STANDARDIZATION OF SEED PRODUCTION TECHNIQUES IN DHAINCHA (*Sesbania aculeata*)

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BY

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CERTIFICATE

Mr. BUKKE HARI NAYAK has satisfactorily prosecuted the course of research and that the thesis entitled **"STANDARDIZATION OF SEED PRODUCTION TECHNIQUES IN DHAINCHA (*Sesbania aculeata*)"** 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 there of has been previously submitted by him for a degree of any university.

(**Dr. K. KANAKA DURGA**)

Date: **Chairperson**

CERTIFICATE

This is to certify that the thesis entitled "**STANDARDIZATION OF SEED PRODUCTION TECHNIQUES IN DHAINCHA (*Sesbania aculeata*)"** submitted in partial fulfilment of the requirements for the degree of **'**Master of Science in Agriculture' of the **Professor Jayashankar Telangana State Agricultural University,** Hyderabad, is a record of the bonafide research work carried out by **Mr. BUKKE HARI NAYAK** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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 investigation have been duly acknowledged by the author of the thesis.

(**Dr. K. KANAKA DURGA)**
Chairperson of the Advisory Committee

Thesis approved by the Student's Advisory Committee

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Date of final viva-voce:

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DECLARATION

I, **BUKKE HARI NAYAK** hereby declare that the thesis entitled **"STANDARDIZATION OF SEED PRODUCTION TECHNIQUES IN DHAINCHA (*Sesbania aculeata*)"** submitted to the **Professor Jayashankar Telangana State 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 any material contained in the thesis has not been published earlier in any manner.

Place: Hyderabad **(BUKKE HARI NAYAK)**

Date: **I. D. No. RAM/14-52**

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	:	Centimetre
m	:	Metre
g	:	Gram
kg	:	Kilogram
t	:	Tonne
q	:	Quintal
cm^2	:	Square centimetre
m^2	:	Square metre
ac	:	Acre
ha	:	Hectare
kg ha^{-1}	:	Kilogram per hectare
t ha^{-1}	:	Tonne per hectare
dS m^{-1}	:	Decisiemen per metre
@	:	At the rate of
B:C	:	Benefit: cost ratio
FBD	:	Fruit bud differentiation
S.Em±	:	Standard Error of mean
S.Ed	:	Standard Error of Difference
C.D.(P=0.05)	:	Critical difference at 5 per cent level of probability
C.V.(%)	:	Co-efficient of variation
DAS	:	Days after sowing
et al.	:	And others
Fig.	:	Figure
h	:	Hours
i.e.	:	That is
%	:	Per cent
Max.	:	Maximum
Min.	:	Minimum
N.S.	:	Non significant
^0C	:	Degree Celsius
N	:	Nitrogen
P_2O_5	:	Phosphorus

K_2O	:	Potassium
pH	:	Potential Hydrogen
$plant^{-1}$	:	Per plant
pod^{-1}	:	Per pod
RF	:	Rainfall
Temp.	:	Temperature
RH	:	Relative humidity
₹	:	Rupees
viz.	:	Namely
etc.	:	And so on
DAP	:	Di-ammonium Phosphate
NAA	:	Naphthalene Acetic Acid
CCC	:	Cycocel
MN	:	Micronutrient
Zn	:	Zinc
B	:	Boron
$ZnS0_4$	:	Zinc Sulphate
L	:	Litre
µl	:	Micro litre

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ABSTRACT

A field experiment entitled **"Standardization of seed production techniques in Dhaincha (*Sesbania aculeata*)"** was conducted during *kharif*, 2015 at Seed Research & Technology Center, Rajendranagar, Hyderabad. The experiment was laid out in a split plot design with three main treatments (with pinching at 20 DAS, without pinching and spray of cycocel @ 75 ppm at peak flowering stage) and five sub treatments (foliar spray with DAP 2%, foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%), foliar spray with NAA @ 40 ppm, foliar spray with DAP 2% + MN Mixture (Zn + B) + NAA and control) in three replications.

Observations on yield and yield attributing characters like plant height (cm), days to first flowering, days to 50% flowering, days to maturity, number of branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, pod yield plant^{-1} (g), seed yield plant^{-1} (g), seed yield ha^{-1} (q), seed recovery percentage and 100 seed weight (g) were recorded. Seed of the harvested produce was tested for seed quality parameters like germination (%), root length (cm), shoot length (cm), total seedling length (cm), seedling vigour index I, seedling dry weight (g), seedling vigour index II, speed of germination, electrical conductivity of seed leachates (µS cm^{-1}) and total fungal colonies.

Pinching treatment has significantly prolonged the time taken for the appearance of the first flower by about four days and days to 50% flowering and maturity by three days. Among the yield and yield attributing characters, pinching of dhaincha crop at 20 DAS exerted profound influence on reducing the height of the plant and improving the number of branches plant^{-1}, number of pods plant^{-1}, seed yield plant^{-1} and seed yield ha^{-1}. The per cent improvement in branches plant^{-1} due to pinching and cycocel spray @ 75 ppm was 30.95% and 11.48%, respectively as compare to without pinching. Similarly, the per cent increase in seed yield due to pinching was 15.38% (over control) and 7.70% (over spray of cycocel @ 75 ppm). On the other hand, foliar spray of cycocel @ 75 ppm resulted in

significant improvement in 100 seed weight. With respect to number of seeds pod^{-1}, foliar spray of cycocel @ 75 ppm and pinching treatment were found superior.

Among the seed quality parameters, the use of growth retardant cycocel significantly contributed to improvement of seedling dry weight and seedling vigour index-II. While, pinching treatment contributed to significant increase in speed of germination and field emergence of dhaincha seeds.

Among different foliar nutritions, dhaincha crop without any foliar spray took maximum days for initiation of first flower (32.7 days) and days to maturity (85 days). The treatment S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5 % + Boric acid 0.3%) contributed to significant increase in pods plant^{-1}, 100 seed weight and seed yield. Among the seed quality traits, the treatment S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA was found superior as it resulted in maximum germination percentage, while S_3 *i.e.* foliar spray with NAA 40 ppm was found promising for speed of germination and field emergence.

