

SEED PRODUCTION OF DHAINCHA
[*Sesbania aculeata* (Wills.) Poir.] AS
INFLUENCED BY SOWING TIME AND
PLANTING DENSITY

BY
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B.Sc. (Ag.)

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CHAIRPERSON: Dr.M.MARTIN LUTHER



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DECLARATION

I, **U. TRIVENI**, hereby declare that the thesis entitled “**SEED PRODUCTION OF DHAINCHA [*Sesbania aculeata* (Wills.) Poir.] AS INFLUENCED BY SOWING TIME AND PLANTING DENSITY**” submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Bapatla

Date:

U.TRIVENI

I.D. No. BAM 09-008

CERTIFICATE

Ms. U. Triveni has satisfactorily prosecuted the course of research and that thesis entitled “**Seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density**” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date:

(M.MARTIN LUTHER)
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CERTIFICATE

This is to certify that the thesis entitled “**Seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density**” submitted in partial fulfilment of the requirements for the degree of ‘**Master of Science in Agriculture**’ of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Ms. UNGATA TRIVENI** under our guidance and supervision.

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

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Date:

(UNGATA TRIVENI)

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LIST OF SYMBOLS AND ABBREVIATIONS USED

%	:	Per cent
@	:	At the rate of
⁰ C	:	Degree Celsius
C.D. (P=0.05%)	:	Critical difference at 5 per cent
C.V.	:	Coefficient of variation
cm	:	Centimetre
DAP	:	Diammonium phosphate
DAS	:	Days after sowing
dSm ⁻¹	:	Deci Seimen per metre
EC	:	Electrical conductivity
<i>et al.</i>	:	And others
Fig.	:	Figure
g	:	Gram
ha ⁻¹	:	Per hectare
HI	:	Harvest index
<i>i.e.</i>	:	That is
K	:	Potassium
K ₂ O	:	Potassium oxide
kg ha ⁻¹	:	Kilogram per hectare
kg	:	Kilogram
MOP	:	Muriate of Potash
m	:	Metre
m ²	:	Square metre
Max.	:	Maximum
Min.	:	Minimum
ml	:	Millilitre
N	:	Nitrogen
NS	:	Non-significant
P	:	Phosphorus
P ₂ O ₅	:	Phosphorus penta oxide
pH	:	Potential of hydrogen ion concentration
RH	:	Relative Humidity

RBD	:	Randomized Block Design
Rs	:	Rupees
SEM±	:	Standard Error of mean
SSP	:	Single Super Phosphate
t	:	Tonne
<i>viz.</i> ,	:	Namely

ABSTRACT

Author	:	U.TRIVENI
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A field study was carried out on clay loam soils of the Agricultural College Farm, Bapatla, during *kharif*, 2010 to determine the optimum sowing time and planting density for maximizing the seed production potential of dhaincha. The study consisted of 18 treatment combinations resulted from six dates of sowing (S₁-July 1, S₂-July 15, S₃-August 1, S₄-August 15, S₅-September 1 and S₆-September 15) and three row spacings (D₁ -30 cm × 15 cm, D₂ - 45 cm × 15 cm and D₃ - 60 cm × 15 cm) arranged in a randomized block design following the factorial concept with three replications.

The results revealed that sowing dates, spacings and their interaction significantly influenced the growth parameters, yield attributes and yield of dhaincha crop.

Among the six different sowing dates studied, dhaincha sown early on July 1 showed better performance in plant height, number of branches per plant and drymatter accumulation followed by July 15 sowing. July 1 sown crop took significantly maximum number of days to attain 50% flowering and maturity over other sowing dates.

The yield attributes (pods per plant and test weight), yields (seed and stalk) and harvest index were also higher with the July 1 sowing followed by July 15 sowing. All these parameters decreased considerably due to delay in sowing time beyond July 15.

Dhaincha sown at closer spacing of 30 cm × 15 cm recorded taller plants. Drymatter accumulation per plant was higher at 60 cm × 15 cm spacing but the total drymatter accumulation was higher with 30 cm × 15 cm which was followed by 45 cm × 15 cm and 60 cm × 15 cm spacings. Close spaced (30 cm × 15 cm) crop reached the stage of 50% flowering and maturity earlier followed by 45 cm × 15 cm and 60 cm × 15 cm spacings.

Yield components *viz.*, number of pods per plant and 1000 seed weight were increased with increase in row spacing from 30 cm to 60 cm. Among the three spacings (30 cm × 15 cm, 45 cm × 15 cm and 60 cm × 15 cm), the seed and stalk yields were significantly higher with 30 cm × 15 cm spacing. However, the harvest index was higher in 60 cm × 15 cm spacing.

Drymatter accumulation with 30 cm × 15 cm spacing at each sowing date was significantly higher over 45 cm × 15 cm and 60 cm × 15 cm spacings. However, drymatter accumulation recorded at July 1 sowing at 30 cm × 15 cm spacing was significantly higher over all other treatment combinations at all the stages of crop growth.

Higher number of pods per plant was recorded at wider spacing of 60 cm × 15 cm with July 1 sowing and it was on a par with July 15 sowing at the same spacing. However, the seed, stalk yields and returns per rupee investment were significantly higher with July 1 sowing at 30 cm × 15 cm spacing which was closely followed by 45 cm × 15 cm spacing at the same sowing and also July 15 sowing at 30 cm × 15 cm spacing.

Overall, the study indicated the need for early sowing from July 1 to July 15 with a row spacing of 30 cm × 15 cm to 45 cm × 15 cm to achieve maximum seed production under Bapatla conditions.

Chapter I

INTRODUCTION

Green manuring is one of the most effective and environmentally sound method of sustaining soil productivity in agriculture. Since the start of green revolution, which was based on the use of chemical fertilizers, the role of green manures in maintaining soil fertility is overlooked. But in recent times the energy intensive inorganic farming is losing its ground in India in view of the unprecedented hike in the cost of chemical fertilizers. Added to this, green revolution agriculture has lead to depletion of soil fertility, ecological and environmental damage. At this juncture, growing of green manure crops, which is a cheap alternative to chemical fertilizers is an inevitable practice in the years to come for sustainable agriculture.

Of the various *in situ* green manuring crops, dhaincha [*Sesbania aculeata* (Wills.) Poir.] is the most important one. The ease of establishment, fast growth leading to accumulation of large quantity of biomass, rich in nutrients especially nitrogen in short periods, and quick decomposition upon incorporation in paddies (puddle rice lands) and can release nutrients as per the need of rice crop made dhaincha the most widely grown green manure crop. Further, it is promising for cultivation in salt affected ill drained soils and areas with high rainfall (Parlawar *et al.*, 2003). Despite this, farmers are averse to continue this practice of dhaincha green manuring owing to various constraints. Scarcity of seed is the main limiting factor for quick expansion of *Sesbania* green manuring.

Green manure crops are mostly grown for biomass production of green matter, which is incorporated prior to its flowering phase. For producing sufficient quantity of green manure biomass, the use of quality seed is of great significance. But the availability of adequate amount of good quality seed at reasonable price is the most significant agronomic constraint limiting green manure usage.

Of the various factors influencing seed production of dhaincha, optimum time of sowing is the most important aspect for obtaining higher yields, as it provides optimum growing conditions. As a short day plant, dhaincha yields higher biomass under longer days. It flowers early under short day conditions resulting in lesser vegetative growth and lower nitrogen fixation. Photosensitivity and narrow ecological adaptability greatly restrict the growing of leguminous green manure crops like dhaincha to a specific season and limited environmental conditions.

As the sunlight and plant density have got close relationship with the crop yield, the number of plants per unit area is one of the prime considerations to obtain higher seed yield of dhaincha. Row spacing is one of the important factors in achieving optimum level of plant density. Optimum plant population utilizes available moisture and nutrients from the soil more effectively and leads to better drymatter production and accumulation which can reflect in yield of crop.

Information on agro-techniques like optimum time of sowing and plant spacing for increased productivity of good quality seed of dhaincha are not available to the farmers. Keeping this in view, an experiment entitled “**Seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density**” was taken up at the Agricultural College Farm, Bapatla with the following objectives.

1. To find out the optimum time of sowing for seed crop of dhaincha.
2. To evaluate seed producing ability of dhaincha at different seeding densities.

Chapter II

REVIEW OF LITERATURE

A field experiment entitled “Seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density” was conducted during *kharif*, 2010 at the Agricultural College Farm, Bapatla. The influence of different sowing dates and planting densities on seed production potential of dhaincha was studied in this experiment.

Every care is taken in this chapter to present the review published on dhaincha. As the available literature on dhaincha seed production is meager, information on other related green manure crops was also reviewed under different sub heads in this chapter.

2.1. Effect of sowing time on growth and yield of dhaincha.

2.2. Effect of planting density on growth and yield of dhaincha.

2.3. Effects of sowing time and planting density on the productivity of dhaincha.

2.1 EFFECT OF SOWING TIME ON GROWTH AND YIELD OF DHAINCHA

2.1.1 Growth

2.1.1.1 Plant height

Sharma and Murthy (1988) reported that sowing of *Sesbania aculeata* (dhaincha) and *Sesbania rostrata* in June recorded the maximum plant height than that sown in December at Rajendranagar, Hyderabad.

On silty loam soils of Faizabad, sowing of cowpea on March 10 resulted in the maximum plant height of cowpea over early (February 18) and late (March 30) sowings (Rajput, 1994).

Jadhav *et al.* (1995) observed the reduction in plant height for every ten days delay in sowing of cowpea from June 1 to July 10 on clayey soils of Rahuri, Maharashtra.

Chittapur and Kulkarni (2003) observed that plant height of sunnhemp decreased when the sowing of sunnhemp delayed beyond August 21st at the College of Agriculture, Dharwad, Karnataka.

Kumar *et al.* (2005) reported that early sowing in June second fortnight recorded the maximum plant height of sunnhemp than delayed sowings up to August first fortnight on clayey soils of Dharwad, Karnataka. Similarly, Kurubetta *et al.* (2008) also reported the maximum plant height of cowpea, when sown in June second fortnight than delayed sowing up to July second fortnight on clayey soils of Dharwad.

Early sowing (June 10th) of cluster bean resulted in a significant increase in plant height over the delayed sowings (June 25th and July 10th) on loamy sand soils of Bathinda, Punjab (Buttar and Kaur, 2010).

2.1.1.2 Number of Branches

Dhaka *et al.* (1992) from Jobner (Rajasthan) observed a significant reduction in number of branches per plant of cowpea with every one week delay in sowing date from July 23 to August 13, whereas, Jadhav *et al.* (1995) from Rahuri observed that the differences in number of branches per plant of cowpea were not significant due to different sowing dates.

Taneja *et al.* (1995) reported higher number of branches per plant with early sowing of clusterbean (June 20th) over delayed sowings (July 10th and July 30th) at Hisar. Similarly, Kumar *et al.* (2006) observed reduction in number of branches per plant with delay in sowing of dhaincha beyond June 20 on sandy loam soils of Hisar, Haryana.

Buttar and Kaur (2010) observed no significant differences in number of branches per plant of clusterbean under different sowing dates on loamy sand soils of Punjab.

2.1.1.3 Drymatter Accumulation

Sharma and Murthy (1988) observed that *Sesbania aculeata* and *Sesbania rostrata* with June (wet season) planting date accumulated the maximum biomass over December (dry season) planting date at Rajendranagar, Hyderabad.

Kumar *et al.* (1991) reported that sowing of cowpea crop with the onset of monsoon gave significantly higher drymatter than that sown at 10, 20 and 30 days delay after the onset of monsoon at Hayatnagar (Hyderabad).

Hiremath and Patel (1996) reported that dhaincha sown on November 15 recorded the maximum biomass than November 30 sowing on clayey soils of Navsari, Gujarat.

From an experiment on monthly sowings of *Sesbania rostrata* from January to December at Coimbatore, Tamil Nadu, Rangasamy *et al.* (1997) revealed that summer sowing *i.e.*, from April to June produced significantly higher biomass than rest of the sowing dates. Similarly, Dekamedhi and Medhi (1999) recorded the maximum drymatter accumulation of *Sesbania rostrata* with May 15th sowing date compared with other dates.

On clay loam soils of Annamalainagar, Tamil Nadu, *Sesbania rostrata* recorded the highest drymatter accumulation during *kharif* season over *rabi* and summer seasons (Jayaram and Panneerselvam, 1999).

Rengalakshmi and Pursothaman (1999a) reported higher drymatter production of *Sesbania rostrata* with sowing during summer season than *kharif* season on deep clay loam soils of Coimbatore.

Kurubetta *et al.* (2008) reported significantly higher drymatter production of cowpea with early sowing dates (June second fortnight) than delayed dates of sowing (July first and second fortnights) on clayey soils of Dharwad.

2.2.1.4 Days to 50% Flowering and Maturity

Bridgit *et al.* (1993) from Pattambi, Kerala, observed no significant difference in number of days taken to attain 50% flowering of cowpea which was sown at different sowing dates.

Ullah *et al.* (1995) observed that the days taken to 50% flowering and maturity in cowpea increased with every 15 days delay in sowing from October 15 to January 30 on clay loam soils at Dhaka, Bangladesh.

Studies at Dharwad with sunnhemp by Tiparaddi *et al.* (2006) revealed that early sowing *i.e.*, July second fortnight with closer row spacing of 30cm recorded more number of days to 50% flowering over later dates of sowing.

Buttar and Kaur (2010) reported that clusterbean sown on June 10th took more number of days to attain maturity followed by June 25th and July 10th sowings dates at Punjab on loamy sand soils.

2.1.2 Yield Attributes and Yield

2.1.2.1 Yield Attributes

Dhaka *et al.* (1992) reported that the yield attributes of cowpea *viz.*, number of pods per plant, number of grains per pod, test weight etc. decreased linearly with delay in sowings of cowpea for every 7 day interval from July 23 to August 13 at Jobner, Rajasthan.

Weerakoon *et al.* (1992) worked on monthly sowing cycles of *Sesbania speciosa* and reported that sowings from April to August months produced the highest seed yield per plant in dry zone of Srilanka.

Deshpande *et al.* (2000) conducted a field experiment with sunnhemp at Parbhani and concluded that delayed sowings beyond 43rd meteorological week (October 26th) reduced the number of seed per plant and test weight of sunnhemp.

Ulemale *et al.* (2002) observed higher number of pods per plant, seeds per pod and seed yield per plant of sunnhemp with early sowing (June 15) than delayed sowings (June 30 and June 15) at Akola.

Chittapur and Kulkarni (2003) from College of Agriculture, Dharwad reported the maximum number of pods per plant and 1000 seed weight when sunnhemp was sown on August 21st and delay in sowing thereafter resulted in a significant reduction of the yield attributes.

