 75, 90 DAS and at harvest.

These results indicated that linseed variety PKVNL-260 was found superior to all the sowing dates for higher dry matter assimilation followed by NL-97 and Padmini at 75, 90 DAS(5.42, 8.85 and 10.02g), respectively and at harvest which was at par with the combination 45 MW along with variety NL-97 at harvest.

Thus, the linseed sown on 45 MW along with variety PKVNL-260 recorded significantly higher dry matter plant^{-1} over rest of the combination. Thus, the variety PKVNL-260 was more resistant to change in climatic condition as it performed well for dry matter assimilation at various sowing dates. The NL-97 variety was most susceptible for climatic change and Padmini variety was moderately resistant to climatic change for dry matter accumulation.

4.3 Post harvest observations

The yield attributes of linseed viz., number of capsules plant^{-1}, number of seeds capsule^{-1}, weight of seed plant^{-1} and test weight as influenced by the different treatments were recorded at harvest and reported in Table 16.

4.3.1 Number of capsules plant^{-1}

Data regarding to mean number of capsules plant^{-1} of linseed as influenced significantly by the different treatments are presented in Table 16 and graphically depicted in Fig.7. The mean number of capsules plant^{-1} was 53.44.

4.3.1.1 Effect of sowing dates

The mean number of capsules plant^{-1} of linseed was significantly influenced due to extended sowing dates. The number of capsules plant^{-1} of linseed was the highest in 45 MW which was at par with 44 MW and significantly superior over rest of the sowing dates. The second best sowing date was 44 MW which was at par with 45 MW and significantly superior over 46 and 47 MW. The variation in number of capsules plant^{-1} by the various sowing dates might be associated with changing climatic conditions with sowing dates.

Table 16: Mean number of capsules plant^{-1}, number of seeds per capsules^{-1}, seed weight plant^{-1} and thousand grain weight (g) as influenced by different treatments

Treatment	Number of capsules plant^{-1}	Number of seeds capsules^{-1}	Seed weight plant^{-1} (g)	Test weight (g)
A. Sowing times:				
S_1 : 44 MW	54.00	9.80	4.55	8.43
S_2 : 45 MW	59.00	10.17	4.71	8.53
S_3 : 46 MW	51.66	9.56	4.26	8.37
S_4 : 47 MW	49.10	9.13	2.05	8.36
S.E. m ±	1.81	0.14	0.12	0.09
C.D. at 5%	5.45	0.44	0.38	NS
B. Varieties :				
V_1: PKVNL-260	62.00	10.02	5.14	8.43
V_2 : NL-97	51.51	9.77	4.23	8.42
V_3 : Padmini	46.81	9.20	3.82	8.41
S.E. m ±	1.02	0.10	0.02	0.07
C.D. at 5%	3.06	0.31	0.07	NS
C. Interaction				
S.E. m ±	2.04	0.21	0.04	0.12
C.D. at 5%	6.10	0.64	0.13	NS
General mean	53.44	9.67	4.39	8.42

Table 17: Number of capsules $plant^{-1}$ as influenced by interaction of sowing dates and varieties

Varieties / Sowing times	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	55.00	55.00	52.00	54.00
S_2 45 MW (2nd week of November)	69.00	56.00	52.00	59.00
S_3 46 MW (3rd week of November)	63.00	49.75	42.24	51.66
S_4 47 MW (4th week of November)	62.00	45.29	41.00	49.10
Mean	62.00	51.51	46.81	53.44
S.E. m $\pm$	2.04			
C.D at 5%	6.10			

Table 18: Number of seeds $capsules^{-1}$ as influenced by interaction of sowing dates and varieties

Varieties / Sowing times	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	9.95	9.75	9.70	9.80
S_2 45 MW (2nd week of November)	10.66	10.06	9.80	10.17
S_3 46 MW (3rd week of November)	10.02	9.92	8.74	9.56
S_4 47 MW (4th week of November)	9.46	9.36	8.57	9.13
Mean	10.02	9.77	9.20	9.67
S.E. m $\pm$	0.21			
C.D at 5%	0.64			

Table 19: Seed weight plant^{-1} (g) as influenced by interaction of sowing dates and varieties

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	5.18	4.43	4.05	4.55
S_2 45 MW (2nd week of November)	5.22	4.60	4.30	4.71
S_3 46 MW (3rd week of November)	5.10	3.99	3.70	4.26
S_4 47 MW (4th week of November)	5.04	3.88	3.24	4.05
Mean	3.14	4.23	3.82	4.39
S.E. m $\pm$	0.04			
C.D at 5%	0.13			

4.3.1.2 Effect of varieties

The linseed variety PKVNL-269 observed significantly higher number of capsules plant^{-1} while Padmini observed significantly lower number of capsules plant^{-1}. The difference in number of capsules plant^{-1} of linseed varieties might be due to genetical makeup of these varieties. Similar results were reported by Singh (1968), Merrien (1996), Kightley *et al.* (1997), Pali and Tripathi (2000) and El-Refaey *et al*. (2008).

4.3.1.3 Interaction effect

The interaction effects of sowing dates and linseed varieties were significant for number of capsules plant^{-1} are presented in Table 17.

The linseed sown on 45 MW along with variety PKVNL-260 recorded significantly higher number of capsules plant^{-1} (69) over rest of combinations.

4.3.2 Number of seeds capsules^{-1} and seed weight plant^{-1}

Data regarding to mean number of seeds capsule^{-1} and seed weight plant^{-1}of linseed influenced by the different treatments are presented in Table 16 and graphically depicted in Fig.7. The mean number of seeds capsule^{-1} and seed weight plant^{-1} were 9.67 and 2.39g, respectively.

4.3.2.1 Effect of sowing dates

The number of seed capsule^{-1} and seed weight plant^{-1} was influenced significantly due to extended sowing dates of linseed at harvest. The sowing of linseed at 45 MW recorded maximum number of seeds capsule^{-1} and seed weight plant^{-1} which was at par with 44 MW and significantly superior over rest of sowing dates. The differences in number of seeds capsule^{-1} might be due to different sowing dates expose the linseed crop to climatic condition hence, obstruction in seed filling in capsule of linseed varieties and adversely reflects it in number of seed capsule^{-1} and seed weight plant^{-1}.

Results are in agreement with those obtained previously by Kumar and Shaktawat (1991), Dudhade *et al*. (1994), Singh (1966), Dixit *et al*. (1990), Shahidullah *et al*. (1997) and Abdul EL-Dayem *et al*. (1998).

4.3.2.2 Effect of varieties

The linseed varieties were differing in their number of seeds capsule^{-1} and seed weight plant^{-1}. The number of seeds capsule^{-1} and seed weight plant^{-1} was found significantly higher in linseed variety PKVNL-260 which was at par with variety NL-97 and significantly superior over Padmini. This might be because of genetical makeup of these varieties were different for seed settling and seed development in capsule.

4.3.2.3 Interaction effects

The interaction effects of sowing dates and linseed varieties were significant for number of capsules plant^{-1} in Table 18. The linseed variety PKVNL-260 interacting with 45 MW recorded significantly higher (10.66) number of seeds capsule^{-1} which was at par with the combination variety NL-97 sown in 45 MW and variety PKVNL-260 sown in 46 MW(10.02) and significantly superior over rest of the treatment combination.

4.3.2.4 Interaction effects

The interaction effects of sowing dates and linseed varieties were significant for seed weight plant^{-1} in Table 19. The sowing date 45 MW along with variety PKVNL-260 found to be significant(3.22g) over rest of combinations for seed weight plant^{-1} which was at par (3.10g) with combination of 46 MW along with variety PKVNL-260 and significantly superior over rest of combination.

4.3.3 Test weight (g)

Data regarding to mean test weight of linseed as influenced by different treatments are presented Table 16 and graphically depicted in Fig. 7. The mean test weight was 8.42g.

4.3.3.1 Effect of sowing dates

The mean test weight (g) were found to be non significant for the sowing dates.

4.3.3.2 Effect of varieties

The mean test weight (g) were found to be non significant for the varieties.

4.3.2.3 Interaction effects

None of the above interaction effects between sowing dates and linseed varieties were found to be significant in respect of the test weight.

4.4 Yield observations

Data in respect of mean seed and straw yield of linseed as influenced by different treatments are presented in Table 20 and graphically depicted Fig. 8. The mean seed and straw yield of linseed were 16.39 q ha^{-1} and 26.69 q ha^{-1}.

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

Data in respect of mean seed yield of linseed as influenced by different treatments are presented in Table 20 and graphically depicted Fig.8. The mean seed yield of linseed was 16.39 q ha^{-1}.

4.4.1.1 Effect of sowing dates

The seed yield of linseed was influenced significantly due to extended sowing dates. The seed yield was maximum (18.43 q ha^{-1}) at 45 MW which was significantly superior over the rest of sowing dates. The second best sowing date was 44 MW which produced significantly more seed yield (17.21 q ha^{-1}) over 46 and 47 MW sowings.

The reduction in seed yield caused due to sowing dates was because of differences in temperature. Sowing date 45 MW was favorable to high seed production because the post anthesis period coincide with the relatively low temperature. However, late sowing 46 and 47 MW were unfavorable to seed yield since low temperature during early sowing might have adversly affected the initial vigour. The results are in conformity with the findings by Bhatt (1965), Singh (1966), Mathur *et al.* (1984), Rajput and Gautam (1993), Ciriciofolo and Bonciarelli (1994), Kalita *et al.* (1999) and Shahidullah *et al.* (1997).

4.4.1.2 Effect of varieties

The seed yield of linseed was influenced significantly due to linseed varieties. The seed yield was significantly higher in PKVNL-260 (18.12 q ha^{-1}) and significantly superior over rest of linseed varieties.

The variety Padmini recorded significantly lower seed yield. The differences in seed yield in linseed varieties might be due to inherent genetical potential of linseed varieties and source single relationship.

4.4.1.3 Interaction effects

The seed yield of linseed as influenced by interaction effects are reported in Table 21. The interaction of variety PKVNL-260 with sowing date 45 MW recorded significantly higher seed yield (19.20 q ha^{-1}) over rest

Table 20: Mean seed and straw yields as influenced by different treatments

Treatment	**Seed yield (q ha^{-1})**	**Straw yield (q ha^{-1})**
A. Sowing times:		
S_1 : 44 MW	17.21	28.68
S_2 : 45 MW	18.43	29.76
S_3 : 46 MW	15.10	24.62
S_4 : 47 MW	14.86	23.72
S.E. m ±	0.12	0.16
C.D. at 5%	0.37	0.48
B. Varieties :		
V_1: PKVNL-260	18.12	28.69
V_2 : NL-97	16.04	26.20
V_3 : Padmini	15.04	25.20
S.E. m ±	0.02	0.12
C.D. at 5%	0.07	0.38
C. Interaction		
S.E. m ±	0.05	0.24
C.D. at 5%	0.16	0.74
General mean	16.39	26.69

Table 21: Seed yield (q ha^{-1}) as influenced by interaction of sowing dates and varieties

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	18.00	18.14	15.48	17.21
S_2 45 MW (2nd week of November)	19.20	18.51	17.57	18.43
S_3 46 MW (3rd week ofNovember)	17.70	13.90	13.70	15.10
S_4 47 MW (4th week of November)	17.58	13.60	13.40	14.86
Mean	18.12	16.04	15.04	16.40
S.E. m $\pm$	0.05			
C.D at 5%	0.16			

Table 22: Straw yield (q ha^{-1}) as influenced by interaction of sowing dates and varieties

Sowing times \ Varieties	V_1 PKVNL-260	V_2 NL-97	V_3 Padmini	Mean
S_1 44 MW (1st week of November)	28.74	28.70	28.60	28.68
S_2 45 MW(2nd week of November)	29.80	29.76	29.72	29.76
S_3 46 MW (3rd week of November)	28.26	24.00	21.60	24.62
S_4 47 MW (4th week of November)	27.94	22.35	20.86	23.72
Mean	28.69	26.20	25.20	26.69
S.E. m $\pm$	0.24			
C.D at 5%	0.74			

of treatment combinations. The results showed that delay in sowing dates of linseed varieties, could not able to assimilate the more biomass and resulted in reduced seed yield of linseed.

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

Data in respect of mean straw yield of linseed as influenced by different treatments are presented in Table 20 and graphically depicted Fig.8. The mean straw of linseed were 26.69 q ha^{-1}.

4.4.2.1 Effect of sowing dates

The straw yield of linseed was influenced significantly due to extended sowing dates. The straw yield was maximum (29.76 q ha^{-1}) at 45 MW which was significantly superior over rest of sowing dates. The second best sowing date was 44 MW which produced significantly more straw yield (28.68q ha^{-1}) over 46 and 47 MW. Seed yield is directly related to growth and yield attributes. All yield attributes were higher in 45 MW sowing.

The reduction in straw yield was due to reduced growth in terms of plant height, number of branches plant^{-1}and dry matter accumulation. In the late sowing 46 and 47 MW the period between anthesis and leaf senescence was curtailed by the onset of relatively higher temperature. Similar results were obtained by Chaudhary *et al.* (1991) and Ciriciofolo and Bonciarelli (1994).

4.4.2.2 Effect of varieties

The straw yield of linseed was influenced significantly due to linseed varieties. The straw yield was significantly higher in PKVNL-260 (28.69 q ha^{-1}) and significantly superior over rest of linseed varieties.

The variety Padmini recorded significantly lower straw yield. The differences in straw yield in linseed varieties might be due to inherent genetical potential of linseed varieties.

4.4.2.3 Interaction effects

The straw yield of linseed as influenced by interaction effects of sowing dates and linseed varieties are presented in Table 22. The interaction of sowing dates 45 MW along with variety PKVNL-260 found statistically significant(29.80 q ha^{-1}) and which was at par with the treatment combination 45 MW along with variety NL-97 (29.76 q ha^{-1}) and variety Padmini (29.72 q ha^{-1}) over rest of combinations.

The results showed that delay in sowing dates of linseed varieties, could not able to assimilate more biomass as results reduced straw yield of linseed.

4.5. Quality studies

4.5.1 Oil content (%)

The mean oil content of linseed as influenced by different treatments are presented in Table 23. The mean oil content in linseed was 37.80 per cent.

4.5.1.1 Effect of sowing dates

The sowing of linseed in different meteorological weeks did not influenced the oil content in seed.

Table 23: Mean oil content in seed and oil yield (kg ha^{-1}) as influenced by different treatments.

Treatment	Oil content in seed (%)	Oil yield (kg ha^{-1})
A. Sowing times:		
S_1 : 44 MW	38.22	657.77
S_2 : 45 MW	37.88	698.13
S_3 : 46 MW	37.77	570.33
S_4 : 47 MW	37.33	554.72
S.E. m ±	0.04	5.61
C.D. at 5%	N.S.	16.80
B. Varieties :		
V_1: PKVNL-260	38.08	690.00
V_2 : NL-97	37.75	605.51
V_3 : Padmini	37.58	565.20
S.E. m ±	0.06	5.30
C.D. at 5%	N.S.	15.50
C. Interaction		
S.E. m ±	0.12	10.61
C.D. at 5%	N.S.	N.S.
General mean	37.80	620.14

4.5.1.2 Effect of varieties

The varieties PKVNL-260, NL-97 and Padmini were statistically non significant for oil content in seed. The oil content in seed is genetic character of genotype.