Among the interaction effects, the treatment combination M_1S_5 *i.e.* pinching + without foliar nutrition took maximum number of days for the appearance of first flower (36), 50% flowering (41.7 days) and maturity. The treatment combination M_1S_2 *i.e.* pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) recorded maximum pods plant^{-1} (31.2) and pod yield plant^{-1}. While, M_1S_3 *i.e.* pinching + foliar spray with NAA 40 ppm was found superior for pod yield plant^{-1} and seed yield plant^{-1}. The combination M_3S_1 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with DAP 2% was found superior for germination, while the interactive effect involving M_2S_3 *i.e.* without pinching + foliar spray with NAA 40 ppm was found promising for seedling characters like root length, shoot length and seedling length, while M_1S_3 i.e., pinching + foliar spray with NAA 40 ppm had better emergence under field conditions.

Therefore, it can be concluded from the experimental results that pinching of the dhaincha crop at 20 DAS in combination with foliar spray of NAA @ 40 ppm and pinching at 20 DAS coupled with foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) may be opted as an effective technique for obtaining maximum quality seed.

Chapter- I

INTRODUCTION

Green manuring is an age old practice of farming for maintaining soil fertility. However, the advent of green revolution has not only increased chemical fertilizer consumption but also marginalized the use of green manures in intensive cropping systems. This is evident from the declining area under green manure crops over time. In 2004-05, green manure crops are cultivated on 3.57 m ha area (FAI, 2007-08). Dhaincha (*Sesbania aculeata*) is the most important green manure crop for *in-situ* incorporation in rice based cropping systems. Further, dhaincha cultivation is promising even under saline soils, ill drained soils and areas which receive heavy rainfall (Parlawar *et al*., 2003). The major constraint for dhaincha cultivation is the lack of availability of adequate quality seeds at appropriate time at reasonable price for small holding farmers or marginal farmers. Dhaincha seed production is mainly concentrated in peninsular India and by the time its seed reaches North India, the prices rise beyond purchase of seed and seed quality is not ensured. The protein rich dhaincha seed as an animal feed (Hossain *et al*., 2001) also demands production of more seed. Hence for realizing higher yield, its seed production technology has to be standardized in terms of nutrient requirement and other cultural practices.

India has changed from a region of food scarcity to food security by increased fertilizer use with subsidized prices and the use of organic manures including green manure crops, declined substantially. Inorganic fertilizers are becoming more expensive therefore sustainability of soil productivity is in vogue. Green manure crops are low cost and effective technology in minimizing the cost of fertilizers and safeguarding soil health and productivity. Almost all green manure crops which are used for in-situ (or) ex-situ incorporation contains all the plant nutrients which are essential for enhancing crop growth and to sustain soil health.

At present, farmers are practising green manuring only in 6.7 million hectares land during *kharif* season which account for 4.5 per cent of net sown area (142 million hectares) in the country. The practice of green manuring is most common in rice growing states like A.P., U.P., Karnataka, Punjab and Orissa which contribute 41, 16, 11, 6, 5 per cent to the total area under green manuring in India, respectively. Whereas, the share of Gujarat (3%), M.P (3%), Himachal Pradesh (2%) and Haryana (1.7%) is not very encouraging and concerted efforts are to be made at all levels to bring more area under green manuring that too under irrigated conditions to sustain the productivity of crop and protection of soil health.

Green manuring a practice of incorporation of green plant biomass into the cultivated fields is one of the most effective and environmentally sound methods of manuring crops. In-situ incorporation of green manure crops provides an opportunity to improve soil physico-chemical environment, cut down the use of chemical fertilizers, which are often blamed for causing environmental pollution and escalating the cost of cultivation of crops. Interest towards green manure crops has been renewed with the growing emphasis on sustained soil productivity in agricultural systems. The benefits deriving from green manure crops are directly related to the amount of biomass and nutrients added into the soil. Biomass production of green manure crops varies widely according to the species of the legumes, environmental conditions, nature of incorporation, native soil fertility, crop management practices and age of green manure crops at the time of incorporation.

Almost all green manure crops which are used for *in-situ* or *ex-situ* incorporation contain all the plant nutrients which are essential for growth and development of any plant species. The main green manure crops grown in India are Dhaincha, Sunhemp, Wild Indigo, Pillipesara, Cowpea, Cluster bean (Guar), Green gram (Mung bean) and Berseem. Among the different green manure crops, Dhaincha *(Sesbania aculeata)* and Sunhemp (*Crotalaria juncea*) have higher accumulation of major and micro nutrients on account of more biomass production and better nutrient composition compared to food legumes which are inferior due to low content of nutrients coupled with less dry matter production.

Dhaincha is the cheapest and best source for improving soil fertility and maintaining the health of a soil ecosystem. It also increases water holding capacity and decreases soil loss by erosion. Dhaincha is an ideal green manure crop as it is quick growing, succulent, easily decomposable with low water requirement and produces maximum amount of biomass. It is quick germinating and fast growing crop and bears more number of nodules which fix atmospheric nitrogen. Growing dhaincha crop in the off season reduces weed proliferation and weed growth and also controls root knot nematodes.

Sesbania cannabina is one of the important species which is available for cultivation in research stations, government farms and farmers in Nepal. *Sesbania rostrata* is another species of dhaincha which was first introduced in Agriculture Farm, Hardinath, Janakpur where its seed production programme was launched. *Sesbania* *rostrata* bears nodules in roots and stems (branches) where N-fixing bacteria "*Rhizobium*" are available and fix atmospheric nitrogen. This species fixes more nitrogen than *Sesbania cannabina* because *cannabina* bears only root nodules. At least 2 tonnes ha^{-1} of seeds can be produced from *rostrata* species whereas *cannabina* can produce only one tonne ha^{-1} of seed. *Sesbania rostrata* fixes nitrogen even in water logged conditions because it bears stem nodules above the soil surface.

In dhaincha, quality seed availability has become problematic to both farmers and government agencies. Hence, timely production and supply of green manure crop seeds especially "*Sesbania aculeata*" at cheapest rates in the state has been given the priority for procurement of the seed and to make it available well in advance to the farmers. Off late, quality seed production of dhaincha is under meager importance in spite of huge demand from farmers and less expertise was carried out in this area. Keeping in view, a study was carried out with the following objectives.