From a field trial on clayey soil of Dharwad by Kumar *et al.* (2005) reported that the number of pods per plant and 1000 seed weight in sunnhemp sown in June second fortnight were superior to that of later dates of sowing up to August first fortnight.

From a field experiment at Hisar, Kumar *et al.* (2006) concluded that delayed sowing of dhaincha beyond the June 20th reduced the number of pods per plant and 1000 seed weight on sandy loam soils.

Tiparaddi *et al.* (2006) observed higher yield attributes of sunnhemp with August second fortnight sowing and delay in sowing date thereafter resulted in a significant reduction at Dharwad.

Kalyani and Reddy (2007) reported from a field experiment at S.V. Agricultural College, Tirupati, that sowing of clusterbean during first fortnight of July recorded the maximum number of clusters per plant and pods per cluster over delayed sowings on sandy loam soils.

Buttar and Kaur (2010) observed higher number of pods per plant and 100 seed weight of clusterbean with early sowing (June 10th) than delayed sowings (June 25th and July 10th) on loamy sand soils of Bathinda, Punjab.

2.1.2.2 Yield

A significant reduction in grain and stalk yields of cowpea was observed with every one week delay in sowing date from July 23 to August 13 at Jobner, Rajasthan (Dhaka *et al.*, 1992).

The results of an experiment conducted on sandy loam soils of Pattambi, Kerala with four dates of sowing (June 30, July 15, July 30 and August 15) revealed that the grain yield of cowpea reduced significantly when sowings were delayed beyond July 15 (Bridgit *et al.*, 1993).

Rajput (1994) observed that sowing of cowpea on March 10 recorded the highest grain yield, straw yield and harvest index over February 18 and March 30 sowings on silty loam soils of Faizabad.

Ekshinge *et al.* (1995) reported that sowing of sunnhemp beyond 41st meteorological week (October 12th) resulted in significant reduction in seed and stalk yields on clayey soils of Parbhani.

Jadhav *et al.* (1995) reported that the seed yield of cowpea decreased linearly with delay in sowings for every ten days interval from the June 1 to July 10 on clayey soils of Rahuri.

Taneja *et al.* (1995) observed that sowing of clusterbean on July 10th recorded the highest seed yield over early (June 20) and late (July 30) sowings at Hisar.

Ullah *et al.* (1995) observed that sowing of cowpea from October 15 to November 15 recorded the maximum seed yield and later decreased with delay in sowings up to January 30 at Dhaka, Bangladesh on clay loam soils.

Rengalakshmi and Pursothaman (1999a) reported that *Sesbania rostrata* sown during summer season reported higher seed yield than that of *kharif* sowing on clay loam soils of Coimbatore.

Sowing of sunnhemp on August 21st recorded significantly higher seed yield over early and later sowing dates at Dharwad (Chittapur and Kulkarni, 2003).

Kumar *et al.* (2005) from a field experiment at Dharwad reported the highest seed yield of sunnhemp sown on June second fortnight over delayed sowings on clayey soils.

From the results of an experiment conducted on sandy loam soils of Hisar with three dates of sowing (June 1, June 20 and July 10) Kumar *et al.* (2006) revealed that seed yield of dhaincha reduced significantly when sowings were delayed beyond June 20.

Clusterbean sown during the first fortnight of July recorded the highest seed and stalk yields over delayed sowings up to August second fortnight on sandy loam soils of S.V. Agricultural College, Tirupati (Kalyani and Reddy, 2007).

The pooled data of three years of experimentation conducted at Bathinda, Punjab by Buttar and Kaur (2010) indicated that clusterbean sown during June 10th recorded 11.3 and 20.6 per cent more seed yield over June 25th and July 10th sowings respectively, on loamy sand soils.

Tiparaddi *et al.* (2006) found that the seed yields of sunnhemp decreased significantly when it was sown beyond August second fortnight at University of Agricultural Sciences Farm, Dharwad.

2.2 EFFECT OF PLANTING DENSITY ON GROWTH AND YIELD OF DHAINCHA

2.2.1 Growth

2.2.1.1 Plant height

Thomas and Palaniappan (1998a) observed the maximum plant height of sunnhemp and pillipesara when planted at closer spacing of 30 cm × 20 cm

than sown at 45 cm × 20 cm or 60 cm × 20 cm on clay loam soils of Coimbatore. Similarly, increase in plant height of *Sesbania sps* was observed with decrease in spacing from 90 cm × 15 cm to 30 cm × 15 cm at Coimbatore on clay loam soils (Rengalakshmi and Pursothaman, 1999a).

In the same way Parlawar *et al.* (2004) reported a significant increase in plant height of dhaincha at closer row spacing of 30 cm over wider row spacings of 45 cm or 60 cm on clayey soils of Akola.

2.2.1.2 Number of Branches per Plant

Patil *et al.* (1991) reported that number of branches per plant of cowpea were significantly higher under wider spacing of 45 cm × 10 cm than 30 cm × 10 cm on clayey soils of Dharwad

Yaragoppa *et al.* (2003) recorded higher number of branches per plant of dhaincha with increase in intra row spacing from 25 cm to 75 cm on sandy loam soils of Raichur. Similarly, on clayey soils of Akola, Parlawar *et al.* (2004) observed the maximum number of branches per plant of dhaincha under wider spacing of 60 cm as compared to medium (45 cm) to closer (30 cm) row spacings.

From the results of an experiment conducted on sandy loam soils of Hisar with three spacings (30 cm, 45 cm and 60 cm), Kumar *et al.* (2006) also revealed that number of branches per plant of dhaincha increased significantly with increase in row spacing.

2.2.1.3 Drymatter Accumulation

Diekmann and De Datta (1990) reported a significant increase in biomass production of *Sesbania rostrata* with the planting density of 10.7 lakh plants ha⁻¹ over rest of the planting densities on clayey soils of Los Banos, Phillipines.

Padre and Ladha (1990) reported the maximum biomass of *Sesbania rostrata* with closer row spacing of 15 cm over wider row spacing of 30 cm at Manila, Philippines.

High population density (6.67 lakh plants ha⁻¹) of *Sesbania rostrata* resulted in the highest drymatter production, followed by medium (4.44 lakh plants ha⁻¹) and low densities (3.33 lakh plants ha⁻¹) on clay loam soils of Dharwad (Halepyati and Sheelavantar, 1991). Similar increase in drymatter production of *S.speciosa* with increased planting density was reported by Weerakoon *et al.* (1992) from Srilanka.

On clayey soils of Navsari, Gujarat, seeding of dhaincha @ 100 kg ha⁻¹ resulted in the maximum biomass compared to that of lower seeding rates of 75 kg ha⁻¹ or 50 kg ha⁻¹ during winter season (Hiremath and Patel, 1996).

Herrera *et al.* (1997) reported that biomass production of *Sesbania rostrata* increased with increase in seeding rate and the highest was recorded at 60 kg seed ha⁻¹ on sandy loam soils of Thailand.

Kavimani *et al.* (1997) reported the maximum drymatter production of dhaincha with plant geometry of 45 cm × 20 cm over 30 cm × 30 cm on sandy loam soils of Kumulur, Tamil Nadu.

Sesbania rostrata planted at 15 cm intra row spacing recorded higher biomass than the other intra row spacings (30 cm, 45 cm and 60 cm) on sandy clay loam soils of Tamil Nadu (Grace *et al.*, 1998).

Thomas and Palaniappan (1998a) recorded significantly higher biomass of sunnhemp under 30 cm × 20 cm spacing than 45 cm × 20 cm or 60 cm × 20 cm on clay loam soils of Coimbatore.

Rengalakshmi and Pursothaman (1999b) reported significant increase in drymatter production of sunnhemp at closer spacing (30 cm × 15 cm) over wider spacings of 60 cm × 15 cm and 90 cm × 15 cm at Coimbatore on clay loam soils.

In a field experiment conducted at Aduthurai, Tamil Nadu, Vendan and Rajeswari (1999) reported an increase in biomass production of *Sesbania* sps. with increase in seeding density and the highest biomass recorded was at 50 kg ha⁻¹.

The maximum biomass yield of dhaincha was obtained with the highest seeding density of 75 kg ha⁻¹ over medium (50 kg ha⁻¹) and lowest (25 kg ha⁻¹) seeding densities on clay loam soils of Agricultural College, Bapatla (Sasikala and Veeraraghavaiah, 2005).

Dhaincha at 100 cm × 75 cm spacing produced significantly higher drymatter accumulation per plant over 100 cm × 50 cm and 100 cm × 25 cm spacings on red sandy loam soils of Raichur, Karnataka (Yaragoppa *et al.*, 2003).

Parlawar *et al.* (2004) obtained significantly higher drymatter production per plant of dhaincha with lower seed rate of 15 kg ha⁻¹ at wider row spacing of 60 cm on clayey soils of Akola.

Reduction in biomass production of *Sesbania* sps. with increase in plant density from 10000 plants ha⁻¹ to 40000 plants ha⁻¹ was noticed by Desai and Halepyati (2007) on clay loam soils of Agricultural College Farm, Raichur.

2.2.1.4 Days to 50% Flowering and Maturity

Tiparaddi *et al.* (2006) reported that sunnhemp with seeding density of 10 kg ha⁻¹ took more number of days (48) to attain 50% flowering when compared to 15 kg ha⁻¹ (46 days) and 20 kg ha⁻¹ (45 days) at Dharwad.

2.2.2 Yield attributes and yield

2.2.2.1 Yield Attributes

Bhadoria and Kushwaha (1995) observed the highest number of pods per plant of clusterbean at 30 cm row spacing than 45 cm row spacing at Gwalior on sandy loam soils.

Results of an experiment on sunnhemp by Deshmukh *et al.* (1997) at Akola revealed that number of pods per plant and seed yield per plant increased significantly with increase in row spacing from 30 cm to 60 cm on clayey soils.

Kavimani *et al.* (1997) observed the highest number of pods per plant, 1000 seed weight of dhaincha at 45 cm × 20 cm spacing than at 30 cm × 30 cm spacing on sandy loam soils of Kumulur, Tamil Nadu.

Kumar *et al.* (1997) observed higher number of pods per plant and seed yield per plant of cowpea at 45 cm row spacing than 30 cm and 60 cm row spacings on loamy sand soils of Haryana.

Sunnhemp, pillipesara and velvet bean recorded the maximum number of pods per plant and seeds per pod under wider spacing (60 cm × 20 cm) than at closer row spacings (45 cm × 20 cm and 30 cm × 20 cm) during both *khariif* and *rabi* seasons on clay soils of Tamil Nadu (Thomas and Palaniappan, 1998b).

Rengalakshmi and Pursothaman (1999b) observed that the number of pods per plant and seeds per pod of sunnhemp at 90 cm × 15 cm spacing were higher than at 60 cm × 15 cm and 30 cm × 15 cm spacings at Coimbatore on clay loam soils.

Ulemale *et al.* (2002) from Akola reported that the number of pods per plant, seeds per pod and seed yield per plant increased significantly with increase in row spacing from 30 cm to 60 cm in sunnhemp.

Similarly Yaragoppa *et al.* (2003) reported that number of pods per plant, seeds per pod and 100 seed weight of dhaincha increased significantly with decrease in plant population from 40,000 plants ha⁻¹ to 13,333 plants ha⁻¹ on red sandy loam soils of Raichur.

2.2.2.2 Yield

Ekshinge *et al.* (1995) did not find any significant difference in seed yield of sunnhemp with different row spacings on clayey soils of Parbhani, Maharashtra.

Mahaldar *et al.* (1991) from their field trials conducted on clay loam soils of Dapoli, recorded significantly higher seed yield of cowpea at 30 cm × 15 cm spacing than at 40 cm × 15 cm or 20 cm × 15 cm.

Patil *et al.* (1991) observed higher cowpea yield at wider row spacing (45 cm × 10 cm) than at closer row spacing (30 cm × 10 cm) on clayey soils of Dharwad.

Results of the experiment conducted at Lakhaoti, Uttar Pradesh, revealed that the highest seeding rate of 30 kg ha⁻¹ recorded the maximum seed and stover yield of clusterbean over rest of the seeding densities on sandy loam soils (Baboo and Rana, 1995).

Bhadoria and Kushwaha (1995) recorded the maximum seed yield of clusterbean with 30 cm row spacing over 45 cm row spacing on sandy loam soils of Gwalior, Madhya Pradesh.

Deshmukh *et al.* (1997) observed higher seed and stalk yields of sunnhemp at closer row spacing (30 cm) than at wider row spacings (45 cm and 60 cm) on clay soils of Akola.

Planting geometry of 45 cm × 20 cm resulted in significantly higher seed yield of dhaincha over 30 cm × 30 cm at Kumulur, Tamil Nadu on sandy loam soils (Kavimani *et al.*, 1997).

Kumar *et al.* (1997) reported that the increase in the seed yield of cowpea at 45 cm row spacing was of the magnitude of 15.7 and 37.8 per cent over 30 cm and 60 cm spacings respectively on loamy sand soils of Haryana.

In contrast, Thomas and Palaniappan (1998b) reported the highest seed yield of sunnhemp, pillipesara and velvet bean at lower plant density (60 cm × 20 cm) than that at medium (45 cm × 20 cm) or high (30 cm × 20 cm) plant densities on clayey soils of Tamil Nadu. Similarly, seed yield of sunnhemp was the maximum with 90 cm × 15 cm row spacing over 60 cm × 15 cm or 30 cm × 15 cm spacing at Coimbatore on clay loam soils (Rengalakshmi and Pursothaman, 1999b).

The maximum seed yield of dhaincha was obtained with low seeding density of 25 kg ha⁻¹ over high seeding densities of 50 kg ha⁻¹ and 75 kg ha⁻¹ on clay loam soils of Agricultural College Farm, Bapatla (Sasikala, 2002).

Yaragoppa *et al.* (2003) reported that the seed yield of dhaincha increased with increase in plant density from 13333 plants ha⁻¹ to 40000 plants ha⁻¹ at Raichur, Karnataka on red sandy loam soils.

Lamani *et al.* (2004) observed that both 45 cm × 10 cm and 60 cm × 10 cm spacings were on a par with each other in increasing the seed yield of sunnhemp and found superior when compared to 30 cm × 10 cm spacing both in *kharif* and *rabi* seasons at Bailhongal, Karnataka on deep black soils.

Parlawar *et al.* (2005) observed higher seed yield of dhaincha at wider row spacing of 60 cm than at closer spacings of 45 cm and 30 cm on clayey soils of Akola.

Sastri (2005) reported significantly higher seed yield of sunnhemp with higher plant density (3.3 lakh plants ha⁻¹) than with lower plant densities (2.22, 1.67, 1.11 lakh plants ha⁻¹) at Raichur.