4.5.1.3 Interaction effects

None of the above interaction effects between sowing dates and linseed varieties on oil content of linseed were significant.

4.5.2 Oil yield (kg ha^{-1})

The mean oil yield of linseed as influenced by different treatments was presented in Table 23. The mean oil yield in linseed was 620.14 kg ha^{-1}.

4.5.2.1 Effect of sowing dates

The linseed sown on 45 MW recorded statistically significant oil yield over rest of the sowing dates. The 45 MW sowing produced higher seed yield resulted in higher oil yield.

4.5.2.2 Effect of varieties

The linseed variety PKVNL-260 recorded statistically significant oil yield over the varieties NL-97 and Padmini as it has higher seed yield.

4.5.2.3 Interaction effects

None of the above interaction effects between sowing dates and linseed varieties on oil yield of linseed were significant.

4.6 Chemical observations

4.6.1 Nutrient concentration

The nutrient concentrations in linseed seed and straw as influenced by different treatments are presented in Table 24.

The mean concentration of nitrogen, phosphorous and potassium in linseed

seed were 4.93, 0.81 and 0.87 per cent, while in straw 1.25, 0.52 and 0.95 per cent, respectively.

4.6.1.1 Effect of sowing dates

The sowing of linseed in different metrological week did not influenced the concentration of nitrogen, phosphorous and potassium in seed and straw.

4.6.1.2 Effect of varieties

Numerically the varieties under study did not showed considerable differences in nutrient concentration of seed and straw.

4.6.1.3 Interaction effects

The interaction effects of sowing dates and linseed varieties were statistically non significant for nutrient concentration in seed and straw at harvest.

Table 24: Total N, P, K content in seed and straw as influenced by different treatments

Treatment	NPK content in seed (%)			NPK content in straw (%)		
A. Sowing times:	**N**	**P**	**K**	**N**	**P**	**K**
S_1 : 44 MW	4.97	0.83	0.88	1.25	0.54	0.94
S_2 : 45 MW	4.98	0.84	0.90	1.27	0.55	1.00
S_3 : 46 MW	4.90	0.81	0.87	1.25	0.53	0.93
S_4 : 47 MW	4.90	0.78	0.84	1.24	0.50	0.92
S.E. m ±	0.04	0.11	0.01	0.06	0.05	0.08
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B. Varieties :						
V_1: PKVNL-260	4.95	0.82	0.89	1.27	0.54	0.96
V_2 : NL-97	4.93	0.81	0.87	1.25	0.52	0.95
V_3 : Padmini	4.92	0.80	0.86	1.24	0.51	0.94
S.E. m ±	0.02	0.07	0.08	0.01	0.08	0.02
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C. Interaction						
S.E. m ±	0.04	0.14	0.16	0.02	0.16	0.04
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	4.93	0.81	0.87	1.25	0.52	0.95

4.6.2 Total nutrient uptake

The data on mean total uptake of nitrogen, phosphorous and potassium by linseed plant at harvest as influenced by the different treatments are presented in Table 25 and graphically depicted in Fig.9.

The mean total uptake of nitrogen, phosphorous and potassium were 114.40, 27.47 and 39.70 kg ha^{-1} respectively.

4.6.2.1 Effect of sowing dates

Nitrogen, phosphorous and potassium in seed and straw varied significantly with sowing time. The sowing of linseed in 45 MW recorded significantly higher uptake of nitrogen, phosphorous and potassium than rest of sowing dates.

This might be due to when nitrogen, phosphorous and potassium were applied to late sown crop the nutrient absorption was very much less during early vegetative growth and apparently below the plant needs. 45 MW recorded higher seed and straw yield which ultimately reflects in higher nutrient uptake.

4.6.2.2 Effect of varieties

The uptake of nitrogen, phosphorous and potassium was influenced significantly with linseed varieties. Significantly higher total nitrogen, phosphorous and potassium uptake was registered in variety PKVNL-260 and it was significantly higher than rest of linseed varieties due to higher seed and straw yield.

Table 25: Total N, P, K uptake by seed, straw and crop as influenced by different treatments

Treatment	NPK uptake in seed (kg ha^{-1})			NPK uptake in straw (kg ha^{-1})			Total NPK uptake by crop (kg ha^{-1})		
A. Sowing times:	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
S_1 : 44 MW	85.53	14.28	15.14	35.85	15.49	26.96	121.38	29.77	42.10
S_2 : 45 MW	91.78	15.48	16.59	37.80	16.37	29.76	129.58	31.85	46.35
S_3 : 46 MW	73.99	12.23	13.14	30.78	13.05	22.90	104.77	25.28	36.03
S_4 : 47 MW	72.81	11.59	12.48	29.41	11.86	21.82	102.23	23.45	34.30
S.E. m ±	0.43	0.22	0.26	0.38	0.12	0.38	0.35	0.20	0.34
C.D. at 5%	1.29	0.66	0.78	1.14	0.36	1.14	1.05	0.61	1.02
B. Varieties:									
V_1:PKVNL-260	89.69	14.86	16.13	36.44	15.49	27.54	126.13	30.35	43.67
V_2 : NL-97	79.08	12.99	13.95	32.75	13.62	24.89	111.83	26.62	38.84
V_3: Padmini	74.00	12.03	12.93	31.25	12.85	23.69	105.24	24.88	36.62
S.E. m ±	0.45	0.25	0.23	0.43	0.13	0.40	0.46	0.28	0.34
C.D. at 5%	1.35	0.75	0.68	1.30	0.39	1.19	1.37	0.84	1.02
C. Interaction									
S.E. m ±	0.91	0.51	0.47	0.86	0.26	0.80	0.92	0.56	0.68
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	80.92	13.29	14.34	33.48	13.99	25.37	114.40	27.47	39.70

4.6.2.3 Interaction effects

The interaction effects of sowing dates and varieties were statistically non significant for nutrient uptake in seed, straw and total uptake by linseed.

4.6.3. Nutrient status in soil

The data in respect of available nitrogen, phosphorous and potassium in soil after harvest as influenced by the different treatments are presented in Table 26. The mean total available nitrogen, phosphorous and potassium after harvest were 142.27, 24.13 and 434.03 kg ha^{-1}, respectively.

4.6.3.1 Effect of sowing dates

The sowing date of linseed significantly influenced the nutrient status in soil after harvest of experimental linseed.

The sowing of linseed in 47 MW recorded significantly maximum available residual nitrogen, phosphorous and potassium than rest of sowing dates. It was followed by sowing of linseed on 44, 45 and 46 MW. The sowing of linseed on 46 MW found at par with 47 MW for phosphorous.

The sowing of linseed in 45 MW recorded significantly lower available nitrogen, phosphorous and potassium. It might be due to more nitrogen, phosphorous and potassium uptake in 45 MW than remaining sowing dates.

Table 26: Available N, P, K in soil after harvest as influenced by different treatments

Treatment	Nitrogen ($kg\ ha^{-1}$)	Phosphorous ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)
A. Sowing times:			
S_1 : 44 MW	140.67	24.03	431.30
S_2 : 45 MW	135.73	23.96	426.50
S_3 : 46 MW	145.37	24.36	438.15
S_4 : 47 MW	147.33	25.16	440.20
S.E. m ±	0.43	0.29	0.51
C.D. at 5%	1.29	0.87	1.53
B. Varieties :			
V_1: PKVNL-260	139.58	22.98	431.04
V_2 : NL-97	142.64	24.11	434.06
V_3 : Padmini	144.59	25.30	437.04
S.E. m ±	0.44	0.31	0.56
C.D. at 5%	1.32	0.93	1.68
C. Interaction			
S.E. m ±	0.89	0.63	1.13
C.D. at 5%	N.S.	N.S.	N.S.
General mean	142.27	24.13	434.03

4.6.3.2 Effect of varieties

Nutrient status in soil was influenced significantly due to linseed varieties. The available residual nitrogen, phosphorous and potassium were registered significantly lower in variety PKVNL-260. The experimental soil contains significantly higher NPK content in linseed variety Padmini grown plot as compared to rest of varieties.

This might be because of more nitrogen, phosphorous and potassium uptake by linseed variety PKVNL-260 and it reflects in higher depletion of NPK in soil.

4.6.3.3 Interaction effects

The interaction effects of sowing dates and varieties were statistically non significant for available residual soil nitrogen, phosphorous and potassium.

4.7 Climatic attributes

4.7.1 Growing degree days

The data pertaining to growing degree days of linseed as influenced by various treatments are presented in Table 27 and graphically depicted in Fig.10.

The mean cumulative growing degree days at emergence, branching, flowering, capsule development and maturity stages were 191, 438, 762, 1091 and 1516, respectively.

Table 27: Cumulative growing degree days (heat units) at different critical growth stages as influenced by different treatments

Treatment	Critical growth stages				
	Emergence	Branching	Flowering	Capsule development	Maturity
A. Sowing times:					
S_1 : 44 MW	201	449	777	1143	1596
S_2 : 45 MW	193	441	769	1135	1580
S_3 : 46 MW	185	433	761	1102	1455
S_4 : 47 MW	185	428	741	985	1434
S.E. m ±	5.19	4.82	6.28	6.84	8.84
C.D. at 5%	15.60	14.64	18.86	20.55	26.56
B. Varieties :					
V_1:PKVNL-260	222	468	781	1108	1540
V_2 : NL-97	185	434	762	1099	1520
V_3 : Padmini	168	414	742	1066	1488
S.E. m ±	4.21	5.21	5.81	2.63	4.36
C.D. at 5%	12.65	15.63	17.45	7.91	13.09
C. Interaction					
S.E. m ±	10.44	10.42	10.63	13.47	17.39
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	191	438	762	1091	1516

4.7.1.1 Effect of sowing dates

The GDD found significant at emergence, branching, flowering, capsule development and maturity stages due to different sowing dates. The maximum value recorded by 44 MW sowing date at all growth stages followed by 45, 46 and 47 MW. The GDD at 45 MW at all growth stages found at par with 44 MW sowing date and significantly superior over rest of sowing dates.

This might be due to lesser heat unit consumed by the crop under late and very late sown conditions were due to sub optimal thermal regime at vegetative phase of the crop in month of January which hastened at reproductive phase and maturity consequently. These results are in agreement with those obtained by Sorlino (1991), Sorlino (1997), Mokashi.(1999) , Singh (2002) and Neog and Chakravarty (2005).

4.7.1.2 Effect of varieties

The GDD found significant at stages emergence, branching, flowering, capsule development and maturity stages due to different linseed varieties. The maximum value recorded by variety PKVNL-260 at all growth stages followed by the varieties NL-97 and Padmini. Similar results were also reported by Gourangakar and Chakravarty (1999), Agrawal *et al.* (2002) and Shaikh *et al*. (2008).

4.7.1.3 Interaction effects

The interaction effect due to sowing dates and linseed varieties were found to be non significant for growing degree days.

4.7.2 Hydrothermal unit

The data pertaining to hydrothermal unit of linseed as influenced by various treatments are presented in Table 28 and graphically depicted in Fig.11.

The mean cumulative hydrothermal unit at emergence, branching, flowering, capsule development and maturity stages were 12178, 27482, 48928, 68464 and

84197, respectively.

4.7.2.1 Effect of sowing dates

The hydrothermal unit found significant at emergence, branching, flowering, capsule development and maturity stages due to different sowing dates. The maximum value recorded by 44 MW sowing date at all growth stages followed by 45, 46 and 47 MW.

This could be explained by the fact delayed sowing resulted in forced maturity of linseed because of high temperature prevailed during reproductive phase of late sown crop.

4.7.2.2 Effect of varieties

The hydrothermal unit found significant at emergence, branching, flowering, capsule development and maturity stages due to different linseed

Table 28: Cumulative hydrothermal units at different critical growth stages as influenced by different treatments

Treatment	Critical growth stages				
	Emergence	Branching	Flowering	Capsule development	Maturity
A. Sowing times:					
S_1 : 44 MW	12816	28188	49891	71711	88625
S_2 : 45 MW	12306	27686	49378	71209	87737
S_3 : 46 MW	11796	27184	48863	69139	80796
S_4 : 47 MW	11796	26870	47579	61798	79630
S.E. m ±	7.68	8.93	26.67	35.20	13.02
C.D. at 5%	23.06	26.81	79.03	105.60	39.08
B. Varieties :					
V_1:PKVNL-260	14097	29320	49947	68861	84280
V_2 : NL-97	11759	27190	48739	68485	84255
V_3 : Padmini	10679	25937	48099	68046	84055
S.E. m ±	8.64	13.90	29.87	41.24	7.92
C.D. at 5%	25.92	41.70	90.01	124.78	23.78
C. Interaction					
S.E. m ±	15.29	17.81	19.75	112.49	15.85
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	12178	27482	48928	68464	84197

varieties. The maximum value recorded by variety PKVNL-260 at all growth stages followed by the varieties NL-97 and Padmini.

4.7.2.3 Interaction effects

The interaction effect due to sowing dates and linseed varieties were found to be non significant for hydrothermal unit.

4.7.3 Photothermal unit

The data pertaining to photothermal unit of linseed as influenced by various treatments are presented in Table 29 and graphically depicted in Fig.12.

The mean cumulative photothermal unit at emergence, branching, flowering, capsule development and maturity stages were 2483, 5540, 9906, 14187 and 19916, respectively.

4.7.3.1 Effect of sowing dates

The photothermal unit found significant at emergence, branching, flowering, capsule development and maturity stages due to different sowing dates. The maximum value recorded by 44 MW sowing date at all growth stages followed by 45, 46 and 47 MW. The lower photothermal unit in delayed sowing can be expected due to relative lower day length and temperature.

Table 29: Cumulative photothermal units at different critical growth stages as influenced by different treatments

Treatment	Critical growth stages				
	Emergence	Branching	Flowering	Capsule development	Maturity
A. Sowing times:					
S_1 : 44 MW	2613	5837	10101	14859	20748
S_2 : 45 MW	2509	5733	9997	14755	20683
S_3 : 46 MW	2405	5564	9893	14324	19240
S_4 : 47 MW	2405	5024	9633	12805	18993
S.E. m ±	21.87	7.71	32.11	28.33	15.47
C.D. at 5%	65.63	23.14	96.30	85.01	46.45
B. Varieties :					
V_1: PKVNL-260	2886	6091	10132	19258	19968
V_2 : NL-97	2398	5410	9886	14196	19916
V_3 : Padmini	2164	5120	9701	14105	19864
S.E. m ±	24.85	41.99	42.09	32.30	4.09
C.D. at 5%	74.59	126.03	126.27	96.91	12.28
C. Interaction					
S.E. m ±	3.71	4.00	4.19	16.61	38.67
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	2483	5540	9906	14187	19916

4.7.2.2 Effect of varieties

The photothermal unit found significant at emergence, branching, flowering, capsule development and maturity stages due to different linseed varieties. The maximum value recorded by variety PKVNL-260 at all growth stages followed by the varieties NL-97 and Padmini.