OBJECTIVES:

1. To study the influence of nipping or pinching of terminal buds on quality seed production
2. To find out the impact of foliar spray of DAP and micronutrients on quality seed production.

Chapter –II

REVIEW OF LITERATURE

The practice of topping or use of growth retardants has proved to be effective in increasing the yield levels of different crops as apical topping breaks the apical dominance and induces development of lateral branches and increases the sites for pod development. Soil application of fertilizer under rainfed situation is seldom remunerative and therefore foliar fertilization may help in obtaining higher returns. Foliar nutrition reduces the loss through absorption, leaching and other processes associated with soil application (Vasilas *et al.*, 1980). Very meager information is available on effect of topping and foliar nutrition on seed yield and quality in seed crop of dhaincha. Therefore, information on other field and horticultural crops is reviewed under the following heads.

2.1 Influence of nipping or pinching of terminal buds on seed yield and seed quality of dhaincha

Narayanan and Narayanan (1987) reported that nipping of terminal bud in sesamum activated the dormant lateral buds to produce more branches which finally resulted in yield increase.

Mishra and Nayak (1997) noticed that nipping of terminal bud at 50 DAS significantly reduced the plant height and increased the number of primary branches, secondary branches, pods plant^{-1} and test weight in jute crop.

Narayanagowda and Jeyanthi (1988) stated that clipping at 60 DAS in chrysanthemum produced more flowers and higher yield than unclipped plants.

Imayavaramban (2000) reported that clipping of terminal buds at 35 DAS altered crop architecture due to induction of more number of branches, lateral branches plant^{-1} that led to greater chance for development of source and sink features in sesame. Increase in branches plant^{-1} and capsules plant^{-1} was also reported in sesame by Venkatachalam (2003).

Arias *et al*. (2001) elucidated under greenhouse conditions that in oleander, pinched plants were significantly shorter than non-pinched plants and plants sprayed with cycocel at lesser doses (50 mg). Plants sprayed at higher dose of 800 mg cycocel were significantly shorter than the control. Pinching plants even without cycocel spray resulted in an increase in the number of shoots plant^{-1}. In addition, pinching resulted in increased root length and CCC sprayed plants resulted in darker and duller colour plants. Hence, neither pinching nor CCC spray at 800 mg substantially improved the ornamental value of the crop.

In dhaincha crop, clipping either at 25 or 35 days after sowing improved the dry weight of the shoot by increasing more number of branches plant^{-1}, but significantly reduced the shoot length (Kathiresan and Duraisamy, 2001).

Wolfson *et al.* (2001) noticed that soft pinching of the stems of Leucadendron enhanced branching and increased the number of export quality stems plant^{-1}. The timing of pinching is crucial for obtaining large number and best quality of the cut branches. Under Israeli conditions, pinching in April – May produced two to four more branches per pinched stem and pinching at later stage decreased quality. Pinching stems that are at least 10 mm in diameter have increased production to 400-700 thousand stems hectare^{-1} year^{-1} as against 200 thousand stems hectare^{-1} year^{-1} obtained by without pinching.

In pigeon pea, nipping of the terminal bud at 50 days after sowing significantly reduced the height of the plant and increased the number of primary and secondary branches and pods plant^{-1} with a seed yield of 1560 kg ha^{-1} (Arjun Sharma *et al.*, 2003).

Arora *et al.* (2003) reported that pinching of marigold plants resulted in delay in bud initiation, first flower visibility as compared to un pinched plants because of delay in formation of physiologically mature shoot for bearing flowers. The increase in number of flowers, weight of flower and yield of flower plant^{-1} reported due to pinching at 20 days after transplanting might be attributed to checked apical dominance and consequently extra energy was diverted into the production of more number of branches and flowers.

In marigold it was found that nipping of terminal buds, axillary buds and associated young leaves significantly shortened days to tuber initiation, decreased total leaf area and dry matter content (Desta and Tekalign, 2008).

Ahmad *et al*. (2007) reported that carnation plants were compact and dwarf with increased number of shoots and maximum number of flowers with higher level of cycocel (1000 mg ha^{-1}) and branch size increased with a concomitant reduction in number of branches plant^{-1}. In addition, delayed flowering and shortened blooming period were observed with pinching.

Significantly superior cane yield (91.90 t ha^{-1}) was recorded with clipping treatment as compared to non-clipping treatment at 55-65 DAP (85.55 t ha^{-1}). Significant increase in higher cane yield with clipping treatment was due to increased number of shoots ha^{-1} (89000) and net millable canes ha^{-1} (78000) as compared to number of shoots ha^{-1} (80 000) and net millable canes ha^{-1} (71000) in non-clipping treatments. (Gaddanakeri *et al*., 2007).

Bhat and Shepherd (2007) and Sunitha *et al*. (2007) observed significant differences in seed yield due to pinching in African marigold, which were attributed to growth and flowering characters.

Kokilavani *et al.* (2007) observed that in sesamum, maximum plant height (114.0 cm) was recorded in without nipping treatment compared to nipping at 25 (102.9 cm), 30 (98.5 cm) and 35 days (95.6 cm) crop stage. Terminal clipping done at 30 days crop stage produced significantly higher number of primary branches $plant^{-1}$ (4.9) over other nipping schedule (without nipping and nipping at 25 days crop stage). While nipping of terminal buds at 35 days crop stage produced lowest number of primary branches $plant^{-1}$ (0.3).

In cape gooseberry (*Physalis peruviana* L.) of the four pinching treatments along with control (20, 30, 40 and 50 cm height), pinching at 20 cm was most effective in reducing the plant height (72.2 cm as compared to 106.2 cm in control) and number of days for flowering (75.5 days after transplanting) and picking (51.6 days after fruit set), while pinching at 40 cm height showed the highest values for the number of primary shoots (9.45), photosynthetic efficiency (1.54 mg cm^{-2} day^{-1}) and leaf chlorophyll content (33.41 mg g^{-1} of fresh weight). Of all the pinching treatments, the fruits picked from the plants pinched at 40 cm plant height were highest in number (42.80) with a yield of 393.48 g $plant^{-1}$(Sharma *et al*., 2008).