2.3 EFFECTS OF SOWING TIME AND PLANTING DENSITY ON THE PRODUCTIVITY OF DHAINCHA

From the field trials at Hisar, Sharma *et al.* (1984) reported higher seed yield of clusterbean with early sowing on July 5 at closer row spacing of 30 cm over delayed sowings.

Cowpea sown with the onset of monsoon gave higher grain and stover yields with 50% of optimum population than with optimum population and 150% of optimum population at Hayatnagar (Kumar *et al.*, 1991).

Pooled data of three years experimentation conducted at Gwalior indicated a significant increase in seed yield of clusterbean with July 10 sowing at closer row spacing of 30 cm than delayed sowings (July 25 and August 8) on sandy loam soils (Bhadoria and Chauhan, 1994).

Ekshinge *et al.* (1995) reported that sowing of sunnhemp from 37th (September 14th) to 41st (October 12th) meteorological week with wider row spacing (60 cm) resulted in significantly higher seed yield per plant than the rest of the sowing dates at Parbhani on clayey soils.

The maximum phytomass of dhaincha was obtained when it was sown early on November 15 with high seeding density of 100 kg ha⁻¹ over lower seeding densities on *vertisols* of Navsari, Gujarat (Hiremath and Patel, 1996).

Results of the experiment conducted by Rengalakshmi and Purshothaman (1999a) on deep clay loam soils of Tamil Nadu, indicated that growing of *Sesbania* sps. during summer with wider row spacing of 120 cm × 15 cm resulted in significantly higher seed yield over *kharif* season.

Deshpande *et al.* (2000) reported that the sunnhemp sown on the 43rd meteorological week (October 26th) with 45cm row spacing produced the highest seed yield at Maratwada Agricultural University Farm, Parbhani.

Ulemale *et al.* (2001) from the field trials with sunnhemp at Akola reported significantly higher seed and stalk yields with June 15th sowing at closer row spacing of 30 cm than delayed sowings.

Results of the experiment conducted by Kumar *et al.* (2006) with dhaincha revealed significantly higher seed and stalk yields with early sowings from June 1st to June 20th at wider row spacing of 60 cm on sandy loam soils of Hisar.

Sowing of sunnhemp during the second fortnight of August with closer row spacing of 30 cm recorded significantly higher seed yield and harvest index than rest of the sowing dates at the University of Agricultural Sciences, Dharwad (Tiparaddi *et al.*, 2006).

Chapter III

MATERIAL AND METHODS

A field experiment entitled "**Seed production of dhaincha (*Sesbania aculeata* (Wills.)Poir.] as influenced by sowing time and planting density**" was conducted during *kharif* 2010 at the Agricultural College Farm, Bapatla. The material used and methods adopted for the experimentation are presented in this chapter.

3.1 EXPERIMENTAL SITE

The experimental site is situated at an altitude of 5.49 m above mean sea level, 15^o54' North latitude, 80^o25' East longitude and about 8 km away from the Bay of Bengal.

3.2 WEATHER CONDITIONS

Weather data recorded during the crop period (01.07.2010 to 02.12.2010) are presented in Table 3.1 and depicted in Fig.3.1 and 3.2. The weekly mean maximum and minimum temperatures ranged from 31.2^oC to 36.5^oC and 21.4^oC to 27.4^oC, respectively, while the average maximum and minimum temperatures during the crop period were 32.3^oC and 24.6^oC, respectively. Similarly, the weekly mean relative humidity ranged from 70.4 per cent to 90.7 per cent with an average of 82.5 per cent. A total of 1402.8 mm rainfall was received during the crop growth period.

3.3 SOIL

Soil samples were collected at random from 0 to 30 cm depth from the experimental field and a composite sample was analysed for physical and chemical properties by following standard methods (Table 3.2). The analysis indicated that the experimental soil was clay loam in texture, slightly alkaline in reaction, low in organic carbon, low in available nitrogen and phosphorus and medium in available potassium.

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The cropping history of the experimental field for the two consecutive preceding years is given below.

Year	<i>kharif</i>	<i>rabi</i>
2007-08	Pigeonpea	Fallow
2008-09	Pigeonpea	Fallow
2009-10	Dhaincha (Present study)	

3.5 EXPERIMENTAL DETAILS

The experiment was laid out in a Randomised Block Design with factorial concept by allocating the 18 treatment combinations at random in each of the three replications. The field layout is depicted in Fig. 3.3.

Design	: RBD with factorial concept
Replications	: 3
Plot size	: 7.2 m × 3.0 m
Crop	: Dhaincha [<i>Sesbania aculeata</i> (Wills.) Poir.]
Treatments	: 18 (6 sowing dates × 3 planting densities)

Sowing dates: 6

S₁ : July 1st

S₂ : July 15th

S₃ : August 1st

S₄ : August 15th

S₅ : September 1st

S₆ : September 15th

Plant densities / Spacings :

D₁ : 30 cm × 15 cm (2,22,222 plants ha⁻¹)

D₂ : 45 cm × 15 cm (1,48,148 plants ha⁻¹)

D₃ : 60 cm × 15 cm (1,11,111 plants ha⁻¹)

3.6 CULTIVAR DESCRIPTION

Dhaincha (*Sesbania aculeata*) seed which was supplied by the Andhra Pradesh State Seeds Development Corporation (APSSDC) has been used in this experiment. In general, dhaincha comes up well in clayey soils and is highly resistant to drought as well as stagnation of water. It makes good growth in 3 to 5 months and produces 20-25 tonnes of green material and 600-1000 kg seed per hectare.

3.7 CULTIVATION DETAILS

3.7.1 Preparatory Cultivation

The experimental field was ploughed twice with tractor drawn cultivator followed by harrowing with offset disc harrow to get the required tilth and levelled. After thorough land levelling, the area was divided into the required number of plots as per the layout plan (Fig 3.3).

3.7.2 Fertilizers

Nitrogen and phosphorus was applied as per the recommendation @ 25 kg N, 50 kg P₂O₅ ha⁻¹ and 30 kg K₂O ha⁻¹ through diammonium phosphate (DAP), urea and muriate of potash(MOP) uniformly to all the plots. An entire quantity of fertilizer was applied along the seeding rows at the time of sowing.

3.7.3 Seeds and Sowing

Healthy and bold seeds were selected and hand dibbled to a depth of 2-3cm by adopting spacing as per the treatment.

3.7.4 Gap Filling

Gap filling was done at 5 days after sowing for each sowing date.

3.7.5 Thinning

Thinning was done at 15 days after sowing by removing excess plants by keeping one plant per hill in all the treatments in each date of sowing.

3.7.6 Weeding

Three hand weedings at fortnightly intervals were carried out starting from 15 DAS to keep the plots free from weeds.

3.7.7 Plant Protection

Minor incidence of tobacco caterpillar (*Maruca testucalis*) was observed. A spray application of Chloropyrifos @ 2.5 ml L⁻¹ and Dichlorovos @ 1ml L⁻¹ was given to control the problem.

3.7.8 Harvesting

The crop was harvested when more than 80% of pods of the randomly selected plants were matured. The border rows were harvested first and treated as bulk separately. The plants in the net plots were cut to the base and dried separately for one week. After drying, the crop plants were threshed by beating with sticks. The threshed out seed was cleaned and weight of the seed was recorded plot wise and expressed as kg ha⁻¹.

3.8 BIOMETRIC OBSERVATIONS

Five plants were selected from net plot and were labelled for continuous record of biometric observations *viz.*, plant height, number of branches and yield attributing characters *viz.*, number of pods, test weight, seed yield and stalk yield at different days. For drymatter production, plants from second row were removed at different days of crop growth period by cutting at ground level.

3.8.1 Plant height (cm)

The five labelled plants in the net plot were used for recording plant height from the base of the plant to the tip of the growing point at 50% flowering and at maturity. The mean value of five plants was computed and expressed as plant height in cm.

3.8.2 Number of Branches Plant⁻¹

The number of branches per plant were counted at 50% flowering and at maturity stages from the tagged plants and averaged and expressed as number of branches per plant.

3.8.3 Drymatter Accumulation

Each time five plants were uprooted from destructive sampling area of the plot (second row), washed to remove soil and were dried first in shade and then in a hot air oven at 60°C till a constant weight was obtained. Dry weight of the plants was taken and expressed in kg ha⁻¹. Samples were taken at 30, 60, 90 days after sowing and at harvest.

3.8.4 Days to 50 per cent Flowering

The day when 50 per cent of plants in every plot showed flowers was recorded and the number of days taken from sowing date to that date was counted and expressed as number of days to 50 per cent flowering.

3.8.5 Days to Maturity

The number of days taken till the plants turned yellow in each treatment was recorded as days to maturity.

3.8.6 Growing Degree Days

A degree day or a heat unit is the departure from the mean daily temperature above the threshold temperature of the crop. Growing Degree Day (GDD) concept assumes that there is a direct and linear relationship between growth of plants and temperature. For dhaincha the base temperature is taken as 10°C (Ritchie and Ne Smith, 1991). The GDD were calculated by the equation (Iwata, 1984).

$$\text{GDD} = \frac{[T_{\max} + T_{\min}]}{2} - T_b$$

Where, T_{\max} : Maximum temperature

T_{\min} : Minimum temperature

T_b : Base temperature

3.8.7 Number of Pods Plant⁻¹

The number of pods from five tagged plants were counted, averaged and expressed as number of pods plant⁻¹.

3.8.8 Test Weight (g)

1000 seeds were counted from a sample drawn at random from the net plot seed yield and its weight was recorded in grams.

3.8.9 Seed Yield (kg ha⁻¹)

Seed yield was obtained by taking the seed yield from net plot, sun dried thoroughly till a constant weight was recorded and expressed in kg ha⁻¹.

3.8.10 Stalk Yield (kg ha⁻¹)

The stalk yield obtained from each net plot was weighed and expressed in kg ha⁻¹.

3.8.11 Harvest Index (%)

Harvest index is the ratio of seed yield to the total biological yield (seed + stalk) and expressed in per cent. It was worked out by using the formula given by Donald and Humblin (1976).

$$\text{H.I (\%)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.9 ECONOMICS

For each treatment, returns per rupee investment was calculated by considering prevailing input cost and output prices. The prevailing labour, seeds and fertilizers were considered for calculation.

$$\text{Gross returns (Rs.)} = \text{Value of the product (Seed + Stalk)}$$

$$\text{Net returns (Rs.)} = \text{Gross returns (Rs.)} - \text{Total cost of cultivation (Rs.)}$$

$$\text{Returns per rupee investment} = \frac{\text{Net returns (Rs.)}}{\text{Total cost of cultivation (Rs.)}} \times 100$$

3.10 STATISTICAL ANALYSIS

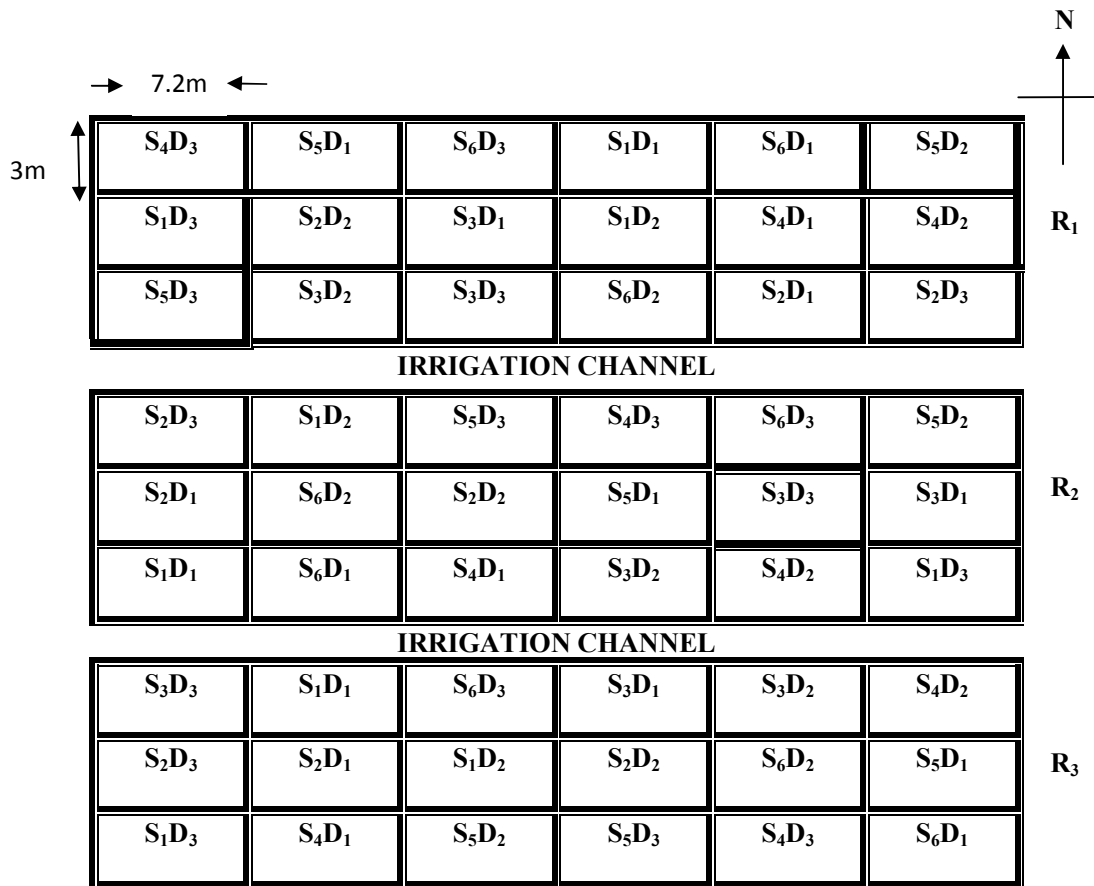
Experimental data was subjected to statistical analysis using analysis of variance procedures outlined for the design as per Panse and Sukhatme (1978). Critical differences were worked out at $p = 0.05$ level to test the significance of the treatment effects, wherever, 'F' test was significant.