4.7.2.3 Interaction effects

The interaction effect due to sowing dates and linseed varieties were found to be non significant for photothermal unit.

4.8. Economic studies

Economics of linseed as influenced by different treatments in respect of the mean gross monetary returns (72,160 Rs. ha^{-1}), cost of cultivation (43,702 Rs. ha^{-1}), net monetary returns (28,458 Rs. ha^{-1}) and B:C (1.50) ratio are presented in Table 30 and graphically depicted in Fig.13.

4.8.1 Effect of sowing dates

The gross (81,092Rs. ha^{-1}) and net monetary returns (37,334Rs. ha^{-1}) and B:C ratio (1.85) were significantly influenced by extended sowing dates. The sowing of linseed in 45 MW recorded significantly higher gross and net monetary returns and B:C ratio than rest of sowing dates. 45MW sowing treatment gave higher yield which ultimately increased gross, net monetary returns and B:C ratio.

This might be due to delayed sowing caused significant reduction in seed and straw yield which reflects decreased in gross and net monetary returns and B:C ratio.

Table 30: Mean gross and net monetary returns, cost of cultivation (Rs. ha^{-1}) and B:C ratio as influenced by different treatments

Treatment	Gross monetary returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio
A. Sowing times:				
S_1 : 44 MW	75724	43758	31966	1.73
S_2 : 45 MW	81092	43758	37334	1.85
S_3 : 46 MW	66440	43647	22793	1.52
S_4 : 47 MW	65384	43647	21737	1.50
S.E. m ±	243.12		148.34	
C.D. at 5%	729.37		445.05	
B. Varieties :				
V_1: PKVNL-260	79728	43702	36026	1.82
V_2 : NL-97	70576	43702	26874	1.61
V_3 : Padmini	66176	43702	22474	1.51
S.E. m ±	285.34		145.12	
C.D. at 5%	856.01		435.38	
C. Interaction				
S.E. m ±	571.68		290.26	
C.D. at 5%	N.S.		N.S.	
General mean	72160	43702	28458	1.50

4.8.2 Effect of varieties

The gross (79728 Rs. ha^{-1}) and net monetary returns (36026 Rs. ha^{-1}) and6 B:C ratio (1.82) were significantly influenced by linseed varieties. The significantly higher gross and net monetary returns and B:C ratio was observed in linseed variety PKVNL-260. This variety gave higher yield which ultimately increased the gross and net monetary returns and B:C ratio.

4.8.3 Interaction effects

The interaction between sowing dates and linseed varieties were statistically non significant for gross and net monetary returns.

5. SUMMARY AND CONCLUSIONS

5.1 Summary

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. The soil of experimental field was clay loam in texture, normal in reaction (7.8) with low available nitrogen (178.48 kg ha^{-1}), high available phosphorous (19.34 kg ha^{-1}) and high available potassium (475.00 kg ha^{-1}).

The experiment was laid out in split plot design with four sowing times and three varieties replicated thrice. The treatments were of four sowing dates *viz.*, S_1 : 44 MW (1st week of November), S_2 : 45 MW (2nd week of November), S_3 : 46 MW (3rd week of November), S_4 : 47 MW (4th week of November) and three varieties *viz.*, V_1 : PKVNL-260, V_2 : NL-97, V_3 : Padmini.

Linseed crop was sown as per sowing treatment 1st sowing on 1st November, 2nd sowing on 8th November, 3rd sowing on 16th November and 4th sowing on 23rd November. In addition to seed yield, straw yield, observation on growth attributes, yield attributes, climate attributes and chemical attributes were also recorded. The quality, nutrient uptake, nutrient status was estimated and economics of treatments were worked out. The results were reported and discussed in foregoing chapters. The silent findings that emerged from study are summarized below.

5.1.2 Effect of sowing dates

Among all the sowing dates 45MW (2nd week of November)sowing date recorded higher growth attributes *viz.*, plant height (69.51cm), dry matter accumulation plant (9.87g). The lowest values for all these characters were recorded by 47 MW (4rd week of November) sowing time.

Yield contributing characters *viz*., number of capsule plant^{-1} (59), number of seed capsule^{-1} (10.17), seed weight plant^{-1} (2.71g), test weight plant^{-1} (8.53g), seed yield (18.43 q ha^{-1}) and straw yield (29.76 q ha^{-1}) were significantly superior in45MW (2nd week of November) over rest of sowing dates.

Seed yield and straw yield was maximum in variety PKVNL-260 and it was significantly maximum in 45MW (2nd week of November) over rest of the sowing dates.

The sowing of linseed in different metrological week did not influence the oil content in seed of linseed. Among all sowing dates 45MW (2nd week of November) recorded significantly maximum uptake of total nitrogen (129.58 kg ha^{-1}), phosphorous (31.85 kg ha^{-1}) and potassium (46.35 kg ha^{-1}) than rest of sowing dates.

After harvest of crop 47 MW (4rd week of November) recorded maximum available of soil nitrogen (147.33 kg ha^{-1}), phosphorous (25.16 kg ha^{-1}) and available potassium (440.20 kg ha^{-1}) found to be significant for different sowing dates.

Meteorological attribute *viz*., growing degree days, photothermal unit and hydrothermal unit found to be significant for different sowing dates.

The gross monetary returns (81,092 Rs. ha^{-1}), net monetary return (37,334 Rs. ha^{-1}), cost of cultivation (43,758 Rs. ha^{-1}) and B:C ratio (1.85) found to be maximum at 45MW (2nd week of November).

5.1.3 Effect ofVarieties

All the growth attributes were increased with the advancement in age of the linseed crop plant height (64.34cm), dry matter accumulation plant^{-1} (9.23g) was found significantly higher in variety PKVNL-260 over NL-97 and Padmini.

Yield contributing characters *viz*., number of capsule plant^{-1} (62), number of seed capsule^{-1}(10.02), seed weight plant^{-1} (3.14g), test weight plant^{-1} (8.43g), seed yield (18.12 q ha^{-1}) and straw yield (28.69 q ha^{-1}) were significantly superior in variety PKVNL-260.

Seed yield (18.12 q ha^{-1}) and straw yield (28.69 q ha^{-1}) was maximum in variety PKVNL-260 and it was superior over NL-97 and Padmini.

The linseed varieties *viz*., PKVNL-260, NL-97 and Padmini were statisticallybnon significant for oil content in seed. The PKVNL-260 variety recorded significantly maximum uptake of total nitrogen (126.13 kg ha^{-1}), phosphorous (30.35 kg ha^{-1}), potassium (43.67 kg ha^{-1}) by linseed than rest of linseed varieties.

After harvest of the crop available soil nitrogen (144.59kg ha^{-1}), phosphorous (25.30kg ha^{-1}) and potassium (437.04kg ha^{-1}) was more withPadmini compared with NL-97 and PKVNL-260.

Meteorological attribute *viz*., growing degree days, photothermal unit, hydrothermal unit found to be non significant for different varieties.

The gross monetary returns (79,728 Rs. ha^{-1}), net monetary return (36,026 Rs. ha^{-1}), cost of cultivation (43,702 Rs. ha^{-1}) and B:Cratio (1.82) found to be maximum for PKVNL-260.

5.1.4 Performance of interaction

The highest dry matter accumulation plant^{-1} (8.85g and 10.02g), number of capsule plant^{-1} (69) recorded with 45MW (2nd week of November) sowing date with variety PKVNL-260 combination at 90 DAS and at harvest respectively.

The 45MW (2nd week of November) with linseed variety PKVNL-260 combination recorded maximum number of capsule plant^{-1}(69), number of seed capsule^{-1} (10.66), seed weight plant^{-1}(3.22g).

Maximum seed yield (19.20 q ha^{-1}), straw yield (29.80 q ha^{-1}) was observed in combination of 45MW (2nd week of November) with linseed variety PKVNL-260.

5.2Conclusions

The following conclusions have been drawn from the present investigation.

1. The sowing date of 45MW (2nd week of November) was found superior for growth, yield attributes and yield of linseed. Thus, sowing on 45MW (2nd week of November) was suitable for extended sowing dates.
2. The linseed variety the PKVNL-260 variety was found,better under extended sowing dates with regards to growth, yield attributes and yield.
3. Economically, PKVNL-260 linseed variety with 45MW (2nd week of November) sowing date obtained higher gross, net monetary returns and B:C ratio.

Thus, it can be advocated that sowing of linseed in 45MW (2nd week of November) with variety PKVNL-260 obtained significantly higher seed yield with the highest net monetary returns and B:C ratio.

The above conclusions, however, based on one season study. For confirmation of these results, the investigation needs to be repeated.

6. LITERATURE CITED

Abd El-Dayem, M.A., Shams, S.A.A. and AbdoKaied, H.M.H. 1998. Effect of plantimg dates and seeding rates on yield and its components of flax (*Linum usitatissimum* L.) grown under newly reclaimed land.Annals.*Agric.Sci.Moshtohar*. 40 (2) : 741-749.

Agrawal, K.K., Upadhyay, A.P., Jain, S. and Bhadauria, P.S. 2002. Thermal requirement of sunflower plant types und three dates of spring planting. *Indian.J. Agromet*. 4(2):165-169.

Anonymous, 2013.FAO Production year book, Food and Agriculture Organisation, India.pp : 567.

Anonymous, 2006a. Annual progress report. All India coordinated Research Project on Linseed. Project Coordinating Unit (Linseed). C.S.A.U.T.campus, Kanpur.

Anonymous, 2006b. Impact of sowing time-cum-newly released varieties of linseed. Annual Progress Report : 103-109.

A. O.A.C. 1980.Official method of analysis.13th Edn.Association on Official Analytical Chemist,Washington D.C.pp.226.

Awasthi, U.D., Singh, R. B.andDubey, S. D.2007. Effect of sowing date and moisture conservation practice on growth and yield of Indian mustard (*Brassica juncea*) varieties. *Indain. J.Agron*. 52(2):151-153.

Bastia, D. K. and Mohanty, S. K. 1999. Response of linseed (*Linum usitatissimum* L.) varieties to fertility levels under rainfed condition. *Indian.J.Agron*. 46 (2) : 343-345.

Belayk, V.B., Semenova, E. F. and Fadeeva,T. M. 2004.Ecoproduction potential of intermediate flax.*Russian.Agric.Sci*. 33(5) : 300-303.

Bhatt, J.G. 1965. Sowing time: A factor in increasing linseed yield in Madhya Pradesh.*The Madras Agric. J.* 52(1): 13-17.

Bhushan, C. andYadav, R. S. 2000. Studies on dry matter accumulation in relation to variable yield in linseed genotypes grown under central Uttar Pradesh condition.*Agric.Sci.Digest*. 26(2):120-122.

Bishnoi, K. C. and Singh, K. 1976. Oil yield and quality parameters of three Raya varieties as affected by sowing time and nitrogen levels. *Indian. J. Agron.* 24(3): 255-263.

Bishnoi, K. C. and Singh, K. 1976. Effect of sowing dates, varieties and nitrogen levels on yield yield attributes of Raya. *Indian. J. Agron*. 24(2): 123-129.

Bouyoucos,G.J.1962. Direction for making mechanical analysis of soil by hydrometer method. Soil Sci.42:225-228.

Casa, R., Russell, G.,Cascio, B. L.and Rossini, F. 1999. Environmental effects on linseed (*Linum usitatissimum* L.) yield and growth of flax at different stand densities.*European J. Agron.*11 : 267-278.

Chaudhary, S.K., Gougulwar, N. M. and Singh, A. K. 1991. Effect of nitrogen and sulphur on seed yield and oil content of 'Varuna' mustard (*Brassica juncea). Indian.J.Agron*. 37(4) : 839-84.

Ciriciofolo, E.andBonciarelli, C. 1994. Linseed in Umbria autumn and spring sowing.Informatore.Agrario. 52 (45) : 39-43.

Cremaschi, D., Vender, C. and Maestrini, C. 1992. Bioagronomic evaluation of linseed varieties, hybrids and ecotypes. Informatore.Agrario.50 (49) : 35-39.

Dixit, J.P., Chourasia, S.K., Pillani, P.V. A. and Khan, R.A. 1992.Assesment of flexibility of sowing time of linseed (*Linum usitatissimum* L.*)* varieties under double-cropping system in Tawa Command.*Indian.J.Agron.* 39(1) : 105-109.

Dixit, J. P., Pillai, P.V.A., Tripathi, S. K. and Khan, R.A. 1997. Influence of temperature in relation to optimum sowing period for winter crops in Tawa command. J. PlantSci.10(1): 201-205.

Dubey, M. P. 2000. Response of late-planted linseed (*Linum usitatissimum* L.) varieties to nitrogen levels under rainfed conditions. *Indian.J.Agron*. 46 (3): 547-551.

Dubey, R.N. and Srivastava, A.N. 1986.Three new linseed varieties. Indian farming 24(3):3-5.

Dubey, R.N. and Srivastava, A.N. 1999.Three new linseed varieties. Indian farming 24(5):3-5.

Dudhade, D.D., Gare, B.N., Khade, K. K. and Ramshe, D. G. 1994. Effect of sowing date on growth, yield attributes and yield of Indian mustard (*Brassica juncea*).*Indian.J.Agron*. 41(3) : 445-447.

El-Refaey, R.A., El-Seidy, E. H. and El-Deeb, I.A. E. 2008. Effect of sowing dates under different environmental conditions on yield and quality characters of some flax genotypes. *Alexandria J.Agric.Res*. 55(2) : 33-41.

Fisher, R.A. 1970. Statistical methods for research workers.14^{th} Ed. London Olive and Boyd, London.pp.112-127.

Fontana, F. and Maestrini, C. 1995.Productivity of some linseed varieties in different enviorments of Northen Italy.SementiElette. 43 (2) : 33-36.

Giri, G. 2000. Effect of irrigation and nitrogen on performance of Indian mustard (*Brassica juncea*) and sunflower (*Helianthus annus*) under two dates of sowing. *Indian.J.Agron.* 46 (2) : 304-308

Gourangakar and chakratry 1999.Thermal growth rate, heat and radiation utilization efficiency of Mustard (*Brasica junica*) under semiarid environment.*J.Agromet.* 1(1): 41-49.

Husain, K., Malik, Y.P., Srivastava, R. L., and Pandey, R. 2009.Production technology and industrial uses of dual purpose of linseed (*Linum usitatissimum* L.).*Indian.J.Agron*.54(4): 374-379.