The application of growth retardants like maleic hydrazide (250 ppm and 500 ppm), mepiquat chloride (500 ppm and 1000 ppm) and lithocin (500 ppm and 1000 ppm) and nipping at one week after tendril formation significantly increased the number of productive branches $plant^{-1}$, pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 100 seed weight and harvest index which are the important yield determining components in cowpea. Among various treatments, the per cent increase in yield was more with mepiquat chloride @ 1000 ppm followed by nipping at one week after tendril formation (Reddy *et al*., 2009).

In chrysanthemum, highest yield in terms of number of flowers plant^{-1} was recorded by pinching at 20 days after sowing (nursery) which was on par with those plants pinched at 10 days after transplanting. Plants were consistently taller in non-pinched plots. Every delay in pinching caused reduction in plant height at final stage during both *kharif* and *rabi* seasons. Maximum seed yield plant^{-1} (7.40 g and 14.33 g) was recorded by pinching at 20 DAS which was on par with pinching at 10 DAT (6.50 g and 12.67 g), respectively during *kharif* and *rabi* seasons. While the seed yield plant^{-1} was minimum (3.10 g and 6.55 g) under late pinching at 40 DAT. (Dorajee Rao and Mokashi, 2012).

Habiba *et al*. (2012) reported that gradual increase in height of the chrysanthemum plant was observed with pinching of the terminal bud from 20 DAT to 90 DAT. Tallest plant (37.7 cm) was recorded from without pinching and the shortest (33.4 cm) was found from with pinching at 90 DAT. Maximum number of leaves (30.1) and flowers plant^{-1} (58.7) were recorded following pinching; and minimum number of leaves (26.8) and flowers plant^{-1} (37.9) were observed under without pinching. Similar results were also reported in chrysanthemum by Rakesh *et al*. (2005). Pinching in chrysanthemum at 90 DAT resulted in maximum number of branches plant^{-1} (4.4) whereas the minimum branches plant^{-1} (3.4) was noticed in without pinching treatment. Similar results were also reported in chrysanthemum by Beniwal *et al.* (2003).

Studies were undertaken to assess, refine and standardize the spacing and pinching for optimum flower yield with better flower quality in Marigold. The maximum flower yield (248.12 q ha^{-1}) was obtained under close spacing (40 x 40 cm) with delayed pinching (40 DAT). Planting at wider spacing (40 x 60 cm) and delayed pinching (40 DAT) increased the size and quality of flowers. However, the increase in number of secondary branches, flowers plant^{-1} and duration of flowering were recorded under delayed pinching (40 DAT) treatment (Ravneet *et al*., 2012).

Satish (2013) during his experiment in sunflower (DSFH-3) observed that nipping of side branches at button stage recorded significantly higher set seed percentage (78.83%), number of seeds (904.03 head^{-1}), seed weight (1.63 kg plot^{-1}), seed yield (11.66 q ha^{-1}), germination (96%) and vigour index (3890) compared to without nipping.

Tripathi *et al*. (2013) reported that topping at 45 DAS in sunhemp was found optimum for attaining maximum seed yield and component traits. Topping at 30 DAS recorded maximum number of primary (6.62) and secondary branches plant^{-1} (15.59) being at par with topping at 45 DAS but significantly superior to no topping. On an average, increase in seed yield due to topping at 45 DAS was noticed to the tune of 12.04%.

In marigold, highest reduction in plant height was recorded with foliar spray of cycocel @ 500 ppm when sprayed under different dates of planting (August : 70.7 cm, September : 63.3 cm and October : 40.93 cm) (Rajyalakshmi *et al*., 2014)

Mohanty *et al.* (2015) conducted a field experiment to study the effect of pinching on seed production in African marigold cv. Sriakole during November, 2007 to June, 2008 with three levels of pinching. Shoot pinching at 30 days after planting was effective in bringing significant improvement in number (173.01) and weight (0.25 g) of seeds head^{-1} as well as seed yield (309.77 kg ha^{-1}).

2.2 Effect of cycocel on seed yield and seed quality of dhaincha

In spring wheat, spray of chlormequat at 500 ppm at flowering stage has been used to reduce stem height and lodging, increase in stem diameter and tillering (Humphries *et al*., 1965). Cycocel reduced plant height but increased the number of leaves, resulting in compact growth of *Pelargonium hortorium* plants, due to reduced internodal distance (Welander, 1984).

In a field study on soybean, foliar application of CCC @ 300 ppm at flower initiation stage increased the number of pods plant^{-1} and decreased stem length (Singh *et al*., 1987).

Jaiswal and Bhambie (1989) stated that three sprays of foliar applications of cycocel on mung bean @ 100 ppm increased the number of pods plant^{-1} and had no effect on 100 seed weight.

Soaking the seeds of Pusa Sawani, okra cultivar for 24 h in solutions of cycocel at 50, 100, 250 or 500 ppm or in NAA at 5, 10 or 25 ppm revealed that NAA at 25 ppm as seed + foliar treatment at 20 and 40 DAS stimulated plant growth, whereas cycocel at 100 ppm as seed + foliar treatment resulted in increased number of shoots and leaves plant^{-1} and seed yield (176.9 q ha^{-1}). Cycocel at 50 ppm as a foliar spray induced early flowering (Arora *et al*., 1990). Cycocel exerted its inhibiting effect more in the stem than in the roots (Lockhart, 1992) and application of CCC @ 500 ppm to gladiolus plant resulted in reduction in stem length (Halevy and Shilo, 1990).

Guroo and Patel *et al*. (1993) in their studies revealed that spraying of chloromequat @ 250 ppm (3 sprays at 30, 45 and 60 days after sowing) on mustard could be used for obtaining maximum net profit with optimum yield. Significant differences were observed for plant height, number of branches plant^{-1}, number of pods plant^{-1}, total nutrient uptake and seed yield.

Combined treatment of cycocel and urea produced a stem shortening of 19% to 20% in spring wheat (Hunger and Peciard, 1994). In sweet pepper, spraying of cycocel @ 200, 1000 and1500 ppm at 30 or 60 days after planting resulted in reduction of plant height at all concentrations but maximum increase in branches plant^{-1} was observed at 1000 ppm (Deka and Shadeque, 1996).