Table 3.1: Weather data during the crop growth period (01-07-2010 to 02 -12- 2010)

Standard week	Date and month	Mean Temperature (⁰ C)		Mean RH (%)	Rainfall (mm)
		Maximum	Minimum		
26	25 June – 01July	36.5	27.4	70.4	11.1
27	02 July – 08July	31.6	25.0	82.0	68.5
28	09 July – 15 July	33.6	25.7	79.5	69.3
29	16 July – 22 July	32.4	24.9	83.0	168.6
30	23 July – 29July	31.7	24.9	84.7	41.4
31	30 July – 05 Aug	33.2	25.4	75.6	42.1
32	06 Aug – 12 Aug	34.6	25.0	78.3	25.9
33	13 Aug – 19 Aug	32.4	25.9	86.0	41.8
34	20 Aug -26 Aug	33.8	24.6	85.2	162.4
35	27 Aug – 02 Sept	32.4	24.9	78.3	89.6
36	03 Sept – 09 Sept	30.7	24.5	85.5	168.8
37	10 Sept – 16 Sept	33.3	24.6	86.1	141.4
38	17 Sept – 23 Sept	32.2	25.7	81.7	5.7
39	24 Sept – 30 Sept	33.1	25.8	81.4	34.2
40	01 Oct – 07 Oct	31.6	24.9	85.5	30
41	08 Oct – 14 Oct	34.3	22.3	74.5	33.6
42	15 Oct – 21 Oct	32.3	24.5	82.8	28.2
43	22 Oct – 28 Oct	32.3	24.3	83.2	59.8
44	29 Oct – 04 Nov	27.9	23.4	90.7	92.9
45	05 Nov – 11 Nov	30.5	23.5	86.2	40.8
46	12 Nov – 18 Nov	30.7	25.0	88.7	46.5
47	19 Nov – 25 Nov	31.4	23.1	82.7	0.2
48	26 Nov – 02 Dec	31.2	21.4	85.1	-
Total					1402.8
Mean		32.3	24.6	82.5	-

Table 3.2: Physical and chemical properties of the experimental soil

Sl.No.	Particulars	Value	Method of analysis
I. Mechanical analysis			
	Sand (%)	23.0	
	Silt (%)	35.0	Bouyoucos hydrometer method (Piper, 1966)
	Clay (%)	42.0	
	Textural class	clay loam	
II. Chemical analysis			
	Soil pH (1:2.5 soil water suspension)	7.80	Glass electrode method (Jackson, 1973)
	EC (dS m ⁻¹ at 25 ⁰ C)	0.20	Conductivity bridge (Jackson, 1973)
	Organic Carbon (%)	0.38	Walkley and Black's modified method (Walkley and Black, 1934)
	Available Nitrogen (kg ha ⁻¹)	210.9	Alkaline permanganate method (Subbiah and Asija, 1956)
	Available P ₂ O ₅ (kg ha ⁻¹)	7.0	Olsen's method (Olsen <i>et al.</i> , 1954)
	Available K ₂ O (kg ha ⁻¹)	160	Neutral normal ammonium acetate method (Jackson, 1973)



Design : RBD with factorial concept
 Plot size : 7.2 m × 3.0 m
 Season : *kharif*, 2010
 Replications : 3
 Treatments : 18 (6 Sowing dates × 3 Spacings)

Sowing dates: 6

S₁ : July 1st ss
 1)

S₂ : July 15th

S₃ : August 1st

S₄ : August 15th

S₅ : September 1st

S₆ : September 15th

Plant densities/ Spacings: 3

D1 : 30 cm × 15 cm (2,22,222 plants ha⁻¹)

D2 : 45 cm × 15 cm (1,48,148 plans ha⁻¹)

D3 : 60 cm × 15 cm (1,11,111 plants ha⁻¹)

Fig. 3.3: Field Layout Plan of the Experiment

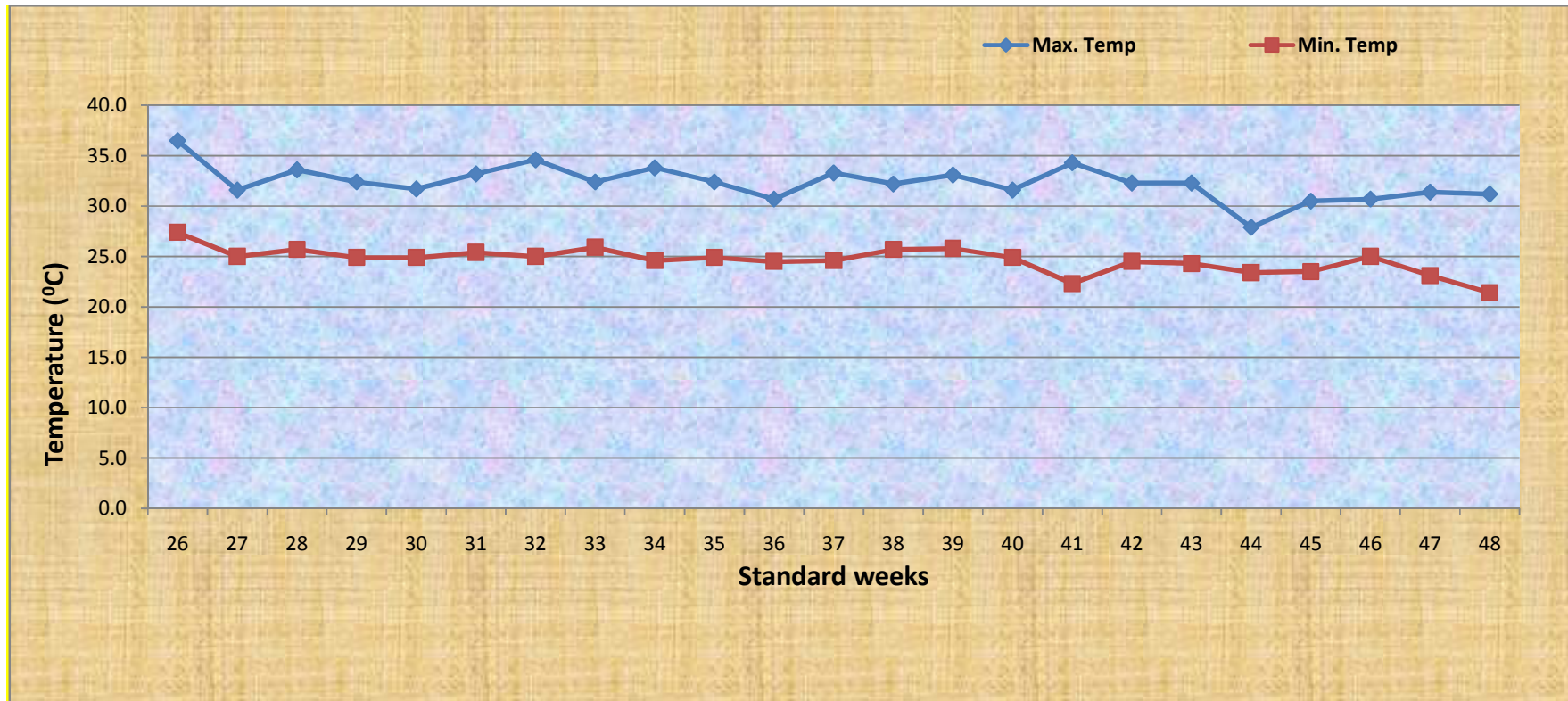


Fig. 3.1 Weekly mean maximum and minimum temperatures during the crop growth period (01-07-2010 to 02-12-2010)

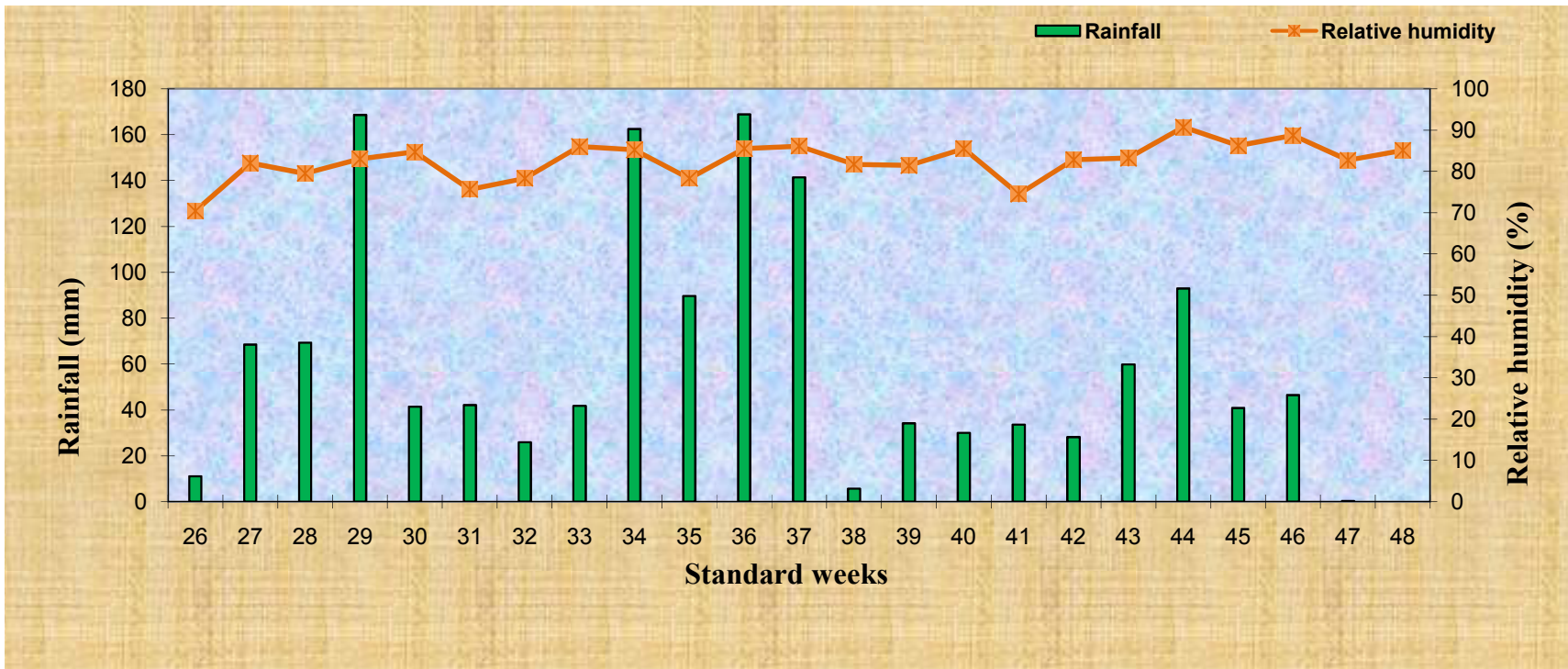


Fig. 3.2 Weekly mean relative humidity and rainfall during the crop growth period (01-07-2010 to 02-12-2010)

Chapter IV

RESULTS AND DISCUSSION

Results and discussion of the field experiment entitled “**Seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density**” conducted at the Agricultural College Farm, Bapatla are furnished in this chapter under different sub heads with statistical interpretation.

4.1 WEATHER PREVAILED DURING THE CROP GROWTH PERIOD

During the crop growth period, the mean maximum and mean minimum temperatures were 32.3⁰C and 24.6⁰C, respectively (Table 3.1 and Fig. 3.1 and 3.2). Mean relative humidity during the crop period ranged from 70.4 per cent to 90.7 per cent with an average of 82.5 per cent. A total of 1402.8 mm rainfall was received during the crop growth period. The crop was not subjected to water stress due to plenty of rainfall received during the crop period.

4.2 GROWTH PARAMETERS

4.2.1 Plant height (cm)

Data pertaining to plant height of dhaincha as influenced by dates of sowing and spacings at 50% flowering and maturity stages are presented in Table 4.1 and 4.2.

Plant height of dhaincha was significantly influenced by both dates of sowing and spacings but not by their interaction at 50% flowering and maturity stages. It was observed from the data that the plant height progressively decreased with delay in sowing from July 1 to September 15 at both the stages. Plant height at July 1 sowing was significantly superior to all other sowing dates at both the stages but, it was on a par with July 15 sowing at maturity. At 50% flowering stage, the plant height at August 1 sowing was on a par with that of July 15 sowing. Plant height of dhaincha with September 15 sowing was noticed inferior when compared to rest of the sowings dates at both 50% flowering and maturity stages.

Taller plants in early sowing might be due to optimum weather conditions during its entire crop growth period, which might have favoured rapid cell division and multiplication resulting in elongation of plants. Enhancement of growth characters with early sowing was also reported by Kumar *et al.* (2005) in sunnhemp, Kumar *et al.* (2006) in dhaincha and Buttar and Kaur (2010) in clusterbean.

Data presented in Table 4.1 and 4.2 revealed that the plant height of dhaincha decreased continuously with increase in inter row spacing from 30 cm to 60 cm at both 50% flowering and maturity stages. Closer spacing of 30 cm × 15 cm resulted in significantly the tallest plants over that recorded with 45 cm × 15 cm and 60 cm × 15 cm spacings. Mutual shading at higher plant densities might have increased the competition for sunlight in plant community leading to elongation of internodes and encouraged the plants to grow erect and taller to capture more solar radiation. These results are in consonance with the work done by Rengalakshmi and Purshothaman (1999a) and Parlawar *et al.* (2004) in dhaincha.

4.2.2 Number of Branches Per Plant

The number of branches per plant was influenced significantly due to dates of sowing and spacings both at 50% flowering and maturity stages but the interaction between them was not significant (Table 4.3 and 4.4).

Data revealed that the number of branches per plant decreased significantly with delay in sowing from July 1 to September 15. The maximum number of branches per plant was recorded with July 1 sowing and was on a par with July 15 sowing at 50% flowering and maturity stages, whereas, the lowest number of branches per plant was observed with September 15 sowing both at 50% flowering and maturity stages. The maximum number of branches per plant with early sowing might be due to the fact that the crop experienced longer period of vegetative stage coupled with favourable weather conditions like optimum temperature, light etc. during crop growing period. Increased number of branches per plant with early sowing was also reported by Kumar *et al.* (2006) in dhaincha.

Number of branches per plant was also influenced significantly by plant spacings. A significant increase in number of branches per plant was resulted due to 60 cm × 15 cm spacing over 45 cm × 15 cm and 30 cm × 15 cm spacings. The lowest number of branches per plant was recorded with 30 cm × 15 cm spacing at 50% flowering and maturity stages.

In general, branching is influenced by interplant competition. Less interplant competition and ample availability of light, moisture and nutrients might have resulted in more number of branches per plant at wider spacings. These results are in accordance with the results reported by Thomas and Palaniappan (1998b) and Parlawar *et al.* (2004) in dhaincha.

4.2.3 Drymatter Accumulation

Data pertaining to drymatter accumulation of dhaincha at 30, 60, 90 DAS and at harvest as influenced by the effect of dates of sowing and spacings are presented in Table 4.5, 4.6, 4.7 and 4.8 and graphically depicted in Fig.4.1. Drymatter accumulation with 30 cm × 15 cm spacing at each sowing date was significantly higher over that produced with 45 cm × 15 cm and 60 cm × 15 cm spacings. However, drymatter accumulation recorded at July 1 sowing at 30 cm × 15 cm spacing was significantly higher over all other treatment combinations at all the stages of crop growth.

At 30 DAS, the drymatter accumulated with July 1 sowing at 30 cm × 15 cm spacing was comparable with 45 cm × 15 cm spacing at same sowing date and July 15 sowing at 30 cm × 15 cm spacing. No significant differences were observed between July 1 and July 15, August 1 and August 15 dates of sowings at 60 cm × 15 cm spacing. Similar drymatter accumulation was recorded when dhaincha sown on July 15 at 45 cm × 15 cm and 60 cm × 15 cm spacings. Delayed sowings (September 1 and September 15) produced significantly lowest drymatter and the differences in drymatter accumulation due to sowing dates and spacings were not significant.