Jackson,M.L.1973. Soil chemical analysis,Prentice Hall of India pvt.Ltd., New Delhi.pp.15-20.

Kalita, H., Bora, P.C., and Debnath, M. C. 1999. Effect of sowing date and tillage on soil properties, nutrient uptake and yield of linseed (*Linum usitatissimum* L.) grown in winter rice (*Oryaza sativa*). *Indian.J.Agron.* 50 (1): 70-72.

Kamlesh, K., Vajpeyi, M. and Dubey, R.N. 2002. Biochemical studies in some linseed (*Linum usitatissimum* L.) genotypes. *Indian.J.Biochem.*15 (1): 59-62.

Khare, J. P., Sharma, R. S., Shukla, K. C., Dubey, M. P. and Madaria, M. K., 1999. Relative performance of linseed under different sowing management in rainfed condition. *J. of oilseed Res.*16(1):78-81.

Khan, M.B., Yasir, T. A., and Madiha, A. 2003. Growth and yield comparison of different linseed (*Linum usitatissimum* L.) genotypes planted at different row spacing. *International.J.Agric.Biol.* 7(3): 515-517.

Kightley, S.P. J. and Thomas, J. E. 1997. Winter linseed variety performance trials. HGCA.Project.Report.37 : 12

Kumar, R. andShaktawat, M. S. 1991. Effect of limited water supply, nitrogen and time of sowing on production of rape (*Brassica napus*). *Indian.J.Agron.* 37(4) : 853-855.

Leto, C., Carruba, A., Tripathi, P. and Tuttolomondo, T. 1993. Yield of linseed and sowing date. Informatore.Agrario.52(45):45-47.

Lisson, S. N. and Mendham, N. J. 1997. Agronomic studies of flax (*Linum usitatissimum* L.) in south-eastern Australia. *Australian.J.Exp.Agric*. 40 (8): 1101-1112.

Mali, R.K., Gupta, B.R.D., Singh, K.K. and Singh, T. K. 2000. Phenology and yield of wheat (*Triticum aestivum*L.*)*in relation to Growing degree days and photothermal units. *Indian J.agric. Sci*. 70 (10): 647-652.

Mangal, K. K. and MakkhanLal, 1991. Performance of varieties of linseed (*Linum usitatissimum* L.) to irrigation schedules.*Indian.J.Agron.* 37(4) : 861-863.

Mastro, G. D. 1994. Linseed in the environment of central-southern Italy.Informatore.Agrario. 52 (45) : 33-35.

Mathur, Y. K., Basant Singh, R. A. and Srivastava, J.P. 1984. Effect of date of sowing on the incidence of Dasineuralini Barnes (Diptera: Ceciomyidae) and yield of linseed.*J. Oilseed Res.*1:77-79

Merrien, A. 1996.Winter or spring flax similar performance.Oleoscope. 36(1) : 32-34.

Mohapatra, S.C.,Bishoyi, B. S. and Patra, H. K. 2007. Effect of sowing dates and varieties on production of linseed (*Linum usitatissimum* L.).Enviornment Ecology. 27(1A) : 436-438.

Mokashi, D. D. 1999.Thermal requriment in sunflower –redgram intercropping in the scarity zone of Maharashtra state.J.Agromet.1(1):37-40.

Murthy, V.R.,Satyanarayan, V. and Mohammad, S. 1998. Impact of seedling time on yield components and yield of soybean (*Glycine max*) genotypes in southern telangana zone of Andhra Pradesh.*Indian.J.Agron.* 46 (2) : 314-318.

Naik, B. S. and Satapathy, P. C. 2000.Selection strategy for improvement of seed yield in late sown linseed.Res.on.Crops. 3(3): 599-605.

Nareshkumar, S. 2005.Thermal unit requirement for leaf growth and phonological development in sunflower.*J. Agromet.* 7(2): 168-173.

Nelson, D.W. and Sommers, L. E. 1982. Total carbon, Organic carban and Organic matter. inA.L.Page (Ed.) Method of Soil analysis. Part II Agronomy monogram. No. 9 America. Soc. Agron. Inc-publisher, Madison, Wisconsin, U.S.A.:11-59.

Neog, P. andChakravarthy, N.V. K. 2005. Termal unit and phonological model for (*Brassica juncea)*. *J.Agromet*. 7(2): 174-181.

Olsen, S.R. And Sommers, L.E.1982.Phosphorus in A.L.Page (Ed.) Method of Soil analysis.Part II Agronomy monogram No.9.America.Soc.Agron. Inc-publisher, Madison,Wisconsin,U.S.A:403-430

Page, A.L., Miller, R. H. and Keeny, D.R.1982. Method of soil analysis 2nd Ed. Soil.Sci.Soc.America,Inc.Madison, Wisconsin,U.S.A.:11-59.

Paikaray, R.K., and Misra, R. C. 1991. Performance of promosing varies of niger (*Guizotia abyssinica*) under optimum and late-sown condition. *Indian.J .Agron*. 37(4) : 866-868.

Pali, G.P and Tripathi, R. S. 2000. Performance of linseed (*Linum usitatissimum* L.*)* cultivars under varying sowing and fertilizer management in rainfed condition. *Indian. J. Agron. 45* (4): 771-775.

Panse, V.G. and Sukhatme, P. V. 1985. Statistical methods for Agricultural Workers.4th Edn. ICAR, New Delhi. pp.145-156.

Popescu, F. and Marinescu, I. 1992. Relative yield as a measure of harvest stability in linseed. Probleme de GeneticaTeoreticasiAlicata. 29 (1) : 39-50.

Patidar, M. and Lal, M. 1991. Performance of linseed (*Linum usitatissimum* L.) varieties at different levels of nitrogen*. Indian.J.Agron*. 37 (4) : 860-861.

Patidar, M. and MakkhanLal, 1992. Performance of linseed cultivars at different levels of nitrogen. Indian J. Agron.37 (4): 860-861.

Payasi, S. K. and Bose, U. S. 1999. Stability for yield and yield attributes in linseed. Advances in Plant.Sci. 12 (2) : 401-406.

Raghuwanshi, R. S., and Thakur, P. 1998. Economic performance of fertilizers on rabi crops. Res.on.Crops. 4(1) : 135-137.

Rajput, R.L., and Gautam, D. S. 1993. Response of sowing dates and nitrogen levels on growth yield and quality of linseed (*Linum usitatissimum* L.). Gujarat.Agric.University.Res.J. 19 (1): 88-93.

Ram, S. D. and Singh, R. S. 1997.Response of linseed (*Linum usitatissimum* L.) varieties to seeding and nutrient management under rainfed conditions.Birsa.*J. Agric. Res. University*. 14(2): 193-195.

Rao,S.S., Dongre, P.R. and Dhurrey, M. K. 2007. Stability behaviors of some linseed genotype under environmental variability. *J. Oilseed Res*. 24(1): 64-67.

Reddy, D.S. (1983). Response of linseed cultivars to varying fertility levels under irrigation. *Masore J. of Agric. Sci*. 17: 91

Saeidi, G. 2000. Effect of seeding date on seed yield and yield components in edible oil genotypes of flax in Isfahan.J.Sci.Tech.Agric.And Natural.Res. 6(3): 175-187.

Sahrawat,K.L. andBurford, J.L.1982.Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland Soil. Soil.Sci.133(1):53-57.

Sarma, N. N. and Sarma, D. 1993.Response of toria (Brassica campestris subsp. Oleifera var. toria) and Indian mustard (*Brassica juncea*) varieties to sowing dates in hill zone of Assam.*Indian.J.Agron*.39 (4) : 685-686.

Seadh, S.E.,Attia, A.N.E., Badawai, M. A. and El-Hety, S.M. S. 2012. Response of seed yield and its components of safflower to sowing dates, nitrogen fertilizer levels and times of foliar application with milagrow.*J.Biol.Sci*. 12(6): 342-348.

Shahidullah, M., Islam, U.,Karim, M.A. and Mondol, R. K. 1997. Performance of four linseed varieties at different dates of sowing.Bangaladesh.*J.Sci. and Industrial Res*. 32(2): 186-190.

Shaikh, F.G., Gokhale, D.N., Rokade, B.S., and Jadhav, P. J. 2008.Effect of sowing date on some growth characters in linseed.*Agromet.J*. 11(2) : 203-205.

Shrma, J.J., Kapur, B.L., and Thakur, D. R. 1995.Performance of linseed (*Linum usitatissimum* L) cultivars under varying dates of sowing in Kullu valley. *Himachal J. Agric.Res.* 21(1&2): 23-26.

Singh, I. and Saini, S. L. and Singh, R. C.1993.Effect of row spacing and fertilizer level on late-sown Indian mustard (*Brassica juncea*) cultivars.*Indian J.Agron*. 41(1): 166-167.

Singh, K. D. 1966. Studies on the effect of varying levels of nitrogen and dates of sowing on yield and quality of linseed (*Linum usitatissimum* L.).*Indian J.Agron.* 24(1) : 215-218.

Singh, K. D. 1968. Studies on the effect of varying levels of Nitrogen and dates of sowing on yield and quality of linseed *(Linum usitatisimum L.). Indian J. Agron.* 13:215-218.

Singh, N. B. and Verma, K. K. 1996. Productivity of late-sown linseed (*Linum usitatissimum* L.) grown under variable resource constraints in rainfed areas of eastern Uttar Pradesh*. Indian J.Agron*. 43 (1) : 158-161.

Singh, P.K. 2002. Effect of intercropping on reflected photo- synthetically active radiation in rainfaid crops.*J. Agromet*. 4(2)187-190.

Singh, R., Patidar, M. and Singh, B. 2001. Response of Indian mustard (*Brassica juncea*) cultvars to different sowing time.*Indian J.Agron*. 46(2) : 292-295.

Singh, T., Singh, V.K., Singh, Y. and Singh, M. K. 2002. Effect of sowing dates, seed rates and sulphur levels on growth, yield, quality and moisture use of rainfed linseed.Enviroment and ecology.25(4):978-982.

Singh, T., Dahiya, K. S. andSidhu, M. S. 2003. Effect of genotype, seedling age and row spacing on performance of transplanted African mustard (Brassica juncea)under late sown conditions.*Indian J. Agron*.51(3):221-224.

Sorlino, D. M. 2004. Dynamics of flowering and reproductive organs abscission in linseed. *Indian J. Agron*. 24(3) : 211-216.

Sorlino, D. 1997. Phenology of flowering linseed.*Indian J. Agron*. 17(1): 7-12.

Turhan, H., Gul, M.K., Egesel, C. O. and Kahrman, F. 2007. Effect of sowing time on grain yield, oil content and fatty acids in rapeseed (*Brassica napus subsp. Oleifera*).Turkish.J.Agric.and Foretsry.35(3) : 225-234.

Verma, K. P. and Pathak, R. K. 1993. Response of linseed (*Linum usitatissimum* L.) varieties to different date of sowing. *Indian J. Agron*. 38(1) : 60-63.

Vrishali, 2005. Relationship of LAI and biomass of soybean with Agroclimatic indices.*J. Agromet*.7(2): 249-254.

Vyas, S. C. and Prasad, K.V. V.1980. Some high yielding disease resistant varieties of linseed. Seeds and farms.6(12): 21-23.

Yadav, R.A., Mathuria, O. P. and Singh, D. 2002. Studies on date of sowing and seed rate of double purpose linseed (*Linum usitatissimum* L.). Plant Archives 5(2): 503-507.

Zubal, P. 2000. The effects of sowing dates, seeding rate and nutrition on yields of the oilseed flax cultivars (*Linum usitatissimum* L.). VedeckePraceVyskumnehoUstavuRastlinnejVyrobyPiest. 30 (1): 33-38.

7.APPENDIX-I

Following rates / prices were considered for calculating cost of cultivation

Sr. No.	Particulars		Unit	Rates (Rs.)
1.	Tractor ploughing		Rs. ha^{-1}	3000
2.	Tractor harrowing		Rs. ha^{-1}	1500
3.	Labour(Female/male)		Rs. Day^{-1} $head^{-1}$	215
4.	Cost of seed		Rs. Kg^{-1}	45
5.	Cost of fertilizers		Rs. Kg^{-1}	
	I.	Urea	Rs. Kg^{-1}	5.64
	II.	Single super phosphate	Rs. Kg^{-1}	8.0
6.	Cost of chemicals			
	I.	Chlropyriphos	Rs. L^{-1}	230
7.	Combiner (Harvesting, threshing, cleaning)		Rs. ha^{-1}	12500
8.	Market price			
	i.	Grain	Rs. q^{-1}	4400
	ii.	Straw	Rs. q^{-1}	20

APPENDIX-II

Cost of cultivation common to all treatments excluding other input cost (ha^{-1})

Sr. no	Particular	Rate (Rs.)
1.	Ploughing	3000
2.	Harrowing	1500
3.	Collection of stubbles	1100
4.	Layout and sowing	2500
5.	Cost of seed	1125
6.	Fertilizers application	1500
7.	Irrigation charges	6500
8.	Plant protection measures	230
9.	Combine charges	12500
10.	Land revenue	260
11.	Interest on working capital @14%	3272
12.	Total common cost of cultivation	43702

8. VITA

Miss. JAYSHRI VITTHAL ADAGALE

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

2014

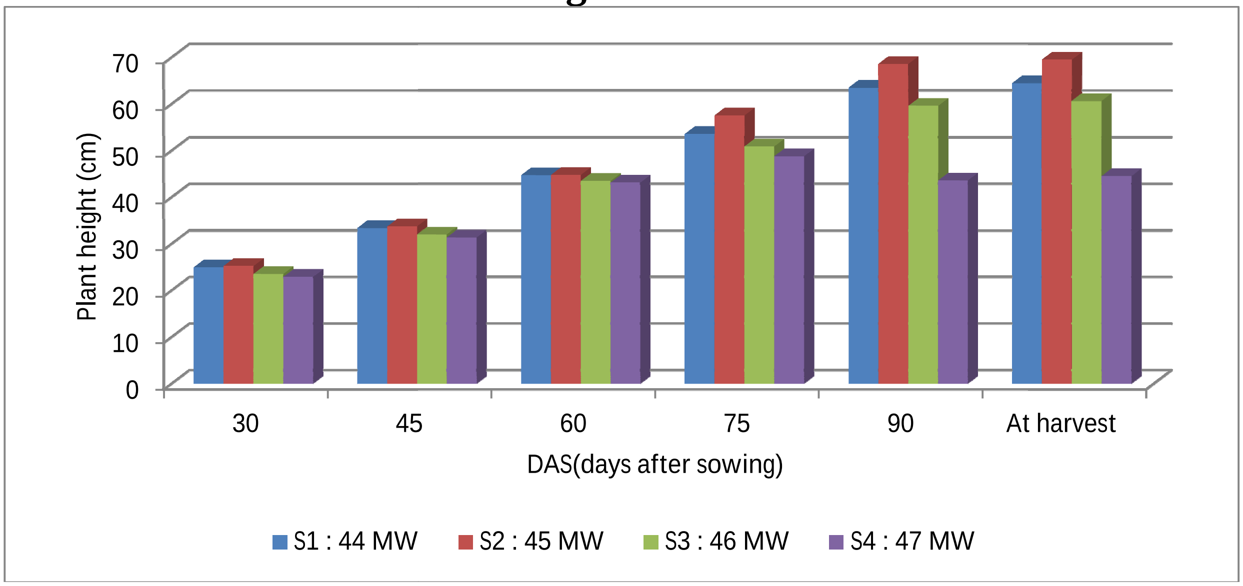
Title of Thesis	**:**Effects of extended sowing dates on varieties of linseed (*Linum usitatissimum* L.)
Major Field	**:** Agronomy
Biographical information	
Personal	: Born at Phaltan, Tal- Phaltan, Dist- Satara, Maharashtra on 22nd June, 1990. Daughter of Mr. Vitthal Hariba Adagale and Mrs. SangitaVitthalAdagale.
Educational	:Passed S.S.C. from Saint Gadage Maharaj Vidyalaya, Oturin 2006 with First class with distinction (85.33 %). Passed H.S.C. from Padmashri Vikhe Patil College of Art's Science and Commers, Pravaranagar in 2008 with First class with distinction (78 %). Received Bachelor of Science (Agriculture) degree in 2012 with First class (82.20 %) from College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Address : Vighanahar, Plot no-70, Ajitnagar, Kolaki
A/P- Phaltan, Tal- Phaltan, Dist- Satara
(415523).