Spraying of cycocel at 300 ppm in mustard reduced plant height as against control (Letimer and Thomas, 1997) and spraying of CCC at 500 ppm in soybean reduced plant height, increased number of pods plant^{-1}, seeds pod^{-1}, seeds plant^{-1} and seed yield as compared to control (Govindan *et al*., 2000).

Pankaj *et al*. (2001) reported that spraying of plant growth regulator CCC at 450 ppm and 500 ppm at 20 DAS decreased stem length and increased the number of pods plant^{-1} in soybean and in onion, spraying of cycocel @ 500 ppm reduced plant height (Haque, 2002).

Spraying of cycocel reduced plant height in green gram. Increase in number of branches plant^{-1}, nodules plant^{-1} and other yield attributing parameters was noticed with single spray of cycocel at 30 DAS. Spraying of cycocel at 30 DAS and 45 DAS @ 100 mg l^{-1} recorded 20.2% increased seed yield over control (Garai and Datta, 2003). Spraying of cycocel at 120 mg l^{-1} significantly decreased shoot height but increased branches plant^{-1} in mung bean (Rahman, 2004). Foliar application of chlormequat resulted in increased branches plant^{-1} in mung bean at 1612.5 g ha^{-1} (Saunder and Freer, 1994) and in green gram @ 100 ppm (Garai and Datta, 2003).

Increased seed yield due to foliar spray of cycocel was reported in pulse and oil seed crops. The increase in seed yield was to the tune of 60% when CCC was sprayed at 100 ppm at flowering stage in mung bean (Garai and Datta, 1999) and mustard (Khan *et al.*, 2003).

In grapes, results revealed that cycocel spray @ 300 ppm did not significantly influence the vigour of grafts. However, mean shoot length was reduced significantly from 198.7 cm in control to 155.13 cm when cycocel was applied four times (at 5+5+3+3 leaf stage) with topping and removal of side shoots. The yield vine^{-1} was also increased by 34.6% when cycocel was applied at 5+5+3+3 leaf stage with topping of side shoots. (Ramteke and Somkumar, 2000).

Spray of NAA @ 200 ppm in okra resulted in increased number of fruits plant^{-1}, fruit yield plant^{-1}, fruit yield ha^{-1} compared with control. Spray of CCC @ 400 ppm at 30 and 45 DAS increased length and girth of the fruit and decreased days to 50 per cent flowering (Kokare e*t al.*, 2006).

Karn Veer *et al.* (2008) observed that spray of cycocel at 600 ppm, NAA @ 60 ppm and ethrel @ 60 ppm in garlic increased bulb yield and other yield attributing characters compared to control.

Improved seed germination, crop growth, number of branches and seed yield in okra was observed with seed soaking in cycocel @ 300 ppm followed by spraying twice at 20 and 40 days age of crop (Prasad and Srihari, 2008).

Pot experiments conducted on mung bean by spraying CCC at 500, 1000 and 1500 ppm at 14 days after the emergence of seedlings revealed that foliar application of CCC at 1000 ppm and 1500 ppm reduced shoot height but increased the pod number plant^{-1}, seed number pod^{-1} leading to increased seed yield plant^{-1} without affecting 1000 seed weight (Shah and Prathapasenan, 2008).

Among different plant growth regulators (Cycocel, GA and NAA), shoot length of sapota was reduced significantly by the application of cycocel @ 400 ppm at fruit bud differentiation stage. While, number of leaves, leaf area, number of fruits as well as yield tree^{-1} were found to be increased. Physical characters of fruits *viz.*, length, diameter and weight of fruit were also increased considerably with the same treatment. NAA @ 100 ppm applied at flowering stage resulted in increased shoot length, number of leaves and leaf area followed by GA at 50 ppm. NAA 100 ppm sprayed at pea stage recorded increased shoot length, more number of leaves and leaf area than applied at lag phase (Shailendra Agrawal and Dikshit, 2008).

Deshmukh *et al.* (2010) observed in chilli significantly tallest plants due to urea spray 2% followed by spray of NAA 25 ppm, GA 25 ppm, while lowest plant height was recorded under the influence of ethrel at 300 ppm, CCC @ 1000 ppm and control (water). Due to foliar application of GA and urea, spread of the plant significantly increased over control.

Foliar application of chemicals and growth regulators at one month after sowing in coriander (*Coriandrum sativum* L.) elucidated significant reduction in plant height and improved field survival and crop stand with cycocel spray (250 ppm). In addition, higher values for relative water content, chlorophyll stability, leaf proline, umbel number, umbellet number and seed number with significant increase in seed yield of 27.42% were recorded (Vijayakumar and Sundareswaran, 2011).

Cycocel (0, 500, 1000 and 1500 mg l^{-1}) sprayed and drenched at 40 DAT was evaluated for its ability to control plant height in *Brassica oleracea*. Cycocel at 1500 mg l^{-1} resulted in about 50 and 20% shorter plants than the control plants at 60 and 90 days after transplant, respectively (Gholampour *et al.,* 2012).

Cycocel as growth retardant exhibited the capacity for profuse branching, higher leaf count, higher flower cluster and better yield plant^{-1} as compared to control (Jitendra *et al.,* 2012). The maximum plant height (140.8 cm) and internodal length (11.8 cm) were recorded with NAA at 100 and 75 ppm, respectively but the lowest plant height (108.7 cm) and internodal length (8.7 cm) were noted at 1000 ppm CCC. The maximum number of branches plant^{-1} (6.67), number of fruits plant^{-1} (27.33) and yield plot^{-1} (8.937 kg) were obtained with CCC at 800 ppm which was at par with CCC at 1000 ppm and NAA at 75 ppm. Therefore, spraying of cycocel at 800 ppm or NAA 75 ppm in okra crop is beneficial for getting higher yield (Mandal *et al.,* 2012).

Bhagure and Tambe (2013) stated that soaking of okra seeds with GA_3 @ 100 ppm followed by foliar spray of cycocel @ 750 and 1000 ppm at 30 and 45 DAS, respectively was found beneficial resulting in early germination (2.75 days) and flowering (34 days), maximum germination percentage (99.5), reduction in plant height (86.7 cm), length of internodes (5.1 cm), increase in number of internodes (15.90), number of branches (3.2), number of fruits (20.5), and yield plant^{-1} (201.3 g plant^{-1}).