At 60 DAS, the drymatter accumulation with July 15 sowing at 30 cm × 15 cm spacing was comparable to that of drymatter accumulation of July 1 sowing at 45 cm × 15 cm spacing. Drymatter accumulation of August 1 sowing was on a par with August 15 sowing at 30 cm × 15 cm spacing. Similarly, July 15 and August 1 sowings were also at par with 60 cm × 15 cm spacing. Both 45 cm × 15 cm and 60 cm × 15 cm spacings did not differ significantly at August 1 sowing. Similarly, August 15 and September 1 sowings also not differed with respect of drymatter accumulation at 45 cm × 15 cm spacing. The lowest drymatter accumulation was recorded with September 15 sowing and the differences in drymatter accumulation due to spacings at this date were not significant.

At 90 DAS, the drymatter recorded with the July 15 sowing was comparable with that of July 1 sowing at 30 cm × 15 cm spacing. No significant difference was observed between 30 cm × 15 cm and 45 cm × 15 cm spacings with respect to August 1 sowing. Similarly, drymatter accumulated at September 1 sowing at 30 cm × 15 cm spacing was at par with that of August 15 sowing at 45 cm × 15 cm and 60 cm × 15 cm spacings. The lowest drymatter accumulation of dhaincha was observed with September 1 sowing at 60 cm × 15 cm spacing.

At harvest, dhaincha sown on July 15 with 30 cm × 15 cm spacing produced similar drymatter as that of July 1 sowing at 45 cm × 15 cm spacing. Similarly, drymatter accumulated with August 1 sowing at 30 cm × 15 cm spacing was on a par with that of July 15 sowing at 60 cm × 15 cm spacing. Drymatter accumulation due to August 15 sowing, with 45 cm × 15 cm and 60 cm × 15 cm spacings was almost similar and it was on a par with that of September 1 sowing at 30 cm × 15 cm spacing. The lowest drymatter accumulation was recorded with September 1 sowing at all the three spacings.

A significant decrease in drymatter accumulation was observed due to delayed sowings at all the stages of crop growth. This might be due to the decreased Growing Degree Days (GDDs) experienced by late sown crop when

compared to early sowings (Fig.4.2). Longer the day length during vegetative phase, greater is the drymatter accumulation. In addition, more plant height and increased number of branches produced due to early sowing might have also contributed to higher drymatter accumulation. Similar results of obtaining the maximum drymatter accumulation with early sowing was also reported by Hiremath and Patel (1996) in dhaincha, Thomas and Palaniappan (1998a), Kumar *et al.* (2005) in sunnhemp and Kurubetta *et al.* (2008) in cowpea.

Increase in row spacing resulted in decrease in drymatter accumulation. Drymatter accumulation with 30 cm × 15 cm spacing was significantly higher than that produced with 45 cm × 15 cm and 60 cm × 15 cm spacings at all the dates of sowing. Higher drymatter accumulation with closer spacing might be due to maximum number of plants per unit area, enhanced plant height and subsequent increase in photosynthetic source. Similar findings were reported earlier by Halepyati and Sheelavantar (1991), Thomas and Palaniappan (1998a) and Rengalakshmi and Purshothaman (1999a).

4.2.4 Days to 50% Flowering and Maturity

Number of days taken to attain 50% flowering and maturity of dhaincha as influenced by dates of sowing and spacings are presented in Table 4.10 and 4.11 and graphically depicted in Fig.4.3 and 4.4.

Perusal of the data revealed that the number of days taken to 50% flowering and maturity decreased significantly with each 15 days delay in sowing from July 1 to September 15. Sowing on 1st July took significantly more number of days to attain 50% flowering (53) and maturity (115) over other sowing dates. The crop sown on 15th September took only 27 and 76 days to attain 50% flowering and maturity stages respectively; however, the number of days taken to maturity not differed significantly between August 1 and August 15 sowing dates.

The prolonged vegetative stage in early sowings might be the reason for delay in 50% flowering and maturity. Whereas, prevailing low temperatures and short day conditions at the early stages of the late sown crop could be the reason for advancement in flowering and maturity of late sown crop when compared to early sowings. Kumar *et al.* (2005) also reported similar results in sunnhemp. A gradual reduction in the duration of clusterbean with delayed sowing was also reported by Buttar and Kaur (2010).

Days taken to 50% flowering and maturity were also significantly influenced due to different row spacings. Crop sown at closer spacing (30 cm × 15 cm) reached the stage of 50% flowering and maturity earlier, followed by 45 cm × 15 cm and 60 cm × 15 cm spacings. There was no significant difference between 30 cm × 15 cm and 45 cm × 15 cm spacings in terms of days taken to maturity. Abiotic stress created due to high plant density in closer spacing might have resulted in early transformation of vegetative phase into reproductive phase. Similar results were also reported by Tiparaddi *et al.* (2006) in sunnhemp.

4.3 YIELD ATTRIBUTES AND YIELD

4.3.1 Number of Pods Per Plant

Data pertaining to number of pods per plant was significantly influenced by dates of sowing, plant densities and their interaction (Table 4.12 and Fig.4.5).

Dhaincha sown early (July 1 and July 15) recorded with the maximum number of pods per plant when compared to later sowings at all the three spacings. No significant difference between August 15 and September 1 sowings in increasing the number of pods per plant at 30 cm × 15 cm spacing and also at 45 cm × 15 cm spacings. Number of pods per plant recorded with August 15 sowing at 60 cm × 15 cm spacing was on a par with that of August 1 sowing at 30 cm × 15 cm and 45 cm × 15 cm spacings. At delayed sowings *i.e.*, on September 1 and September 15, the differences in number of pods per plant due to the spacings were not significant.

Higher number of pods per plant in the early sowings might have been due to adequate and increased availability of photosynthates and better seed filling with maintenance of better source - sink relationship. Similar increase in number of pods per plant with early sowing was also reported by Bhadoria and Chauhan (1994) in clusterbean, Kumar *et al.* (2005) in sunnhemp and Kumar *et al.* (2006) in dhaincha.

Dhaincha sown at wider spacing of 60 cm × 15 cm produced significantly higher number of pods per plant at each date of sowing when compared to other two spacings (45 cm × 15 cm and 30 cm × 15 cm). Less inter plant competition in wider spacing and ample availability of light, moisture and nutrients might have resulted in more number of branches per plant, which in turn, increased the number of pods per plant. These results were in conformation with the results reported by Deshmukh *et al.* (1997) in sunnhemp and Thomas and Palaniappan (1998b).

4.3.2 Test Weight (g)

Test weight of dhaincha was significantly influenced by dates of sowing and spacings but not by their interaction (Table 4.13 and Fig 4.6).

Seed weight decreased significantly with every 15 days delay in sowing. Test weight of dhaincha was significantly highest with the July 1 sowing and it was at par with that of July 15 and August 1 sowing dates. Similarly, August 1 sowing was on a par with August 15 sowing in increasing the test weight of dhaincha. The lowest test weight was observed with September 15 sowing. More test weight under early sowings might be due to the enhanced translocation of food reserves leading to better seed filling and bold grains. The results obtained were in accordance with those of Dhaka *et al.* (1992), Jadhav *et al.* (1995) in cowpea, Bhadoria and Chauhan (1994) in clusterbean and Kumar *et al.* (2006) in dhaincha.

A significant increase in test weight was with 60 cm × 15 cm row spacing, and it was on a par with that of 45 cm × 15 cm row spacing. Similarly, no significant difference was observed between 45 cm × 15 cm and 30 cm × 15 cm spacing in respect of test weight. At higher plant densities inter - plant competition for light, space and nutrients were more and thereby affecting the translocation of assimilates for efficient filling of grains. These results are in conformity with those reported by Deshmukh *et al.* (1997) in sunnhemp, Rengalakshmi and Purshothaman (1999a), Yaragoppa *et al.* (2003), Parlawar *et al.* (2004) in dhaincha.

4.3.3 Seed Yield (kg ha⁻¹)

The data pertaining to seed yield of dhaincha as influenced by dates of sowing and spacings and their interaction effect are presented in Table 4.14 and depicted in Fig 4.7.

The seed yield significantly decreased with delay in sowing with all the three spacings studied. Dhaincha sown on July 1 with 30 cm × 15 cm spacing produced significantly the highest seed yield (1031 kg ha⁻¹), however, it was comparable with that of 45 cm × 15 cm spacing (951 kg ha⁻¹) at the same date of sowing and also at 30 cm × 15 cm spacing (926 kg ha⁻¹) with July 15 sowing.

The differences in seed yield due to sowing from August 1 to September 1 either with 45 cm × 15 cm spacing or 60 cm × 15 cm spacing were not significant. However, wider spacings (60 cm × 15 cm and 45 cm × 15 cm) at August 15 sowing produced similar seed yield as that of September 1 sowing with closer spacing of 30 cm × 15 cm. The lowest seed yield was obtained with September 15 sowing and it did not differ significantly between the three spacings (60 cm × 15 cm, 45 cm × 15 cm and 30 cm × 15 cm). A significant increase in seed yield of early sowing over delayed sowings might be due to more congenial conditions like adequate amount of rainfall during the entire crop growth period and partitioning of higher proportions of its total

drymatter into reproductive parts of the plant. Added to the above, better growth and development of early sown crop when compared to later dates of sowing in all aspects might have reflected in better yield expression. Ulemale *et al.* (2001) in sunnhemp, Kalyani and Reddy (2007) and Buttar and Kaur (2010) in clusterbean reported similar results of increased seed yield with early sowings.

The yield reduction with delayed sowings might be due to its shortened duration and perceptible reduction of growth and yield attributes recorded at all the stages of crop growth. Besides, the reduction in yield with delayed sowings can also be attributed to low temperature and lower accumulation of Growing Degree Days (GDD).

Seed yield of dhaincha at 30 cm × 15 cm spacing with each sowing date was significantly higher than that produced with 45 cm × 15 cm and 30 cm × 15 cm spacings. Though all the yield attributing characters were higher at wider spacings, the higher number is not sufficient to compensate the yield that obtained due to higher plant population per unit area from closer spacing. Similar increase in seed yield at closer spacing was also reported by Deshmukh *et al.* (1997) and Sastri (2005) in sunnhemp and Yaragoppa *et al.* (2003) in dhaincha.

4.3.4 Stalk Yield (kg ha⁻¹)

The data pertaining to stalk yield of dhaincha as influenced by interaction of dates of sowing and spacings are presented in Table 4.15.

The highest stalk yield of dhaincha was recorded with July 1 sowing at 30 cm × 15 cm spacing compared to the rest of the treatment combinations. Similar increase in stalk yield was observed with 30 cm × 15 cm spacing at all the sowing dates over other two spacings. However, the stalk yield recorded with July 1 sowing was comparable with that of July 15 sowing at 30 cm × 15 cm spacing and also with 45 cm × 15 cm spacing at July 1 sowing.

There were no significant differences in stalk yields of July 1 and July 15 sowings at 60 cm × 15 cm spacing. Stalk yields recorded with 45 cm × 15 cm and 60 cm × 15 cm spacings did not differ significantly both at August 1 and September 1 sowings. Sowing on July 15 with wider spacing (60 cm × 15 cm) produced similar stalk yield as that of August 1 sowing at 30 cm × 15 cm spacing.

Dhaincha sown on September 15 sowing produced similar stalk yield both at 30 cm × 15 cm and 45 cm × 15 cm spacings, but, the stalk yield recorded with 60 cm × 15 cm spacing was significantly the lowest compared to all other treatment combinations.

Better performance of early sown crop can be attributed to prevailing high temperature and accumulation of maximum Growing Degree Days(GDD) when compared to later sowings resulting in increased biomass production. The maximum stalk yield under early sown crop was also reported by Rajput (1994), Dhaka *et al.* (1992) and Kurubetta *et al.* (2008) in cowpea, Ulemale *et al.*(2001) in sunnhemp, Kalyani and Reddy (2007) in clusterbean.

A progressive decrease in the stalk yield from closer spacing to wider spacing is mainly attributed to the higher plant number coupled with enhanced plant height obtained at closer spacing. Though the individual plant weight was higher at wider spacing, it could not compensate to the loss in stalk yield caused due to the less number of plants per unit area. The reduction in stalk yield with increase in spacing or decrease in plant density was in agreement with the results reported by Yaragoppa *et al.* (2003) in dhaincha, Deshmukh *et al.* (1997) and Ulemale *et al.*(2001) in sunnhemp, Janmeja Sharma(1991), Kumar *et al.* (1996), Sheoran and Rana (2007) and Kurubetta *et al.* (2008) in cowpea.

4.3.5 Harvest Index(%)

Data on harvest index, a measure of ability of crop to translocate photosynthates from production sites to sink as influenced by sowing dates was recorded and presented in Table 4.16 and graphically depicted in Fig.4.8.

The harvest index of dhaincha was significantly the highest with July 1 sowing which was on a par with that of July 15 sowing. Similarly, there was no significant difference between harvest index recorded at July 15 and August 1 sowings and also August 1 and August 15 sowings, whereas, harvest index of September 15 sown crop was significantly the lowest and it was on a par with September 1 sown crop. Higher yield attributes at early sowing might have contributed to higher harvest index, as it produced more grain yield due to efficient partitioning of drymatter produced. These results are in accordance with those reported by Ulemale *et al.* (2001) in sunnhemp, Janmejai Sharma (1991) and Kurubetta *et al.* (2008) in cowpea.

Row spacing and the interaction of dates of sowing and row spacing failed to affect the harvest index.

4.3.6 Economics

The data (Table 4.17) on economics of dhaincha revealed that gross returns, net returns and returns per rupee investment are influenced due to sowing dates and spacings.

Data revealed that dhaincha sown on July 1 and July 15 at all the three spacings recorded the maximum gross income, net income and returns per rupee investment over the rest of the sowing dates, however, the July 1 sowing at 30 cm × 15 cm spacing recorded significantly the highest gross returns (Rs. 50,891 ha⁻¹), net returns (Rs.33,668 ha⁻¹) and returns per rupee investment (1.95). The maximum seed yield recorded with early sowings might have resulted in more net income and returns per rupee investment. Negative net returns and returns per rupee investment with delayed sowings might be due to

the higher cost of cultivation than the gross returns obtained. Kumar *et al.* (2005) reported the maximum gross returns, net returns and returns per rupee investment with early sowing in sunnhemp. Similar results of maximum net income and returns per rupee investment with early sowing were also reported by Kumar *et al.* (2006) in dhaincha and Kurubetta *et al.* (2008) in cowpea.