Email : jayshri22690@rediffmail.com

Mobile No. : +919422077729
+917709648206

Sowing times



Varieties

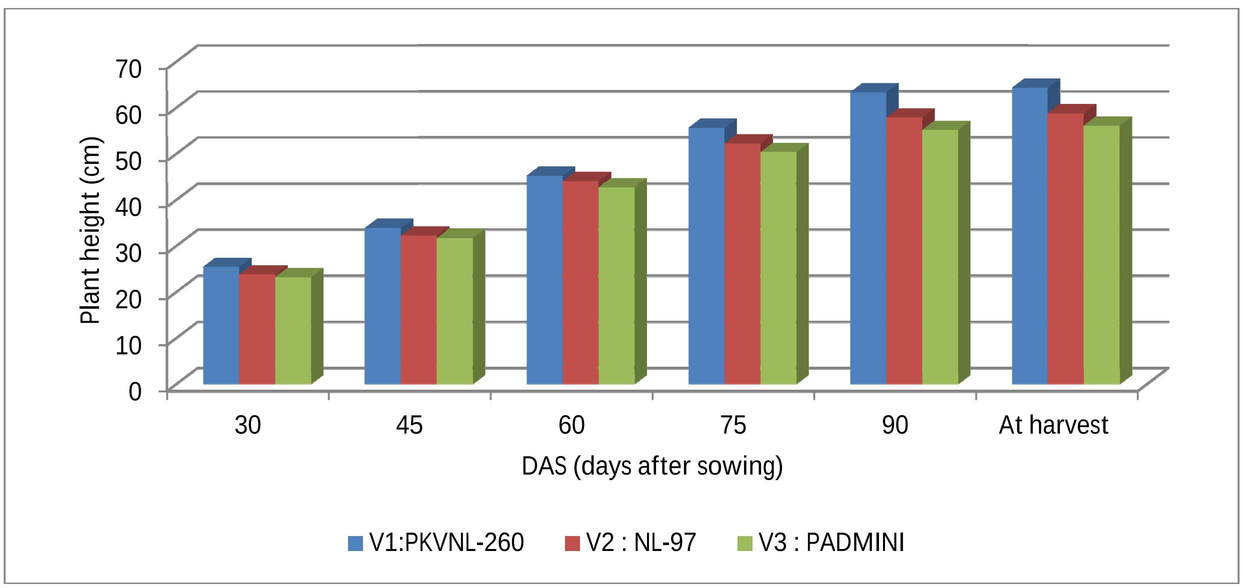


Fig.3 Mean plant height (cm) as influenced periodically by different treatments

Varieties

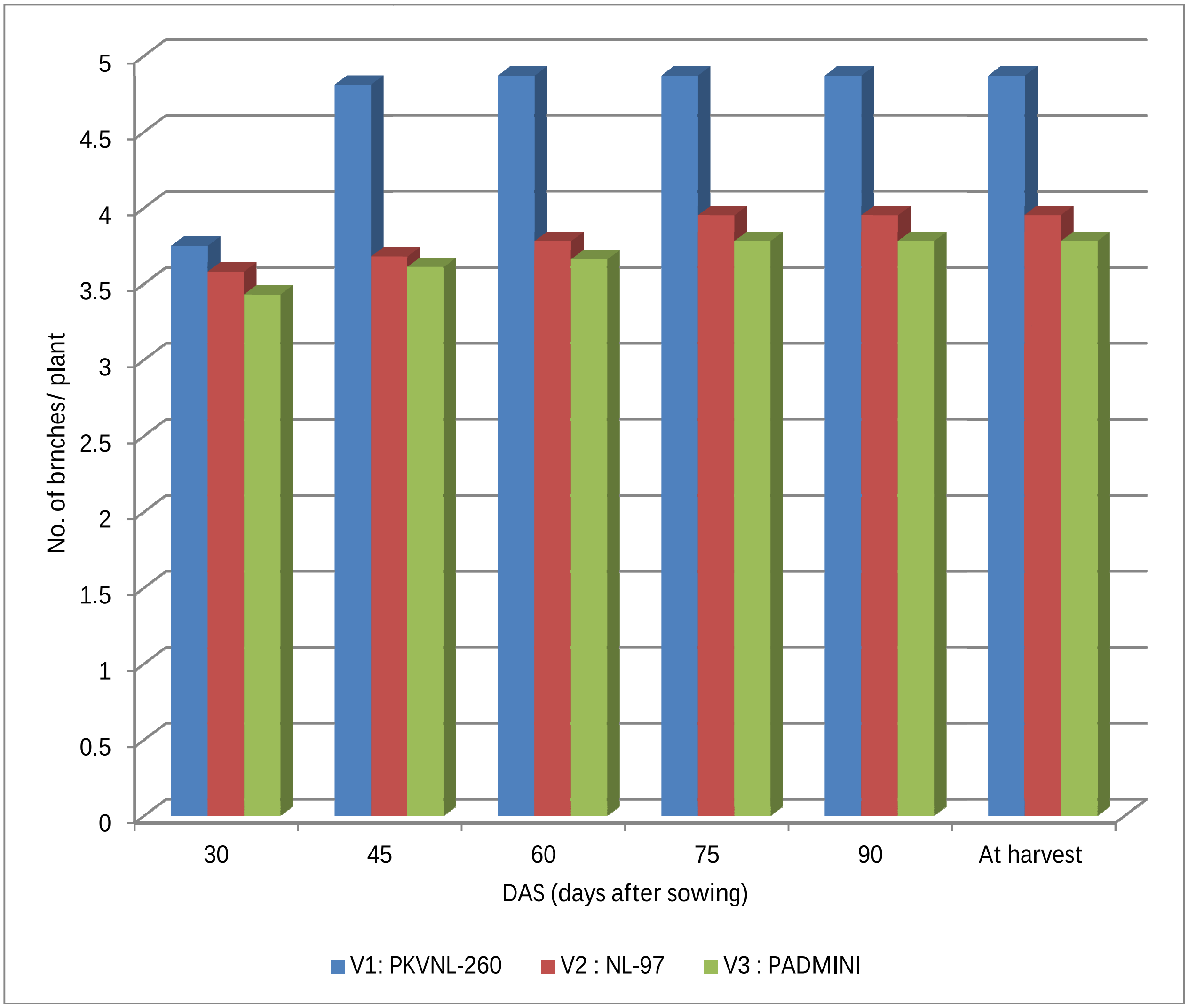
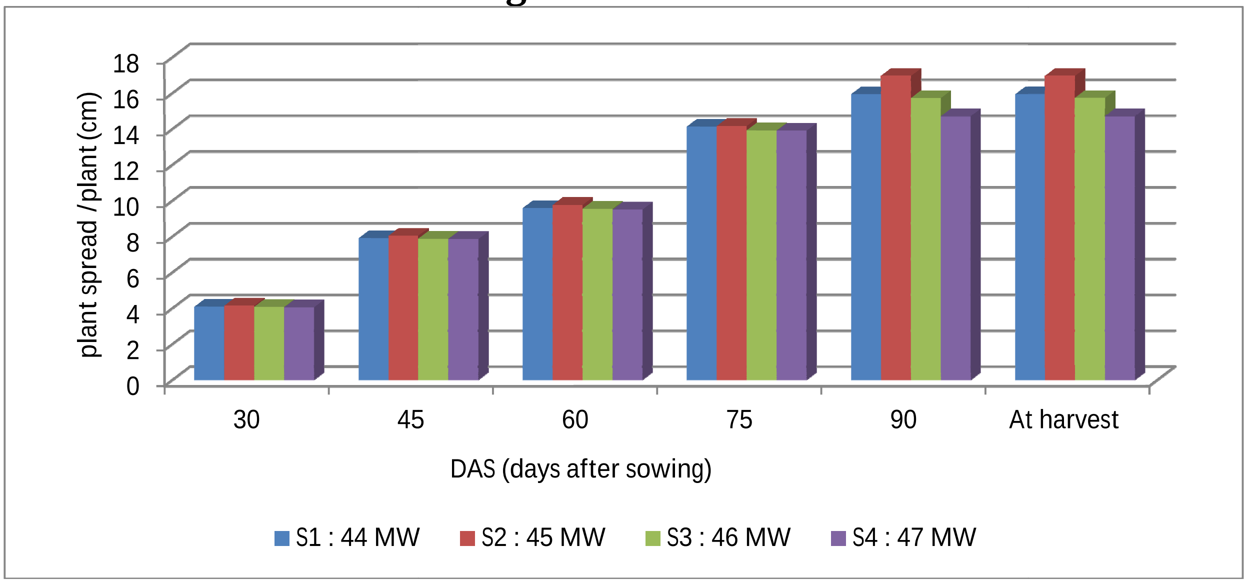


Fig. 4 Mean number of branches plant^{-1} as influenced periodically by different treatments

Sowing times



Varieties

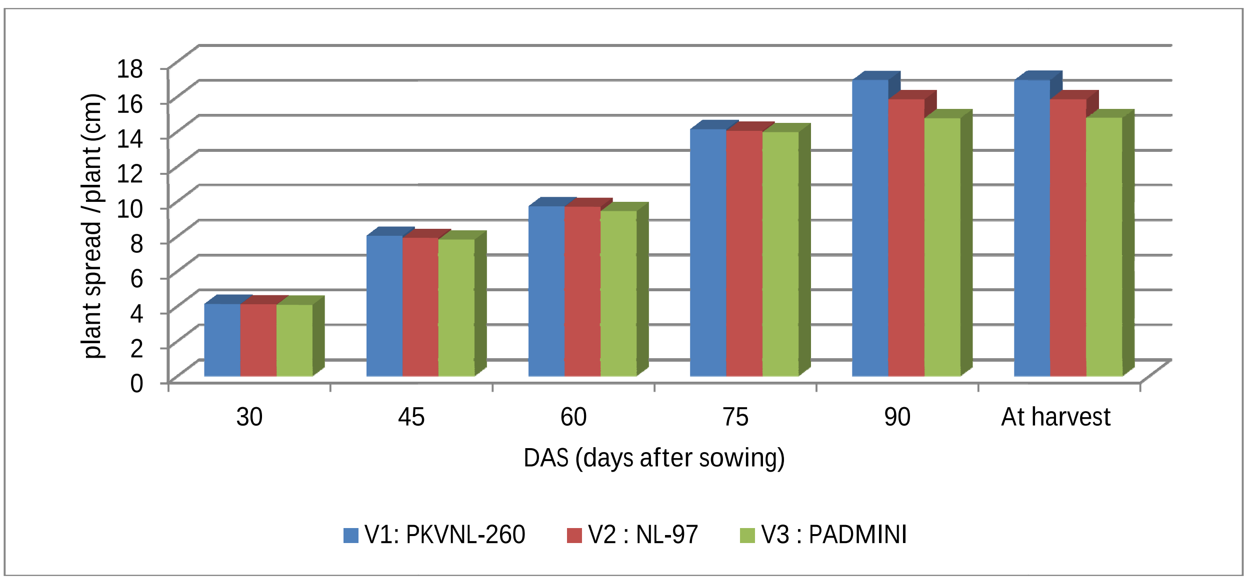
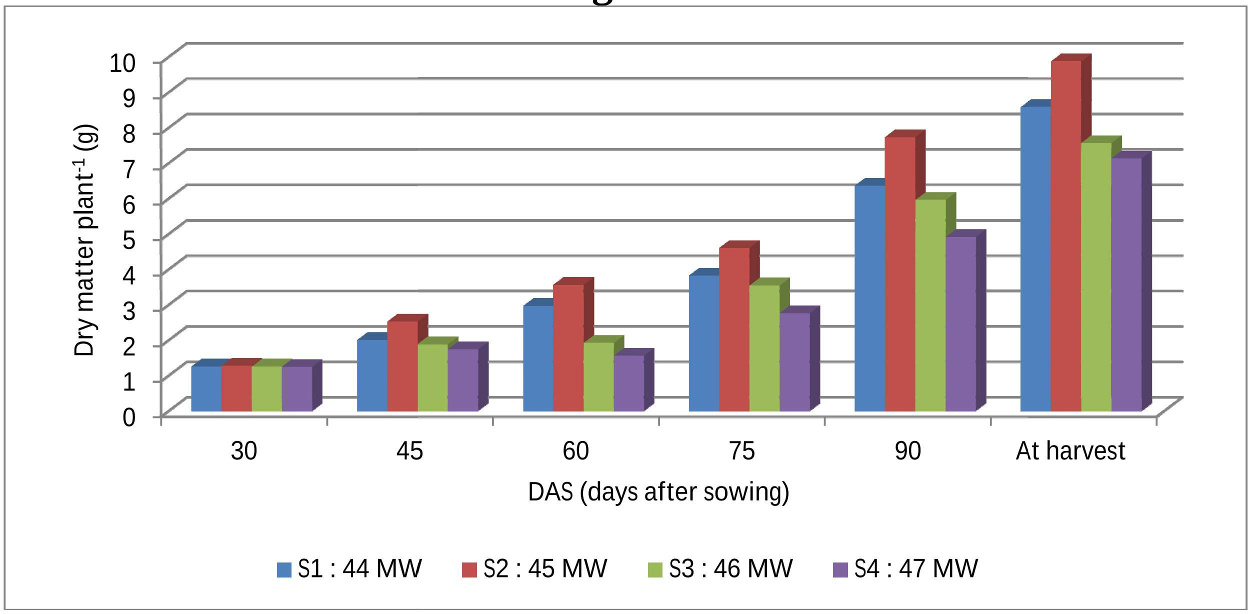