Studies on the effect of plant growth regulators and time of application on growth and tuber yield of *Coleus forskohlii* revealed that application of cycocel at 250 ppm significantly suppressed the vegetative growth and cycocel spray @ 250 ppm and 500 ppm produced highest number of branches plant^{-1} (Susila and Reddy, 2013).

Maximum fruit weight and seed number fruit^{-1} was observed in the plants sprayed with GA_3 @ 20 ppm at 20 and 40 DAS, and maximum fruit length was recorded in plants treated with triacontanol @ 4000 ppm. Among the micronutrients, $ZnS0_4$ @ 0.4% recorded maximum fruit weight, $FeS0_4$ @ 0.2% maximum fruit length and Borax @ 0.2% recorded fruit diameter in okra (Usha Rani *et.* al., 2013).

Pourmohammad *et al.* (2014) studied the effect of foliar spray of cycocel (0, 600, 1200 ppm) at development stage of flower buds in rapeseed. The results indicated that foliar application of cycocel during the early stages of reproductive stage increased plant dry weight, 1000 seed weight in branches, harvest index and seed yield. In wheat, application of chlormequat chloride significantly increased number of spikes m^{-2}, 1000 grain weight and grain yield when compared to control. The highest grain yield was recorded with application of chlormequat chloride at 4-leaf stage and the lowest grain yield without application of chlormequat chloride (Latifkar *et al.,* 2014).

2.3. Impact of foliar spray of DAP, micronutrients and growth regulators on seed yield and seed quality of dhaincha

Beyer and Quebedeaux (1974) reported that a single application of NAA at concentrations ranging from 500 to 5000 ppm increased number of pistillate flowers of cucumber to develop into fruits, with minimum in the control. Fruit shape was normal but the growth was slightly retarded at 5000 ppm. They further reported that application of N-l- naphthylphthalamic acid had positive effect on fruit set and development in cucumber.

In cowpea, application of NAA (500 ppm) increased the seed yield of cowpea significantly due to increased morphological traits like total dry matter, leaf area and yield components *viz.,* number of pods plant^{-1} at 80 DAS and at harvest, number of seeds pod^{-1}, pod length and 100 seed weight (Ganiger *et al.*, 2002).

Jayaram and Ramaiah (1980) reported significant increase in seed yield in cowpea due to application of NAA and this increase was due to more number of pods plant^{-1} and number of seeds pod^{-1}.

Foliar application of salicylic acid at 100 ppm + DAP 2% + KCl 1% + NAA 40 ppm had significantly improved the pods cluster^{-1} and seed yield of green gram. The increase in yield was due to the increase in the number of flowers plant^{-1} and higher fertility coefficient imparted by the foliar application of nutrient chemicals and plant growth regulators (Chandrasekhar and Bangarusamy, 2003). Similarly, the retention of flowers and pods can be increased by either foliar application of nutrients or plant growth regulators as reported by Sharma and Dey (1986) in green gram.

Foliar spray of 2% DAP recorded significantly superior number of pods plant^{-1}, fertility coefficient, number of seeds pod^{-1}, seed yield, stover yield, test weight and harvest index in chickpea (Karan Singh, 1989) and K nutrition increased pods cluster^{-1} in rapeseed and mustard (Majumdar *et al.*, 1989).

Maximum yield in bottle gourd was reported with spray of NAA @ 200 ppm (Islam *et al.*, 1990). Foliar application of NAA improved the pod number in pigeon pea (Mishra and Singh, 1991). Foliar application of NAA and KCl was found effective for increasing the flower number in mung bean (Rajendran, 1991).

Srinivasan and Ramasamy (1992) reported increase in grain yield (29%), branches plant^{-1} (4), pods plant^{-1} (15.8), pod length (19.6), seeds pod^{-1} (18.1) and seed yield (932.3 kg ha^{-1}) in rainfed cowpea due to foliar spray of DAP @ 2% at 20 and 30 DAS when compared to control.

Kavimani *et al.* (1997) reported maximum seed weight and seed yield in dhaincha with soil application of single super phosphate (20 kg ha^{-1}) along with foliar spray of DAP (2%) at flowering stage as compared to single application of both.

Osman *et al.* (2000) reported that foliar application of zinc @ 0.4% increased the seed yield of soybean. Foliar application of NAA @ 30 ppm concentration on French bean increased the number of leaves and branches (Singh and Singh, 2000).

In dhaincha, foliar spray of 2% DAP + 1% K enhanced the shoot length, shoot dry weight and number of branches plant^{-1} (Kathiresan and Duraisamy, 2001) and in green gram, foliar spray of 2% DAP resulted in significantly higher number of pods plant^{-1} and 100 seed weight as compared to control (Pandian *et al.*, 2001).

Foliar application of N, P and K with chelated micronutrients has increased the grain yield of black gram (Manivannan *et al.*, 2002). Foliar application of 1% DAP + 0.5% urea recorded significantly more number of pods plant^{-1} in irrigated black gram (Subramani *et al.*, 2002). More number of pods plant^{-1} was recorded in black gram when 2% DAP was sprayed along with soil application of potassium (Yakadri and Ramesh, 2002).

Jayarani Reddy *et al*. (2004) observed that foliar application of NAA 20 ppm + K 0.5% on red gram, significantly increased the dry matter production and seed yield. A considerable increase in yield (400 kg ha^{-1}) in chick pea was observed due to foliar spray of 0.5% zinc sulphate at flower initiation stage (Masood Ali and Mishra, 2001).

Elamathi and Pradeep (2007) reported that foliar application of DAP 2%, NAA 40 ppm, B @ 0.2% and Mo @ 0.05% at 30 DAS significantly increased the height and dry weight of plants, number of pods $plant^{-1}$, seeds pod^{-1}, test weight and grain yield over control.

Nigamananda and Elamathi (2007) conducted studies on green gram and revealed that 2% foliar spray of DAP and NAA 40 ppm twice at 25 and 35 DAS significantly increased the number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight, number of flowers, fertility coefficient, grain yield and haulm yield. Foliar application of NAA @ 40 ppm at pre flowering stage in black gram influenced growth characteristics by showing increased plant height, more number of branches and higher leaf area index (Jayakumar *et al*., 2008). Foliar spray of 2% DAP in urdbean recorded the highest plant height (39 cm) and number of branches $plant^{-1}$ at harvest (8.48) (Kumar *et al*., 2008).