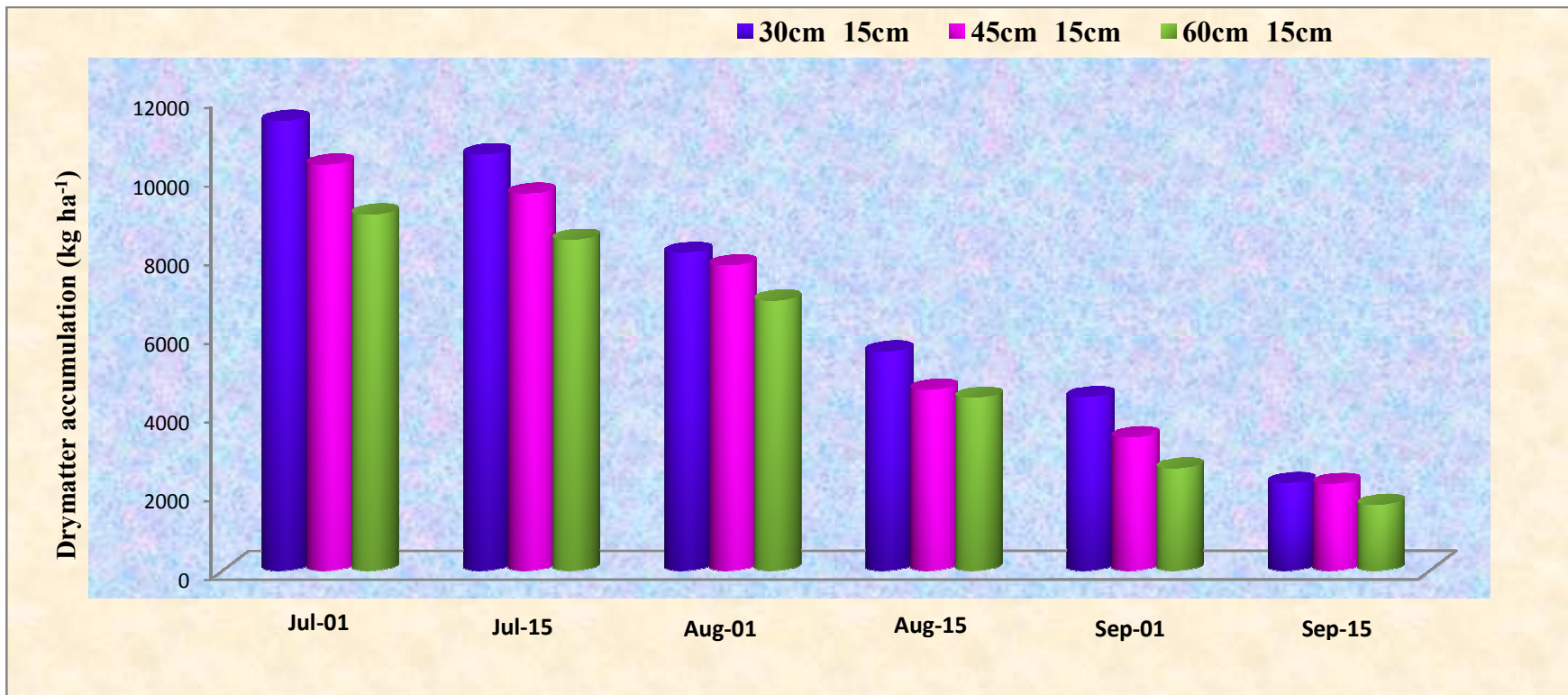


Fig.4.1 Drymatter accumulation(kg ha⁻¹) of dhaincha at harvest as influenced by date of sowing and spacing

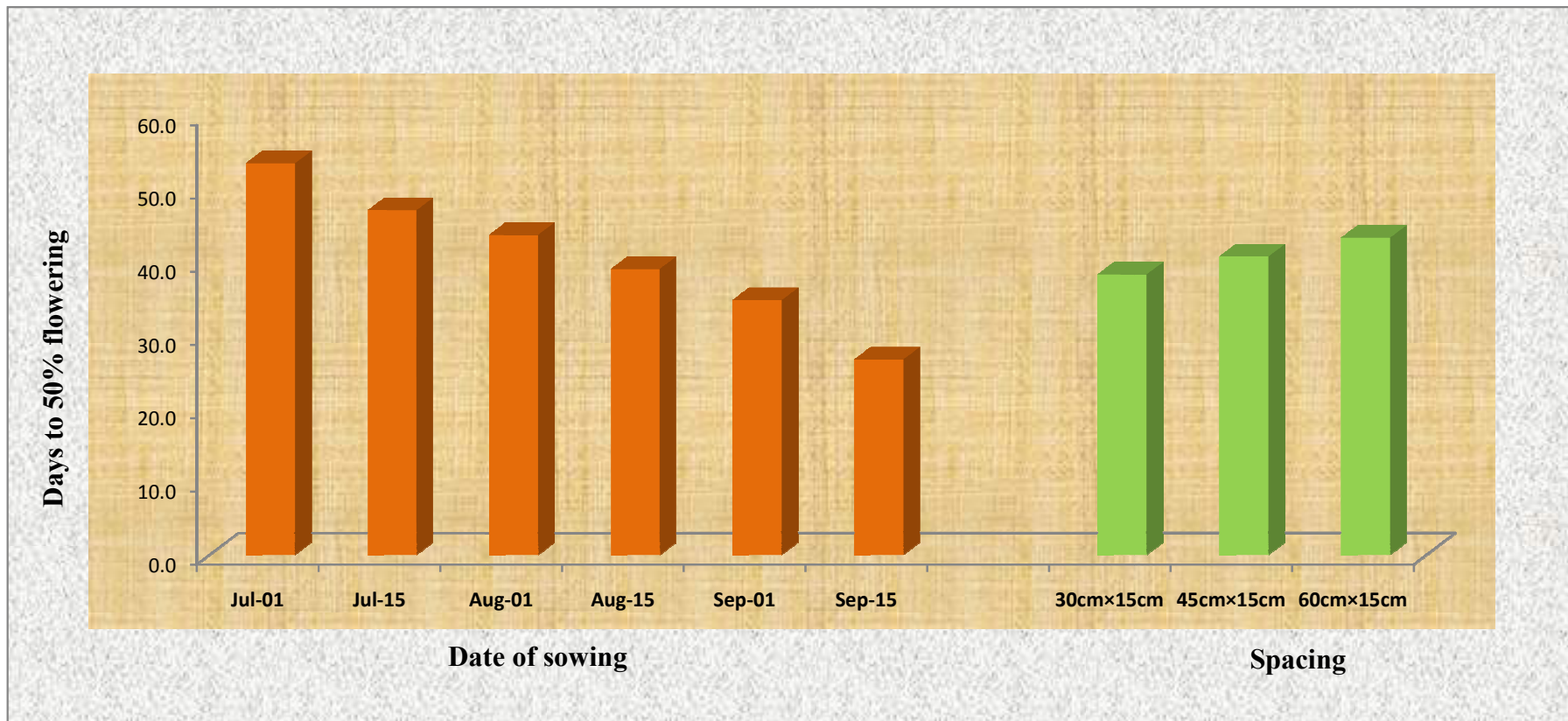


Fig.4.3 Days to 50% flowering of dhaincha as influenced by date of sowing and spacing

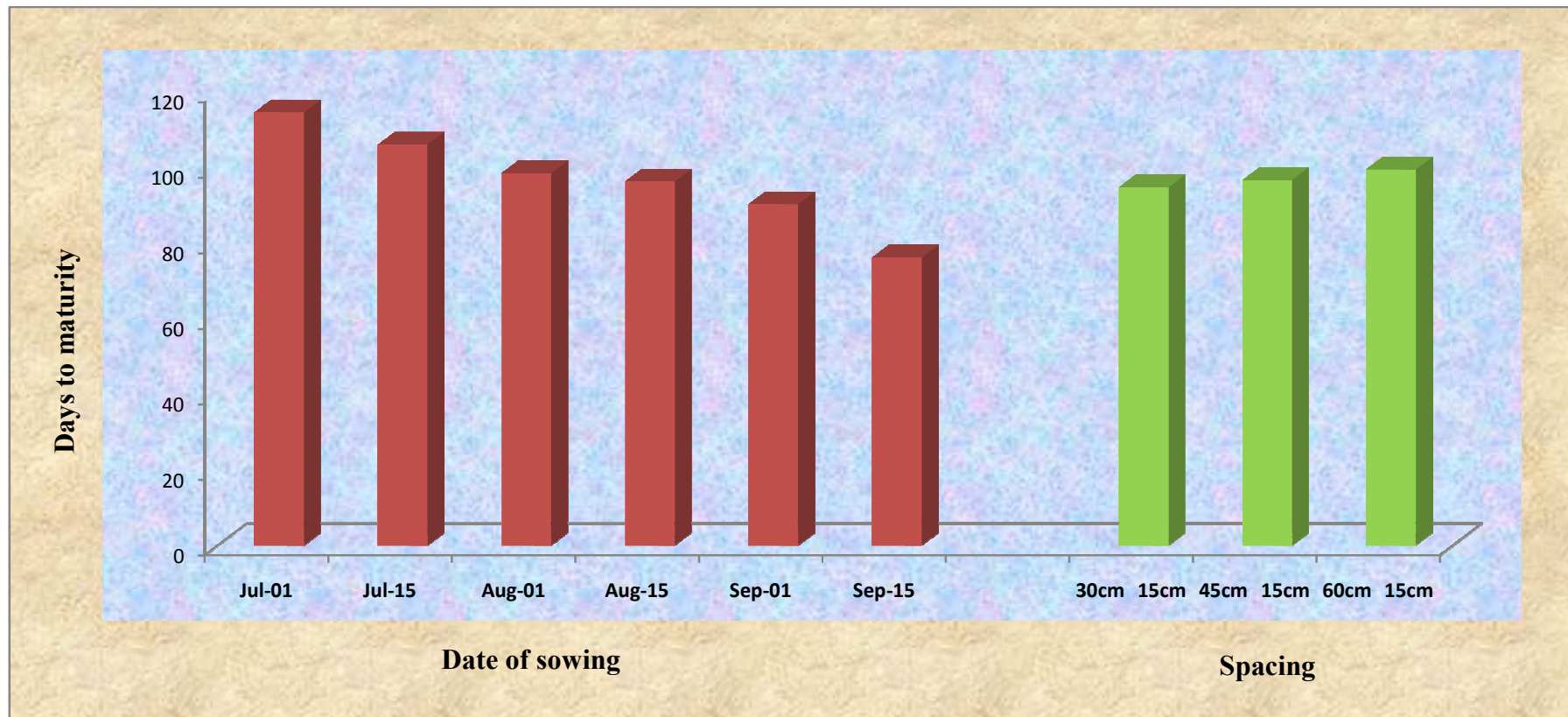


Fig.4.4 Days to maturity of dhaincha as influenced by date of sowing and spacing

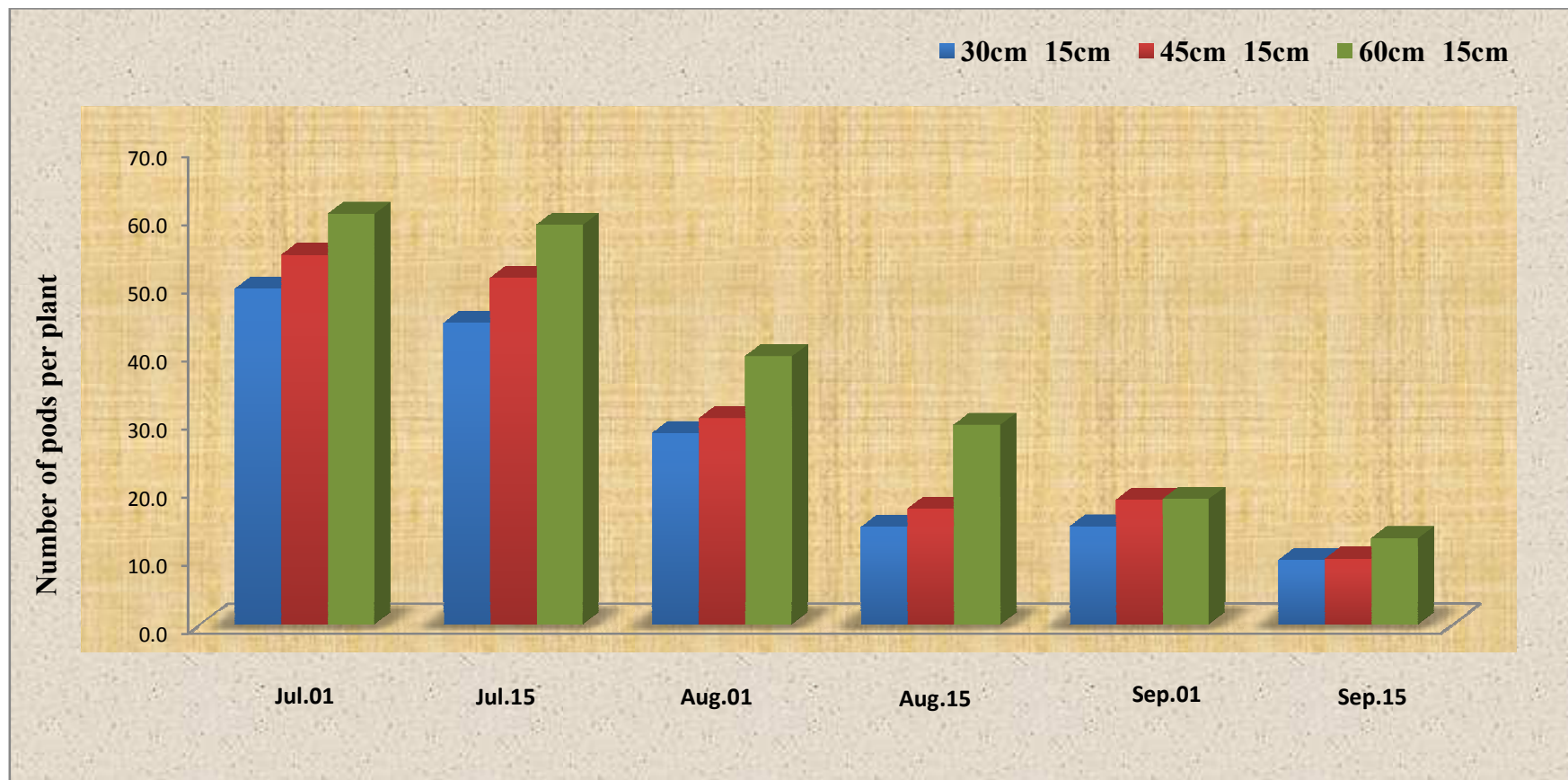


Fig. 4.5 Number of pods per plant of dhaincha as influenced by date of sowing and spacing