Fig. 5 Mean plant spread plant^{-1} (cm) as influenced periodically by different treatments

Sowing times



Varieties

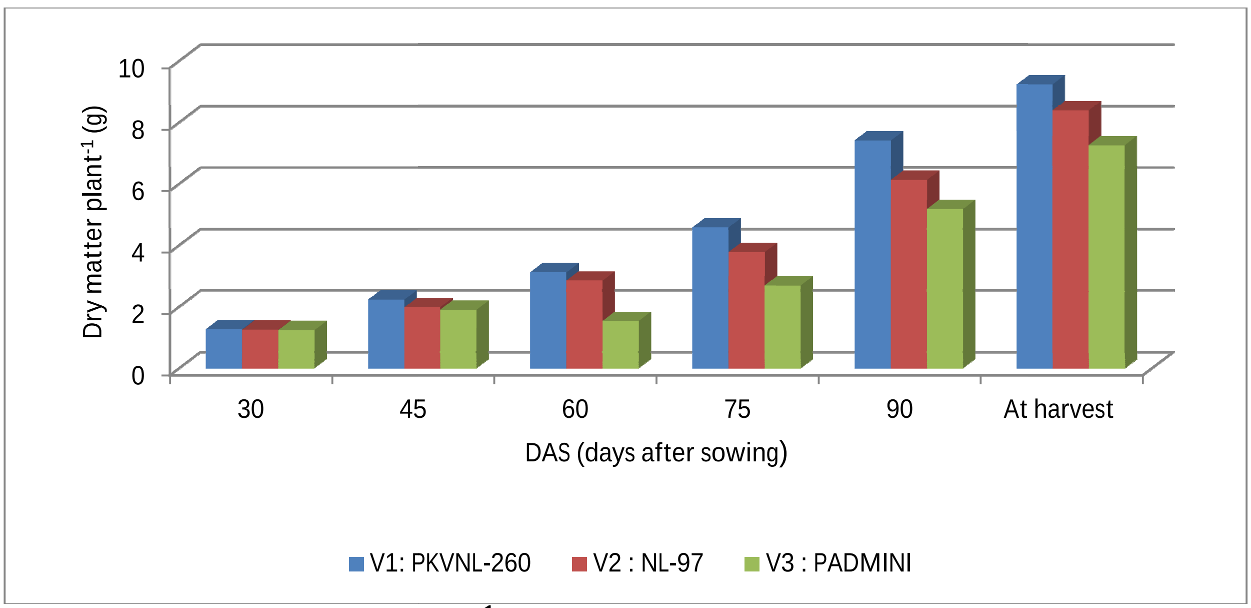
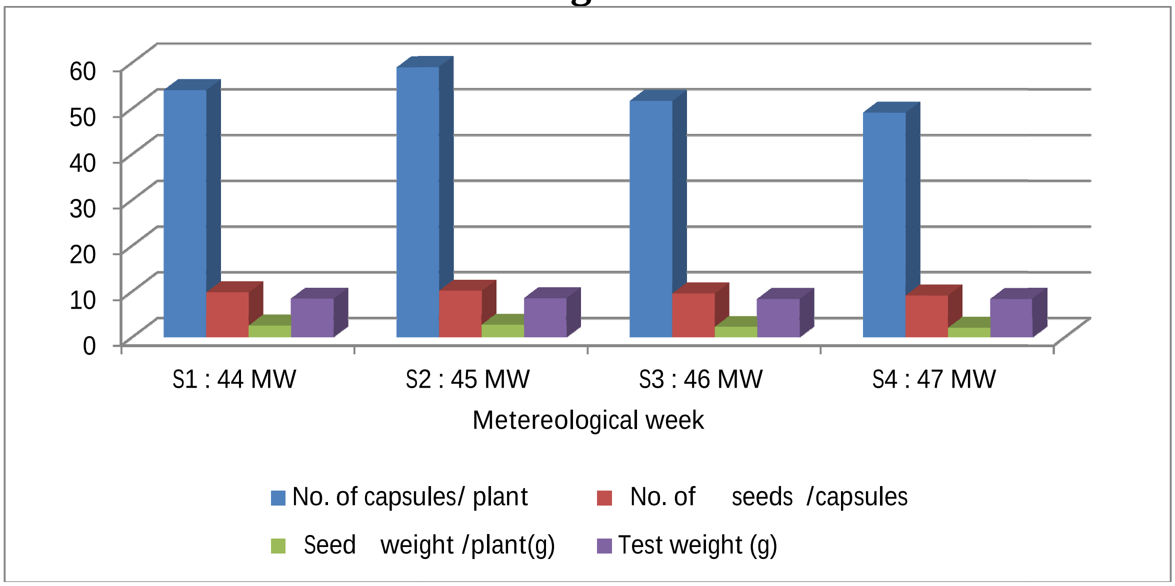


Fig.6 Mean dry matter plant^{-1} (g) as influenced periodically by different treatment

Sowing times



Varieties

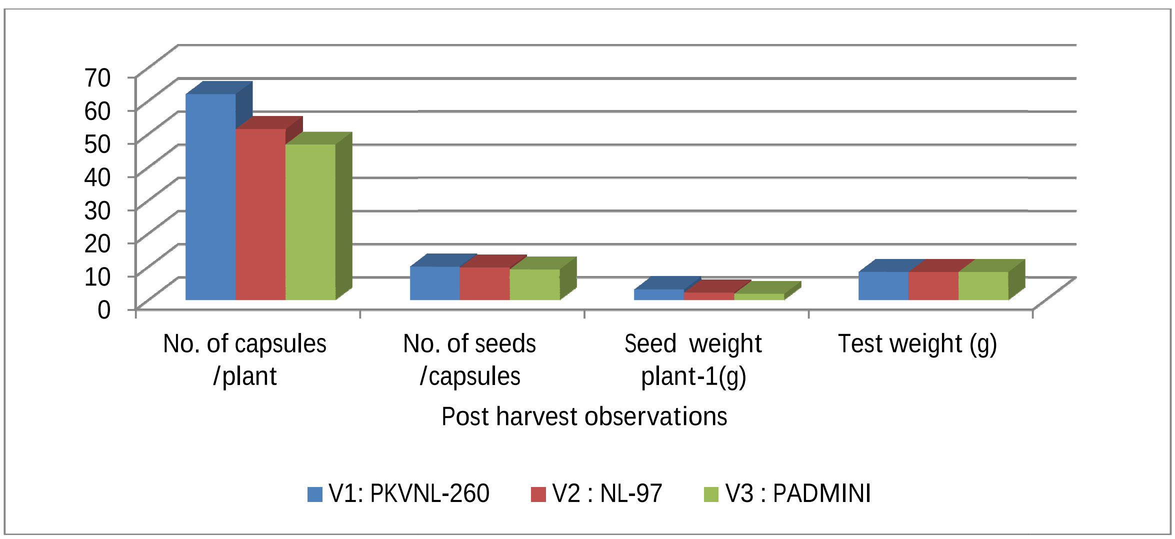
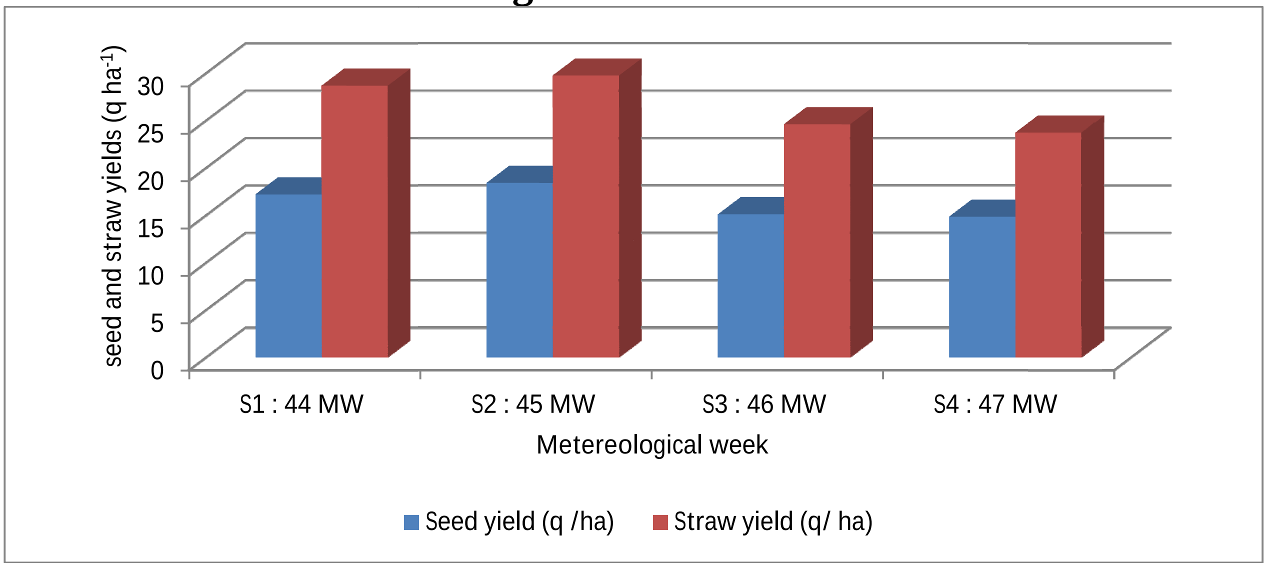


Fig.7 Mean number of capsules plant^{-1}, number of seeds per capsules^{-1}, seed weight plant^{-1} and thousand grain weight (g) as influenced by different treatments

Sowing times



Varieties

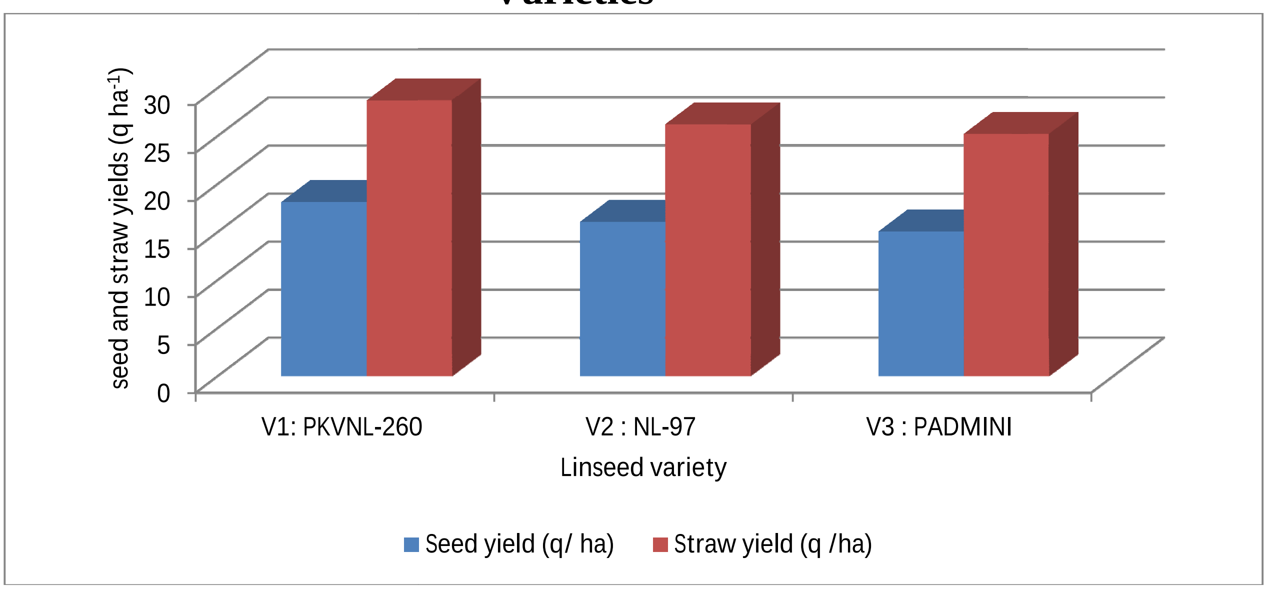
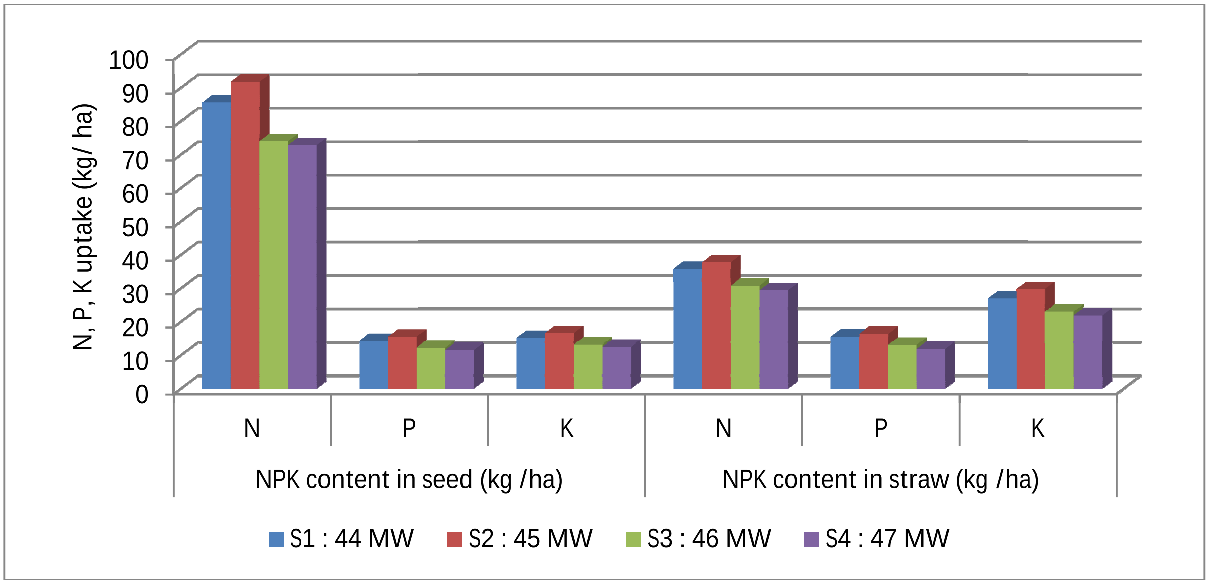


Fig.8 Mean seed and straw yields (q ha^{-1}) as influenced by different treatment