Foliar nutrition of cowpea significantly increased the number of pods $plant^{-1}$ i.e., 31.7 and 27 per cent increase in number of pods $plant^{-1}$ due to foliar application of 2% DAP and 2% urea, respectively. Number of seeds pod^{-1} was significantly higher in 2% DAP indicating an increase of 14.7% over water spray Significantly higher seed yield of cowpea (1227 kg ha^{-1}) was recorded with foliar spray of 2% DAP, which was 23.9 per cent higher over water spray, but remained at par with 2% urea (1189 kg ha^{-1}) (Choudhary and Yadav, 2011).

Foliar application of cycocel (250 ppm) at one month after sowing of Coriander improved field survival and crop stand. The spray also promoted the yield contributing traits like primary and secondary branches, umbel number, umbellet number, seed number with significant increase in seed yield (Vijayakumar and Sundareswaran, 2011).

Doss *et al*. (2013) observed significant increase in growth, yield components (number of fruits $plant^{-1}$, pod length, number of seeds pod^{-1} and 100 seed weight) and grain yield with foliar application of 2% DAP, 1% K and 200 ppm NAA at 22^{nd} and 30^{th}

day old black gram seedlings. Maximum grain yield was recorded with 1% K + 200 ppm NAA concentration as compared to control.

Satish (2013) in studies on sunflower (DSFH-3) observed that boron spray @ 0.2% recorded significantly higher seed set percentage (76.76%), number of seeds (911.53 head^{-1}), seed weight (1.65 kg plot^{-1}), seed yield (11.75 q ha^{-1}), germination (96.4%) and vigour index (3937) compared to without boron spray.

Shashi Kumar *et al*. (2013) observed that application of RDF as a basal dose and foliar spray of NAA @ 40 ppm + 0.5% chelated micronutrient + 2% DAP at 35 and 50 DAS of black gram recorded significantly higher growth components like plant height (37.1 cm), number of branches (8.3 plant^{-1}), leaf area index (4.18), and total dry matter production (15.98 g plant^{-1}) and also higher grain yield (1298 kg ha^{-1}).

In mash bean, foliar application of 2% DAP significantly improved growth, yield and quality (Venkanna *et al*., 2013). Foliar application of NAA @ 50 ppm at 30 and 37 DAS recorded highest yield (44% increase over control) of green gram by increasing pod number, number of seeds pod^{-1}, length of pod and 1000 seed weight (Ajay Kumar *et al,* 2014).

Gowthami and Rama Rao (2014) revealed that foliar applicationon of potassium nitrate @ 2% + boric acid @ 50 ppm + zinc sulphate @ 1% at 30 and 60 DAS to soybean was found superior in increasing plant height, number of branches, number of leaves, leaf area, total dry matter, number of pods plant^{-1}, test weight and seed yield in soyabean followed by potassium nitrate @ 2% + boric acid @ 50 ppm at 30 and 60 DAS compared to control.

Rajyalakshmi and Rajasekhar, (2014) in African marigold noticed that the foliar spray of NAA (100 ppm), CCC (500 ppm) and manual pinching were compared with control under three dates in August, September and October months. The highest reduction in plant height was recorded with 500 ppm cycocel spray (70.7 cm, 63.3 cm & 40.9 cm, respectively in August, September and October dates of planting). Significant increase in number of side shoots and number of flowers plant^{-1} was recorded due to application of growth retardant cycocel @ 500 ppm.

Surya (2015) reported that vigour of marigold plant was significantly increased due to foliar application of NAA and microelements. The spray of 100 ppm NAA at 15 days after transplanting and 0.5% $ZnSO_4$ at 30 days after transplanting was significantly effective for yield of marigold. Minimum plant height was observed in control, while the maximum height was recorded by NAA 100 ppm.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled "Standardization of seed production techniques in Dhaincha (*Sesbania aculeata*)" was conducted in *kharif*, 2015. The details of the experimental materials used and method adopted during the conduct of the experimental investigation are described hereunder.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The present investigation was carried out at Seed Research & Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *kharif*, 2015. The farm is geographically situated at an altitude of 542.3 m above Mean Sea Level at 17^0 $19^,$ N latitude and 78^0 $28^,$ E longitude and fall under the Southern Telangana Agro-climatic Zone.

3.2 CLIMATE

The monthly meteorological data pertaining to rainfall, temperature, relative humidity and sun shine hours prevailed during crop growth period from June to September was obtained from the Meteorological Observatory located at Agricultural Research Institute, Rajendranagar, Hyderabad. Mean meteorological data during crop growth period at weekly intervals of each month are presented in Appendices I to VI.

3.3 CHARACTERISTICS OF THE EXPERIMENTAL FIELD

A perusal of data on soil properties of experimental field in Table 1 revealed that the soil was neutral in reaction, low in available nitrogen, medium in phosphorus and high in available potassium.

Table 1: Soil properties of the experimental field

S. No.	Parameter	Value
a.	Soil reaction (pH)	7.4
b.	Electrical conductivity (dS m^{-1})	0.214
c.	Available N (kg ha^{-1})	150
d.	Available P_2O_5 (kg ha^{-1})	40
e.	Available K_2O (kg ha^{-1})	300

3.4 EXPERIMENT DETAILS

3.4.1 Field trial

The present experiment (Plate 1) was laid out in a Split plot design with pinching as main treatments and foliar sprays as sub treatments. There are three different levels of main treatments and five different levels of sub treatment. The experiment was conducted with three replications. The details of treatments are furnished below.