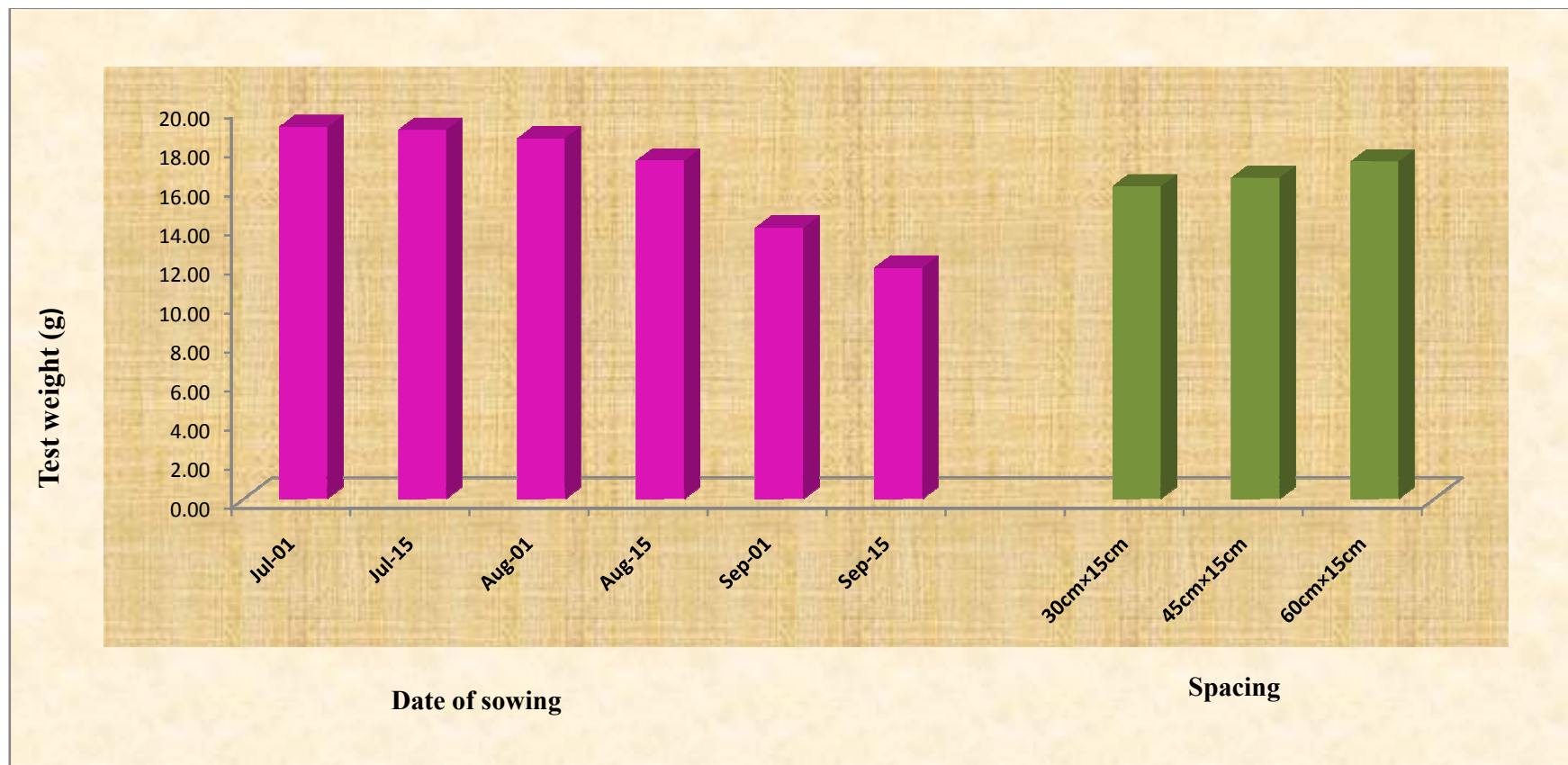


Fig.4.6 Test weight (g) of dhaincha as influenced by date of sowing and spacing

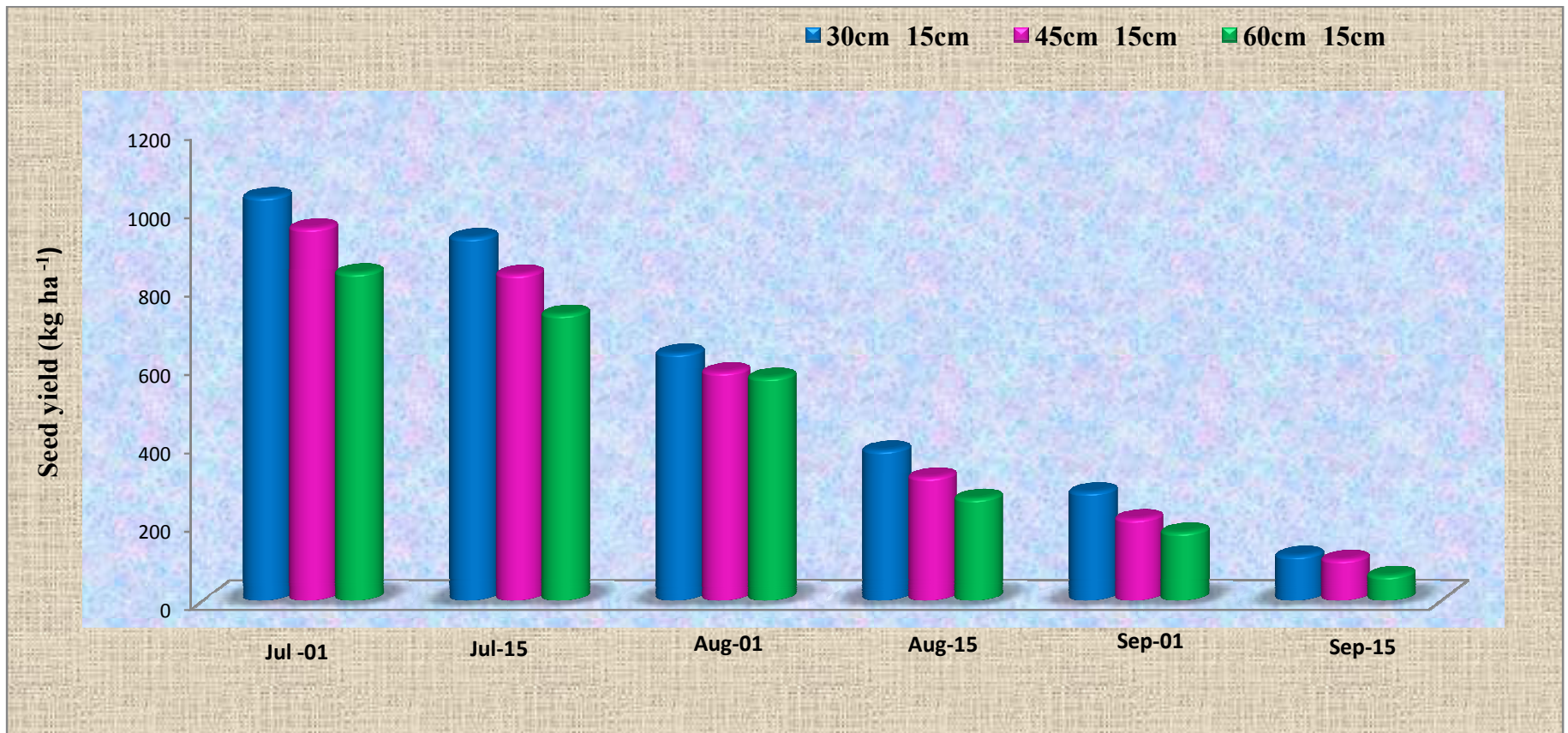


Fig.4.7 Seed yield (kg ha⁻¹) of dhaincha as influenced by date of sowing and spacing



Fig.4.8 Harvest index (%) of dhaincha as influenced by date of sowing

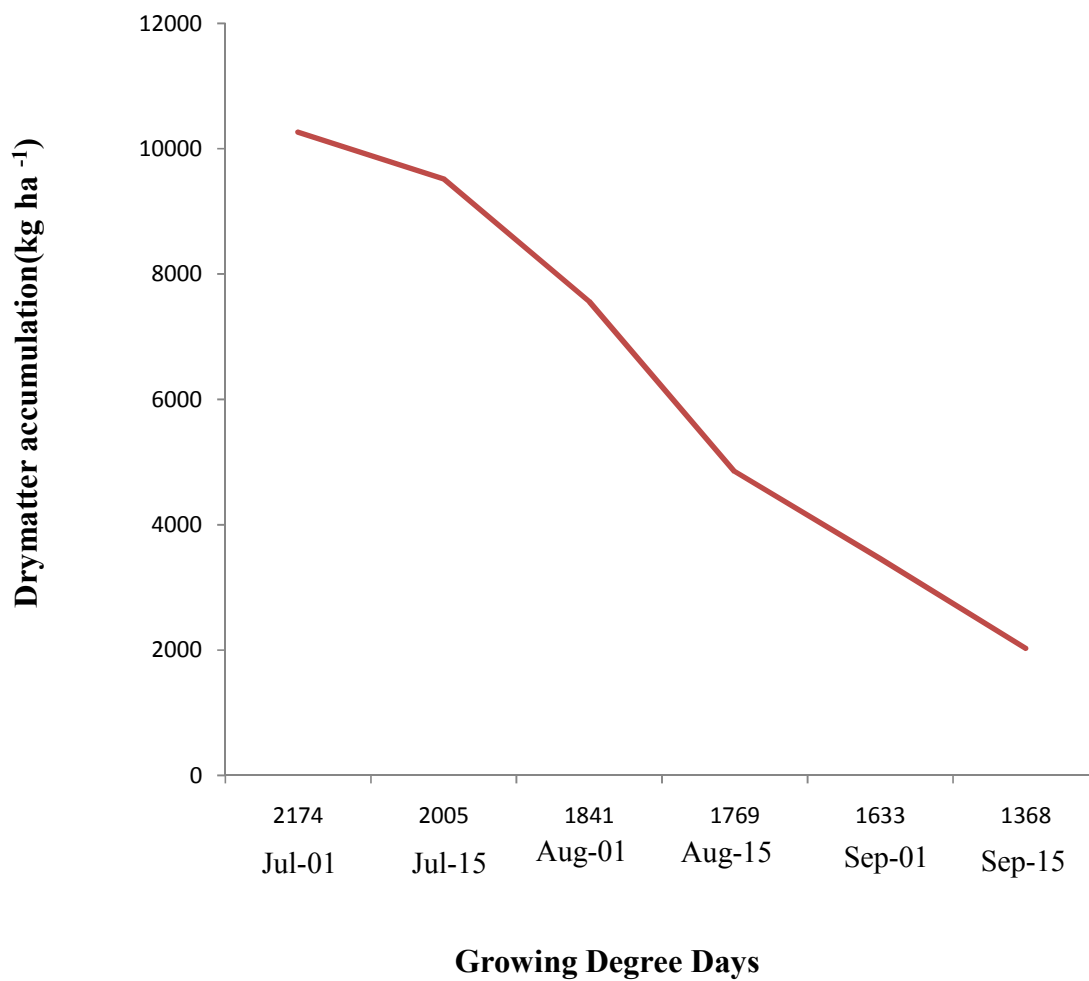


Fig.4.3 Relationship between drymatter accumulation of dhaincha and growing degree days(GDD) during different sowing dates

Table 4.1. Plant height (cm) of dhaincha at 50% flowering as influenced by date of sowing and spacing

Row spacing (D)	Plant height(cm)						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm ×15 cm	225	186	185	147	95	61	150
45 cm ×15 cm	217	183	176	132	87	55	142
60 cm ×15 cm	202	181	171	110	81	51	133
Mean	215	183	177	130	88	56	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		2	7	5.1			
Row spacing (D)		2	5				
S × D		4	NS				

NS: Non significant

Table 4.2. Plant height (cm) of dhaincha at maturity as influenced by date of sowing and spacing

Row spacing (D)	Plant height (cm)						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm × 15 cm	361	340	281	217	180	150	255
45 cm × 15 cm	334	336	268	214	177	138	245
60 cm × 15 cm	328	328	244	202	173	134	235
Mean	341	335	264	211	177	141	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		4	12	5.0			
Row spacing (D)		3	8				
S × D		7	NS				

Table 4. 3. Number of branches per plant of dhaincha at 50% flowering as influenced by date of sowing and spacing

Row spacing (D)	Number of branches plant ⁻¹						
	Date of sowing (S)						Mean
	July 1	July 15	August 1	August 15	September 1	September 15	
30 cm ×15 cm	11.7	11.4	8.5	6.1	4.1	1.5	7.2
45 cm ×15 cm	13.1	13.9	9.9	7.3	4.7	2.8	8.6
60 cm ×15 cm	16.3	15.0	11.2	8.7	6.7	3.1	10.2
Mean	13.7	13.4	9.9	7.4	5.2	2.5	
		SEm±	CD (P=0.05)	CV%			
Date of sowing (S)		0.4	1.1	13.7			
Row spacing (D)		0.3	0.8				
S × D		0.7	NS				

Table 4.4. Number of branches per plant of dhaincha at maturity as influenced by date of sowing and spacing

Row spacing (D)	Number of branches plant ⁻¹						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm × 15 cm	18.7	17.3	15.8	9.7	7.5	5.1	12.4
45 cm × 15 cm	21.9	20.6	17.2	11.1	7.8	6.3	14.2
60 cm × 15 cm	22.7	21.9	18.1	14.5	8.5	6.5	15.4
Mean	21.1	19.9	17.0	11.8	8.0	6.0	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		0.5	1.4	10.2			
Row spacing (D)		0.3	1.0				
S × D		0.8	NS				

Table 4.5. Drymatter accumulation (kg ha⁻¹) of dhaincha at 30DAS as influenced by date of sowing and spacing

Row spacing (D)	Drymatter accumulation (kg ha ⁻¹)						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm × 15 cm	1138	942	664	524	267	240	629
45 cm × 15 cm	1007	773	564	484	237	210	546
60 cm × 15 cm	686	747	471	410	225	184	454
Means	944	821	566	473	243	212	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		13	38	7.6			
Row spacing (D)		9	27				
S × D		23	66				

Table 4.6. Drymatter accumulation (kg ha⁻¹) of dhaincha at 60DAS as influenced by date of sowing and spacing

Row spacing (D)	Drymatter accumulation (kg ha ⁻¹)						
	Date of sowing (S)						Mean
	July 1	July 15	August 1	August 15	September 1	September 15	
30 cm × 15 cm	5319	4296	3482	3274	2448	1304	3354
45 cm × 15 cm	4444	3951	2854	1926	1709	1017	2650
60 cm × 15 cm	3941	2682	2578	1444	1104	1015	2127
Means	4568	3643	2971	2215	1754	1112	
		SEm±	CD (P=0.05)	CV%			
Date of sowing (S)		65	188	7.2			
Row spacing (D)		46	133				
S × D		113	325				