Sowing times



Varieties

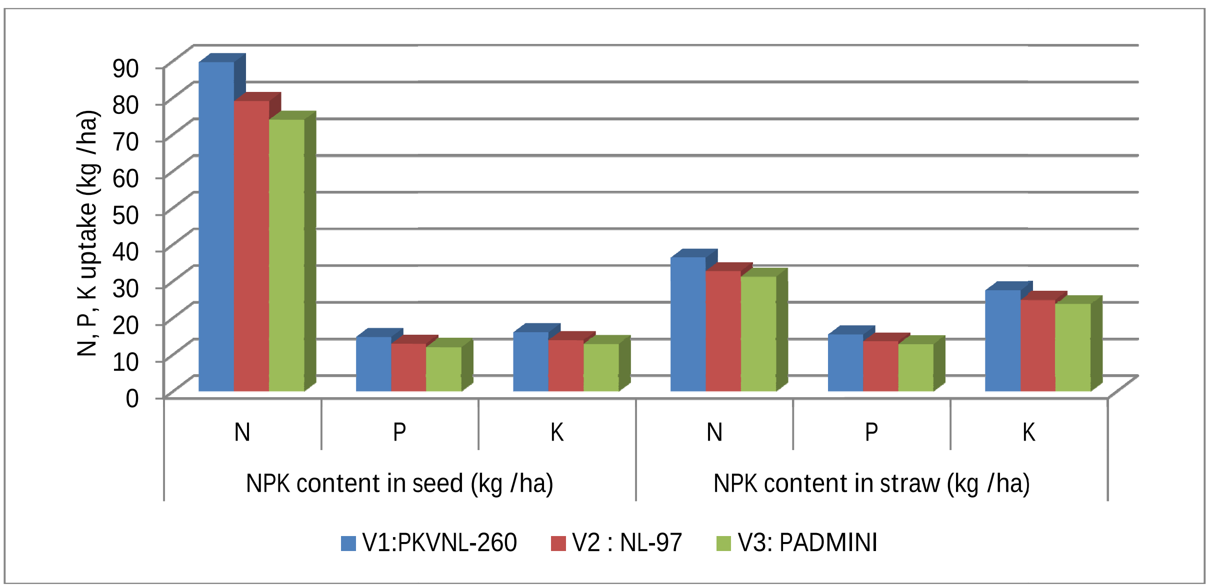
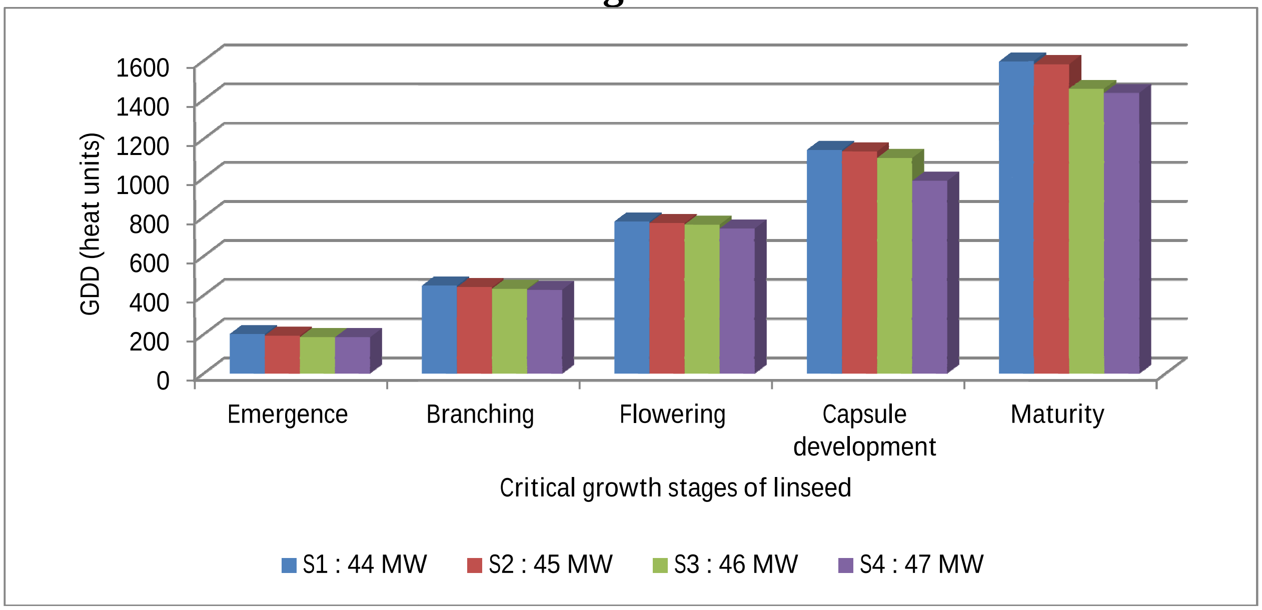


Fig.9 Total N, P, K uptake (kg ha^{-1}) by seed, straw and crop as influenced by different treatments

Sowing times



Varieties

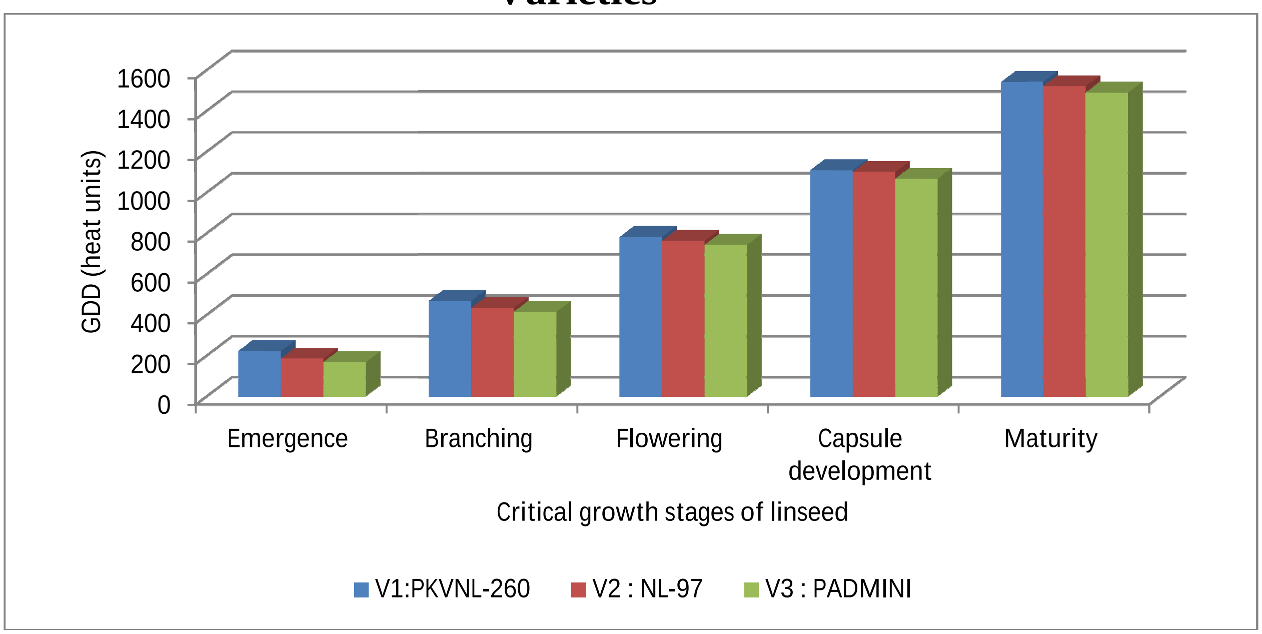
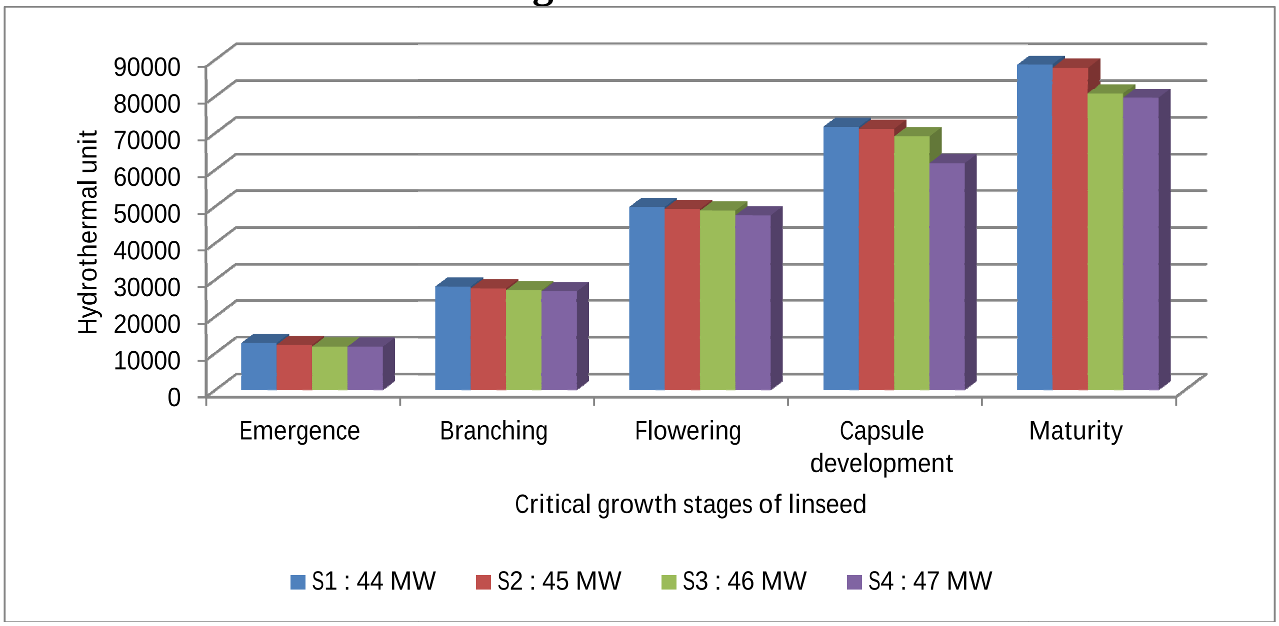


Fig.10 Cumulative growing degree days (heat units) at different critical growth stages as influenced by different treatments

Sowing times



Varieties

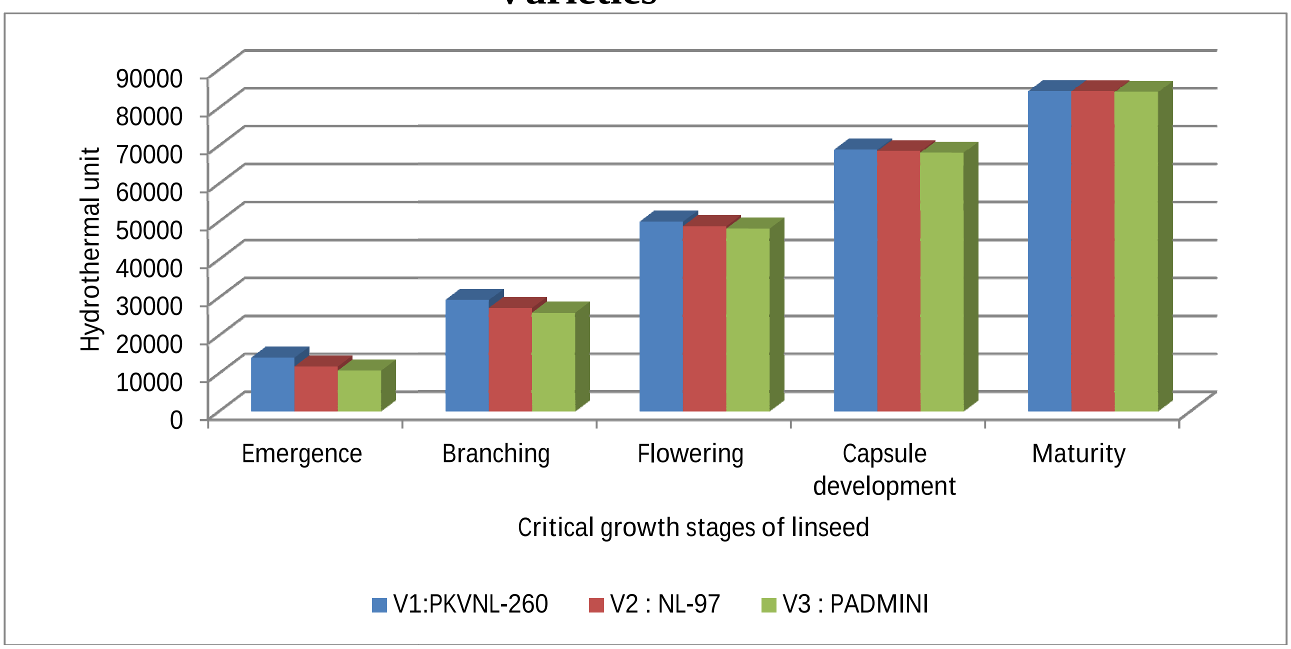
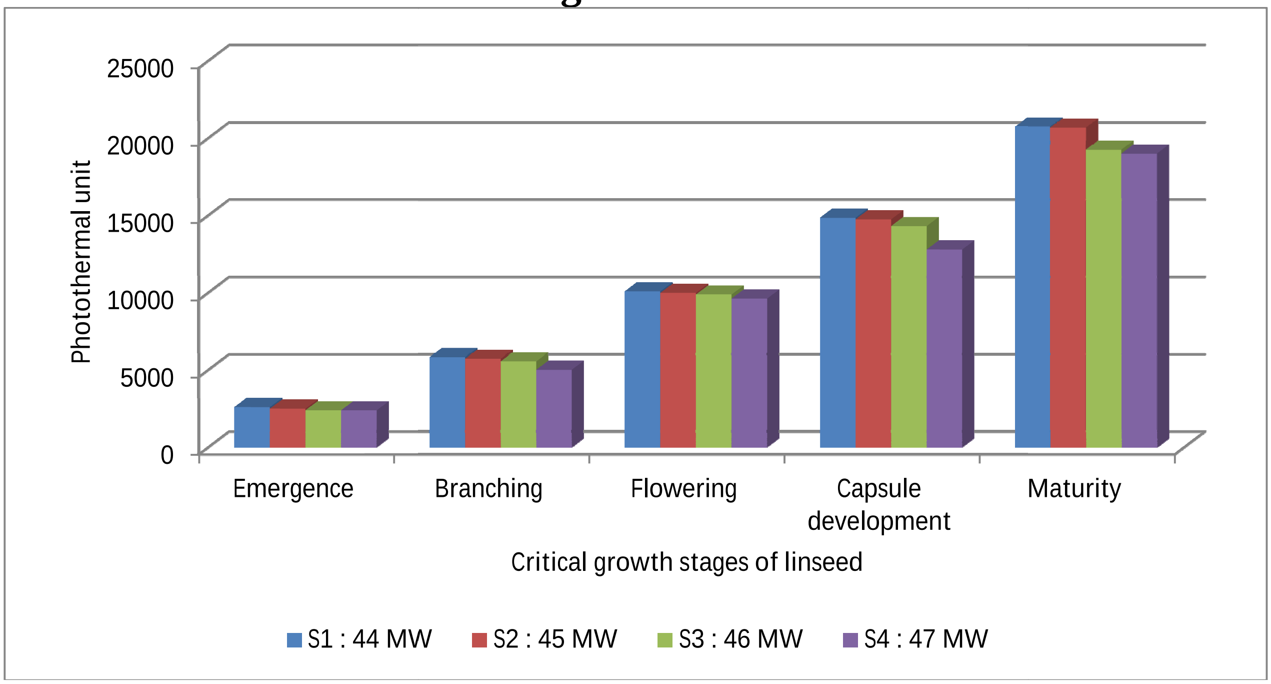