Table 4.7. Drymatter accumulation (kg ha⁻¹) of dhaincha at 90DAS as influenced by date of sowing and spacing

Row spacing (D)	Drymatter accumulation (kg ha ⁻¹)					
	Date of sowing (S)					
	July 1	July 15	August 1	August 15	September 1	Mean
30 cm × 15 cm	10932	10223	7983	5556	4407	7820
45 cm × 15 cm	9786	9142	7723	4579	3378	6922
60 cm × 15 cm	8937	8166	6815	4374	2593	6177
Mean	9885	9177	7507	4836	3459	
		SEm±	CD(P=0.05)	CV%		
Date of sowing (S)		96	276	4.1		
Row spacing (D)		74	214			
S × D		166	477			

Table 4.8. Drymatter accumulation (kg ha⁻¹) of dhaincha at harvest as influenced by date of sowing and spacing

Row spacing (D)	Drymatter accumulation (kg ha ⁻¹)						Mean
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1*	September 15**	
30 cm × 15 cm	11432	10579	8075	5568	4407	2222	7047
45 cm × 15 cm	10318	9580	7755	4594	3378	2200	6305
60 cm × 15 cm	9049	8404	6861	4390	2593	1667	5494
Mean	10266	9521	7564	4851	3459	2030	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		96	275	4.6			
Row spacing (D)		68	195				
S × D		166	477				

*September 1st sown crop was harvested at 90 DAS

** September 15th sown crop was harvested at 76 DAS

Table 4.9. Growing degree days (GDD) accumulation of dhaincha during different dates of sowing and spacings

Row spacing (D)	Growing Degree Days						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm ×15 cm	2150	1958	1798	1730	1613	1321	1762
45 cm ×15 cm	2174	2005	1843	1752	1630	1360	1794
60 cm ×15 cm	2200	2053	1882	1824	1657	1422	1840
Means	2174	2005	1841	1769	1633	1368	

Table 4.10. Days to 50% flowering of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Days to 50% flowering						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm ×15 cm	51	45	41	36	32	24	38
45 cm ×15 cm	53	46	44	39	35	27	41
60 cm ×15 cm	56	50	46	42	37	29	43
Mean	53	47	44	39	35	27	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		0.4	1.2	3.1			
Row spacing (D)		0.3	0.9				
S × D		0.7	NS				

Table 4.11. Days to maturity of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Days to maturity						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm ×15 cm	113	103	96	94	89	73	95
45 cm ×15 cm	115	106	99	95	90	76	97
60 cm ×15 cm	116	109	101	100	92	80	100
Mean	115	106	99	96	90	76	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		1	3	3.3			
Row spacing (D)		1	2				
S × D		2	NS				

Table 4.12. Number of pods per plant of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Number of pods plant ⁻¹						Mean
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	
30 cm ×15 cm	49.3	44.3	28.1	14.3	14.4	9.5	26.7
45 cm ×15 cm	54.3	50.9	30.3	17.0	18.3	9.7	30.1
60 cm ×15 cm	60.3	58.7	39.4	29.3	18.5	12.7	36.5
Mean	54.6	51.3	32.6	20.2	17.1	10.6	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		0.9	2.6	8.8			
Row spacing (D)		0.4	1.2				
S × D		1.6	4.5				

Table 4.13. Test weight (g) of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Test weight (g)						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm × 15 cm	18.58	18.28	18.02	16.79	13.30	11.05	16.00
45 cm × 15 cm	18.96	18.78	18.42	16.89	14.06	11.62	16.45
60 cm × 15 cm	19.64	19.64	18.95	18.28	14.31	12.85	17.28
Means	19.06	18.90	18.46	17.32	13.89	11.84	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		0.49	1.43	9.00			
Row spacing (D)		0.35	1.01				
S × D		0.86	NS				

Table 4.14. Seed yield (kg ha⁻¹) of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Seed yield (kg ha ⁻¹)						
	Date of sowing (S)						Mean
	July 1	July 15	August 1	August 15	September 1	September 15	
30 cm ×15 cm	1031	926	631	384	277	115	561
45 cm ×15 cm	951	833	583	315	209	105	499
60 cm ×15 cm	836	731	570	261	175	64	439
Mean	939	830	595	320	220	95	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		13	36	7.5			
Row spacing (D)		9	26				
S × D		22	63				

Table 4.15. Stalk yield (kg ha⁻¹) of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Stalk yield (kg ha ⁻¹)						Mean
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	
30 cm ×15 cm	8969	8261	6027	4021	3244	1419	5324
45 cm ×15 cm	8020	7195	5524	3291	2402	1254	4614
60 cm ×15 cm	6595	6145	5293	2695	2012	754	3916
Means	7861	7200	5615	3336	2553	1142	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		96	277	6.3			
Row spacing (D)		68	196				
S × D		167	480				

Table 4.16. Harvest index (%) of dhaincha as influenced by date of sowing and spacing

Row spacing (D)	Harvest index (%)						
	Date of sowing (S)						
	July 1	July 15	August 1	August 15	September 1	September 15	Mean
30 cm ×15 cm	10.32	10.08	9.50	8.75	7.99	7.64	9.05
45 cm ×15 cm	10.62	10.37	9.55	8.75	8.06	7.72	9.18
60 cm ×15 cm	11.27	10.65	9.78	8.83	7.99	7.84	9.39
Mean	10.74	10.37	9.61	8.78	8.01	7.73	
		SEm±	CD(P=0.05)	CV%			
Date of sowing (S)		0.33	0.94	10.41			
Row spacing (D)		0.23	NS				
S × D		0.57	NS				

Table 4.17. Returns per rupee investment of dhaincha as influenced by date of sowing and spacing

Treatment	Seed yield (kg ha ⁻¹)	Income from seed (Rs ha ⁻¹) (A)	Stalk yield (kg ha ⁻¹)	Income from stalk (Rs ha ⁻¹) (B)	Gross returns (Rs ha ⁻¹) (A+B=C)	Cost of cultivation (D)	Net returns (Rs ha ⁻¹) (C-D=E)	Returns Per Rupee Investment (E/D)
S ₁ D ₁	1031	49994	8969	897	50891	17223	33668	1.95
S ₁ D ₂	951	46116	8020	802	46918	16936	29982	1.77
S ₁ D ₃	836	40565	6595	659	41225	16792	24433	1.46
S ₂ D ₁	926	44930	8261	826	45756	17223	28533	1.66
S ₂ D ₂	833	40391	7195	719	41110	16936	24174	1.43
S ₂ D ₃	731	35444	6145	614	36058	16792	19266	1.15
S ₃ D ₁	631	30613	6027	603	31216	17223	13993	0.81
S ₃ D ₂	583	28299	5524	552	28851	16936	11915	0.70
S ₃ D ₃	570	27626	5293	529	28155	16792	11363	0.68
S ₄ D ₁	384	18624	4021	402	19026	17223	1803	0.10
S ₄ D ₂	315	15287	3291	329	15616	16936	-1320	-0.08
S ₄ D ₃	261	12649	2695	270	12918	16792	-3874	-0.23
S ₅ D ₁	277	13444	3244	324	13769	17223	-3454	-0.20
S ₅ D ₂	209	10127	2402	240	10367	16936	-6569	-0.39
S ₅ D ₃	175	8478	2012	201	8679	16792	-8113	-0.48
S ₆ D ₁	115	5568	1419	142	5710	17223	-11513	-0.67
S ₆ D ₂	105	5083	1254	125	5208	16936	-11728	-0.69
S ₆ D ₃	64	3104	754	75	3179	16792	-13613	-0.81

Seed price: Rs. 48.50 per kg ; Stalk price: Rs. 100 per tonne

Chapter V

SUMMARY AND CONCLUSIONS

The salient findings of the study on “seed production of dhaincha [*Sesbania aculeata* (Wills.) Poir.] as influenced by sowing time and planting density” are summarized in this chapter. The study was conducted at the Agricultural College Farm, Bapatla on clay loam soil during *khariif*, 2010. The study consisted of 18 treatment combinations resulted from six dates of sowing (S₁-July 1, S₂-July 15, S₃-August 1, S₄-August 15, S₅-September 1 and S₆-September 15) and three planting densities (D₁-30 cm × 15 cm, D₂ - 45 cm × 15 cm and D₃ - 60 cm × 15 cm) arranged in a randomised block design with factorial concept and replicated three times.

The results indicated that dhaincha sown early on July 1 recorded enhanced growth characteristics like taller plants, higher number of branches per plant, more drymatter accumulation, more number of days to attain 50% flowering and maturity than that of delayed sowings dates up to September 15.

Yield components like number of pods per plant and test weight were higher with July 1 sowing and subsequent reduction in yield attributes was observed due to delayed sowings. Seed yield, stalk yield and harvest index were also significantly higher in July 1 sown crop when compared to those of later sowings. The July 15 sown crop was also performed on a par with the July 1 sown crop with respect to all growth parameters, yield attributes and yield. Further delay in sowing of dhaincha beyond July 15 resulted in marked reduction of growth and yield of dhaincha.

Plant height, total drymatter accumulation of dhaincha increased significantly with decrease in row spacing from 60 cm × 15 cm to 30 cm × 15 cm. But reverse is the case with number of branches per plant and drymatter accumulation per plant. Though the total drymatter accumulation was higher at 30 cm × 15 cm spacing, per plant drymatter accumulation was higher at 60 cm × 15 cm spacing.

Drymatter accumulation was significantly influenced by interaction effect of dates of sowing and spacings at all the periods of observation (30, 60, 90 DAS and at harvest). Dhaincha sown at 30 cm × 15 cm spacing recorded with the highest drymatter accumulation at each date of sowing up to September 15. However, the July 1 and July 15 sowings resulted in the maximum drymatter accumulation at 30 cm × 15 cm spacing and it was followed by 45 cm × 15 cm at all the stages of observation.

Crop sown early on July 1 took significantly more number of days to attain 50% flowering (53) and maturity (115) over later sowing dates. Whereas, September 15 sown crop attained its 50% flowering and maturity stages within 27 and 76 days respectively. Similarly, 60 cm × 15 cm spacing took significantly more number of days to 50% flowering and maturity over 45 cm × 15 cm and 30 cm × 15 cm spacings.

Crop sown with a wider spacing of 60 cm × 15 cm, at each date of sowing produced significantly higher number of pods per plant over closer spacing. The July 1 sown crop produced the highest number of pods per plant at 60 cm × 15 cm spacing and it was on a par with July 15 sowing at the same spacing. Crop sown on July 1 and July 15 produced significantly higher number of pods per plant at all the three spacings. Test weight was the highest with the July 1 sowing which was on a par with that of July 15 and August 1 sowings. A significant increase in test weight was observed due to 60 cm × 15 cm spacing and it was comparable with that of 45 cm × 15 cm spacing.

An increase in seed yield was observed with decrease in spacing from 60 cm × 15 cm to 30 cm × 15 cm. The 30 cm × 15 cm spacing with the July 1 sowing produced the highest seed yield over other treatment combinations. But, the seed yield recorded with July 1 sowing at 45 cm × 15 cm spacing and July 15 sowing at 30 cm × 15 cm spacing was comparable with that of July 1 sowing at 30 cm × 15 cm spacing. Whereas, the crop sown in the month of September produced the lowest seed yields at all the three spacings.

The stalk yield increased with decrease in row spacing from 60 cm × 15 cm to 30 cm × 15 cm at each date of sowing. The stalk yield recorded with 30 cm × 15 cm spacing at the July 1 sowing was significantly higher than other treatment combinations, but it was comparable with the July 15 sowing at the same spacing; whereas, the stalk yield observed with September 15 sowing at 60 cm × 15 cm spacing was significantly the lowest compared with all other treatment combinations

Harvest index of dhaincha decreased significantly with delay in sowing time. Higher harvest index was recorded with July 1 sowing and the harvest index recorded with July 15 sowing was on a par with that of July 1 sowing.

The July 1 sown dhaincha crop at 30 cm × 15 cm spacing recorded significantly the highest gross returns (Rs.50,891 ha⁻¹), net returns (Rs.33,668 ha⁻¹) and returns per rupee investment (1.95) over the rest of the treatment combinations.

CONCLUSIONS

Based on the results of present investigation, the following conclusions are drawn:

- ♣ Sowing of dhaincha from July 1 to July 15 found to be the optimum sowing time for getting higher productivity.
- ♣ Closer row spacing of 30 cm × 15 cm with a density of 1,11,111 plants ha⁻¹ found to be the optimum spacing for dhaincha followed by 45 cm × 15 cm spacing (1,48,148 plant ha⁻¹).
- ♣ Sowing of dhaincha at July 1 with 30 cm × 15 cm spacing realized higher seed yield and high returns per rupee investment compared to other combinations.

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*** Original not seen**

Note: The pattern of literature cited above is in accordance with the guidelines for thesis presentation Acharya N.G. Ranga Agricultural University, Hyderabad.

APPENDIX

CALENDER OF OPERATIONS

S.No	FIELD OPERATION	DATE OF OPERATION		
1.	Preparatory cultivation			
	a. Ploughing and Levelling			29-06-10
	b. Layout			30-06-10
2.	Sowing and Fertilizer application			
	S ₁			01-07-10
	S ₂			15-07-10
	S ₃			01-08-10
	S ₄			15-08-10
	S ₅			01-09-10
	S ₆			15-09-10
3.	Intercultural operations			
	a. Gap filling			
	S ₁			05-07-10
	S ₂			20-07-10
	S ₃			05-08-10
	S ₄			20-08-10
	S ₅			05-08-10
	S ₆			20-09-10
	b. Thinning			
	S ₁			
	S ₂			
	S ₃			
	S ₄			
	S ₅			
	S ₆			
	c. Hand weeding			
	S ₁	15-07-10	01-08-10	15-08-10
	S ₂	01-08-10	15-08-10	01-09-10
	S ₃	15-08-10	01-09-10	15-09-10
	S ₄	01-09-10	15-09-10	01-10-10
	S ₅	15-09-10	01-10-10	15-10-10
	S ₆	01-10-10	15-10-10	01-11-10
4.	Plant Protection			
	Chlorpyrifos and Dichlorovos		18-09-10	25-09-10
5.	Harvesting			
	S ₁			25-10-10
	S ₂			05-11-10
	S ₃			10-11-10
	S ₄			20-11-10
	S ₅			01-12-10
	S ₆			10-12-10

Legend:

S_1 : July 1st

S_2 : July 15th

S_3 : August 1st

S_4 : August 15th

S_5 : September 1st

S_6 : September 15th