Fig.11 Cumulative hydrothermal units at different critical growth stages as influenced by different Treatments

Sowing times



Varieties

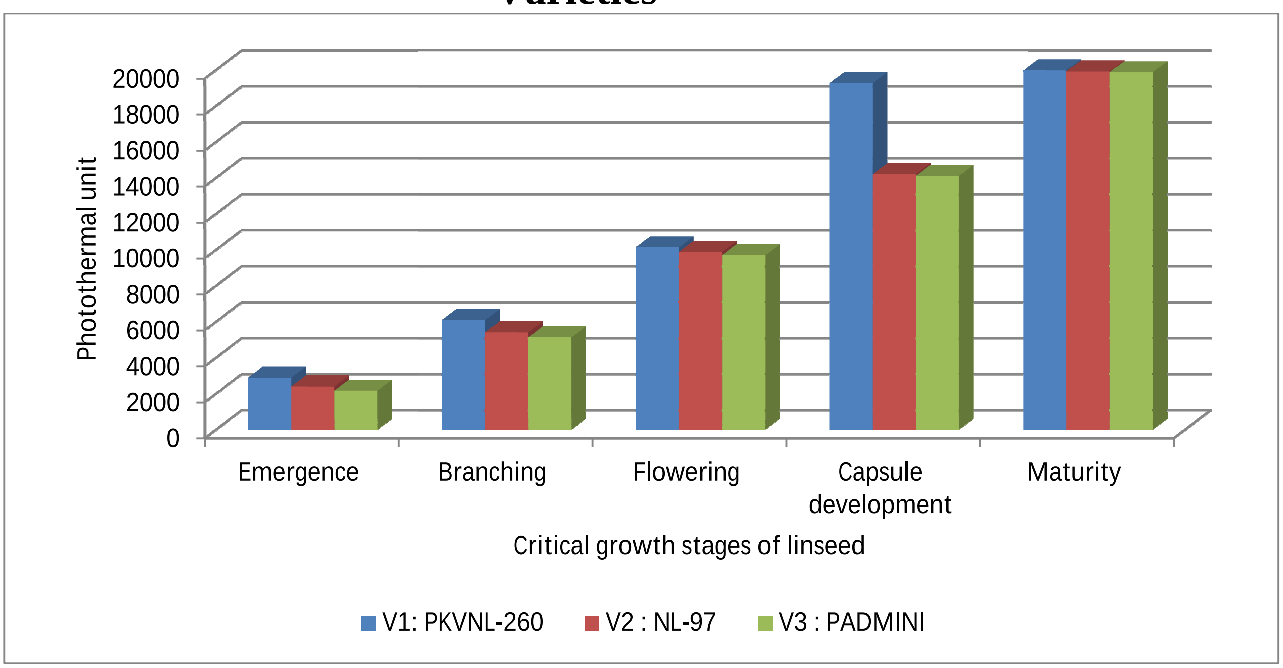
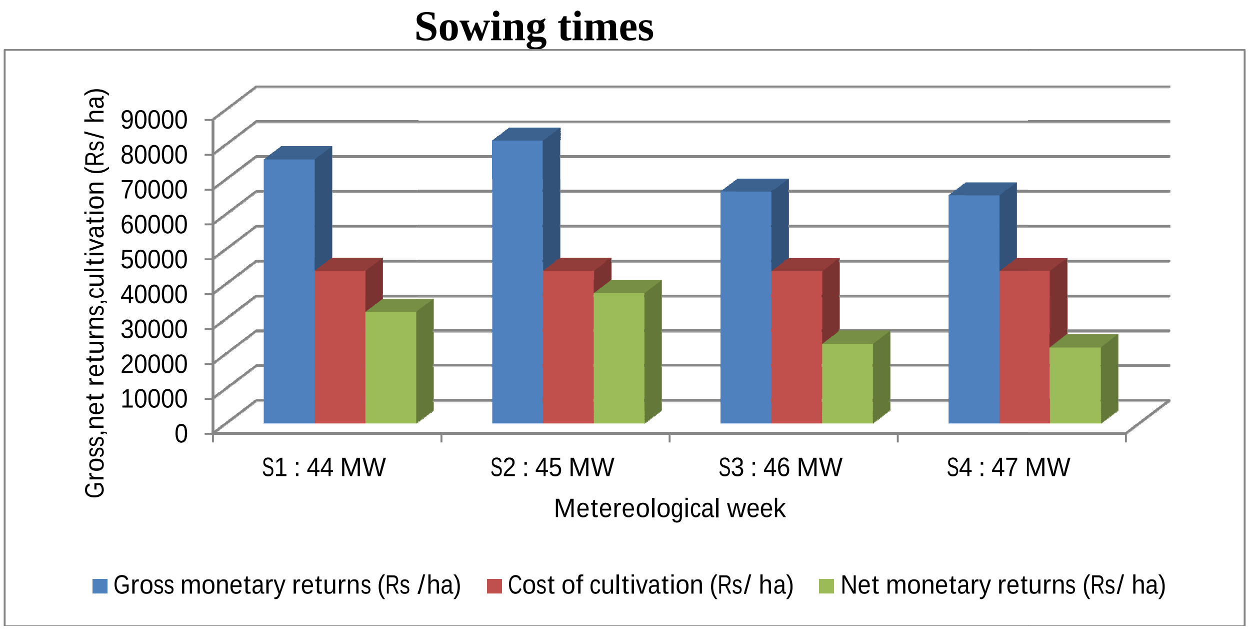


Fig.12 Cumulative photothermal units at different critical growth stages as influenced by different treatments



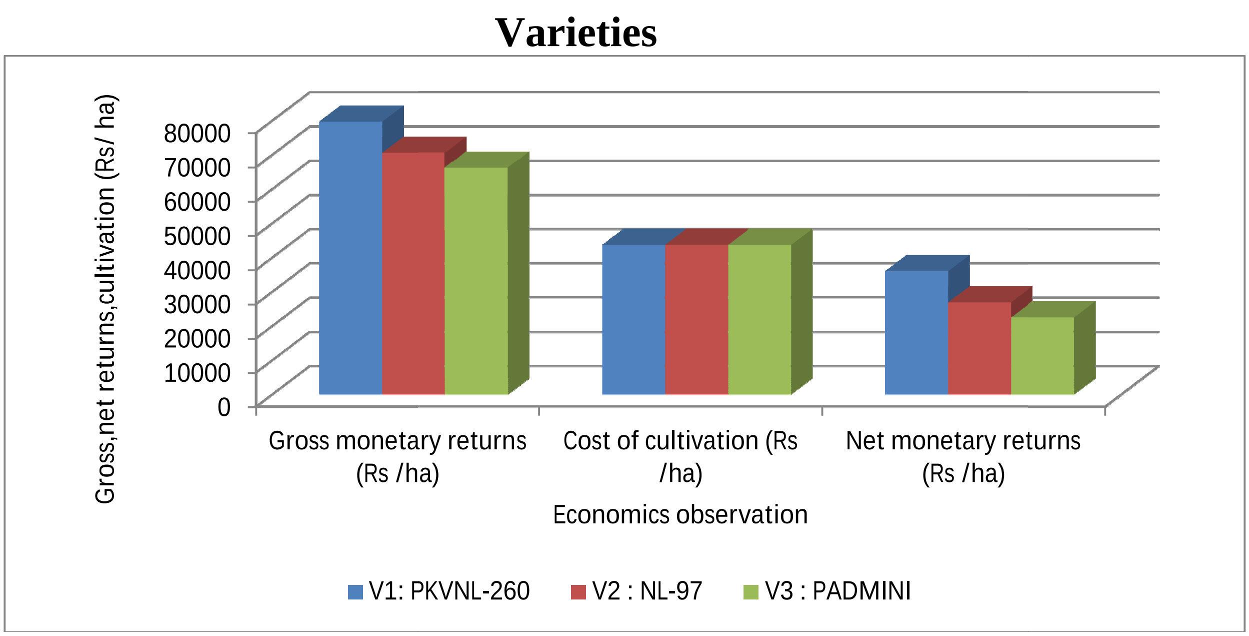


Fig.13 Mean gross and net monetary returns, cost of cultivation (Rs. ha^{-1}) and B:C ratio as influenced by different treatments

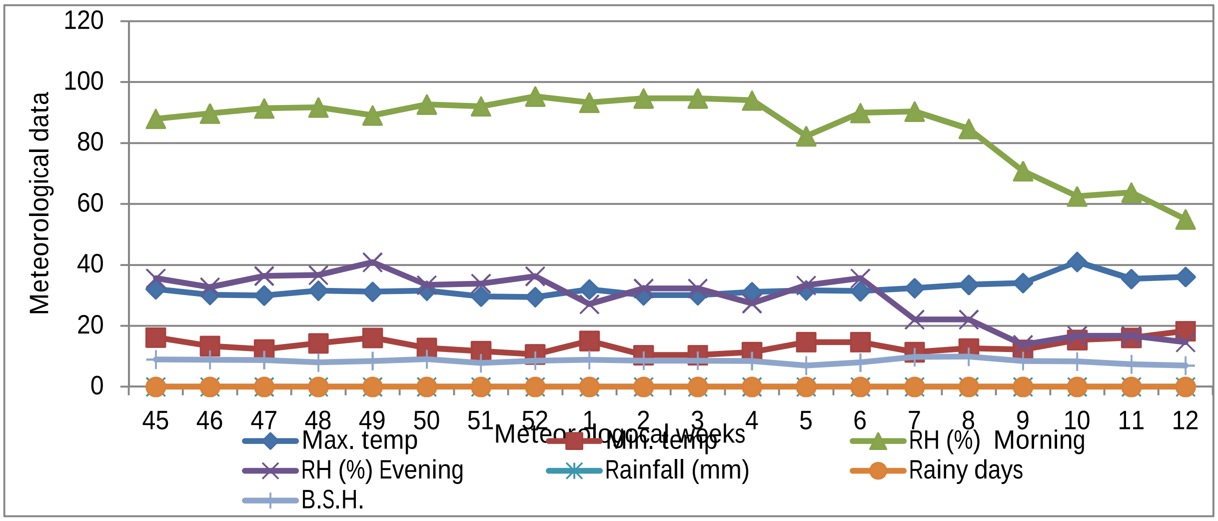


Fig.1 Weekly meteorological data recorded during the experimental periods

(November 2012 to March 2013)

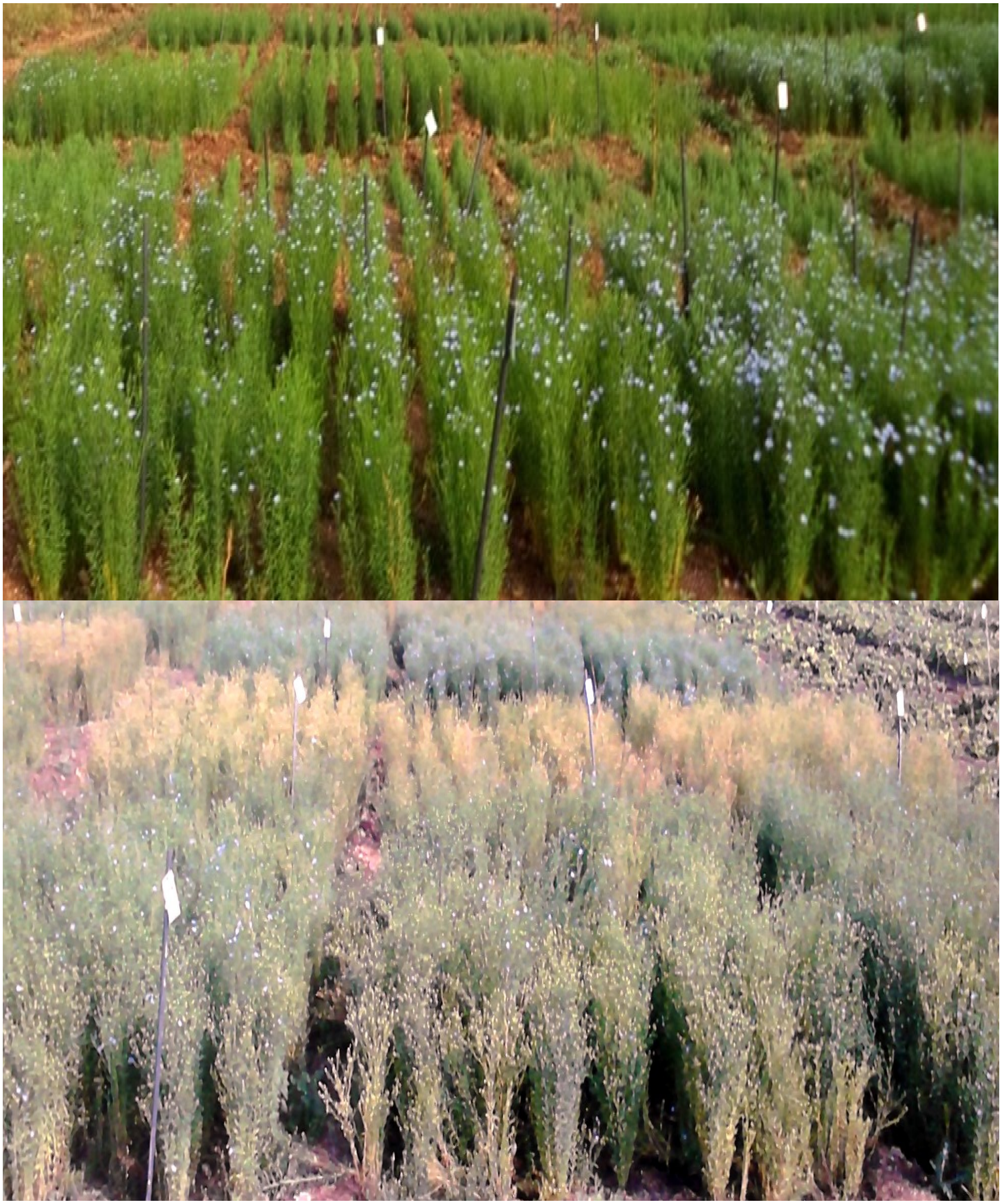


Plate 1 : General view of the experiemental plot

Plate 2 : PKVNL-260 variety along with 45 MW (2nd week of November)

Plate 3 : Experimental linseed field plot with 47 MW (4th week of November) sowing date