Treatments

Main plot: Pinching/Cycocel (3)

M1: With pinching at 20 DAS (Plate 2 and 3)

M2: Without pinching (Plate 4)

M3: Spray of Cycocel @ 75 ppm at peak flowering stage (Plate 5 and 6)

Sub plot: Foliar nutrition (5)

T1 - Foliar spray with DAP @ 2%

T2- Foliar spray with MN Mixture ($ZnS0_4$ @ 0.5% + Boric acid @ 0.3%)

T3- Foliar spray with NAA 40 ppm

T4- Foliar spray with DAP @ 2% + MN Mixture (Zn + B) + NAA

T5- Control

3.5 PACKAGE OF PRACTICES

3.5.1 Land preparation

Field was deep ploughed once with tractor drawn mould board plough followed by two harrowings with disc harrow and later once with cultivator. The land was leveled in order to maintain uniform distribution of rain water and irrigation water to ensure uniform seed germination without stagnation at any one point.

3.5.2 Fertilizer application

Recommended dose of phosphorus and potassium in the form of single super phosphate and muriate of potash, respectively was applied as basal dose to the crop. Nitrogen in the form of urea was given in three equal splits *viz.*, 1/3 as basal, 1/3 at 30 DAS and the remaining 1/3 at flowering stage.

3.5.3 Seeds and sowing

Healthy and bold seeds were selected and hand dibbled to a depth of 3-4 cm by adopting a spacing of 60 x 20 cm. The experiment was sown on 15.06.2015 with fifteen treatments in three replications in the plot size of 24.75 m^2 (15 rows of 2.75 m length each).

3.5.4 Weed control

Pre emergence application of Pendimethalin @ 1.25 kg $acre^{-1}$ was carried out immediately after sowing within one day before the soil gets dried. Further post emergence spraying with pursuit @ 1 ml l^{-1} at 20 to 25 DAS was carried out for the control of broad leaved weeds. Weeding was done manually at 15 and 45 DAS to keep the plot free from weeds.

3.5.5 Harvesting

Harvesting was done when the maturity symptoms were observed. Plot wise threshing and cleaning was done and the seeds were separated (Plates 7 to 12) and seed yield was recorded after thorough drying and expressed in kg ha^{-1}. The border rows were harvested first and treated as bulk and kept separately and sun dried thoroughly. Yield obtained from sample plants were also added to respective treatment yield.

3.6. OBSERVATIONS RECORDED

3.6.1 Plant height (cm)

In each treatment, five normal plants were chosen at random for recording plant height. The plant height was measured from the ground level up to the tip point at 90 days after sowing and at harvest from the tagged plants and the mean value was expressed in centimeter. Average values were computed and expressed as plant height.

3.6.2 Days to first flowering

Number of days from the emergence of first flower to bud formation was recorded from the date of sowing. The average was calculated and expressed as days to first flowering.

3.6.3 Days to 50% flowering

In each treatment, number of days required to 50% flowering was recorded by visual observation and expressed as days to 50% flowering.

3.6.4 Days to maturity

Number of days required to maturity of the crop was recorded by visual observation in each treatment.

3.6.5 Number of branches plant^{-1}

Five tagged plants were used to record number branches plant^{-1} and counted at 60 DAS and harvest.

3.6.6 Number of pods plant^{-1}

At harvest, the total number of matured and filled pods from five tagged plants in each plot was counted, averaged and expressed as number of pods plant^{-1}.

3.6.7 Pod length (cm)

Pods from five plants were selected randomly and the pod length was measured with the help of measuring scale from base to tip of the pod and expressed in centimeters.

3.6.8 Number of seeds pod^{-1}

The total number of matured and filled in pods from tagged plants in each plot were counted, averaged and expressed as number of pods plant^{-1}

3.6.9 Pod yield plant^{-1} (g)

Pods selected for recording pod number and seed number were weighed, average value was computed and expressed as pod yield plant^{-1} in grams.

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

After threshing and cleaning, the weight of seeds of the earlier selected pods was recorded in grams individually. The mean was worked out and expressed as seed yield plant^{-1} in grams.

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

Seed yield obtained from each plot was multiplied with the factor for obtaining seed yield ha^{-1} and it was expressed in quintals.

3.6.12 Seed recovery (%)

Seed recovery percentage for each treatment was calculated as per the following formula

$$\text{Seed recovery (\%)} = \frac{\text{Seed yield plant}^{-1}\text{ (g)}}{\text{Pod yield plant}^{-1}\text{ (g)}} \times 100$$

3.6.13 Number of pickings

During the crop growth period, three pickings were made in each treatment at ten days interval. In each picking, the fully matured pods were harvested and dried.

3.6.14 100 seed weight (g)

Hundred seeds were counted at random from the harvested produce of first and second pickings of each treatment, weighed and recorded in grams.

3.6.15 Seed moisture content (%)

The moisture content of dhaincha seeds was determined by the hot air oven method as per ISTA rules (Anonymous, 1996). Five grams of coarsely ground seed material from each treatment in three replication were dried in a hot air oven maintained at a temperature of 103 ± 10^{O}C for a period of 17 hours. Then samples were cooled in desiccators and moisture content was determined by using the formula given below and expressed in percentage.

$$\text{Moisture content (\%)} = \frac{W2 - W3}{W2 - W1} \times 100$$

W1 = Weight of empty aluminium cup (g)

W2 = Weight of empty aluminium cup with ground seed before drying (g)

W3 = Weight of empty aluminium cup with ground seed after drying (g)

3.6.16 Seed germination (%)

The laboratory test for germination of dhaincha seed was conducted as per the ISTA Rules (Anonymous, 1996) by adopting Between Paper method. One hundred seeds each in four replications were taken from each treatment and uniformly placed on germination paper. The rolled towel was kept in the seed germinator maintained at constant temperature of 25± 0.5^{0}c and 95 per cent relative humidity. The first count and final count were taken on fourth and seventh day, respectively. On the day of final count, the number of seeds germinated as normal seedlings were counted and the per cent seed germination was calculated as follows

$$\text{Seed germination (\%)} = \frac{\text{Number of germinated seedlings}}{\text{Total number of seeds plated}} \times 100$$

3.6.17 Root length (cm)

Ten normal seedlings each from every treatment were randomly selected on seventh day of germination test to measure the root length. The root length was measured from the collar region to the tip of the root. Average root length of ten seedlings was computed and expressed in centimeters.

3.6.18 Shoot length (cm)

Ten randomly selected normal seedlings used for recording root length were used for recording shoot length. The shoot length was measured from the collar region to the apex. The average value was computed and expressed in centimeters.

3.6.19 Total seedling length (cm)

Ten normal seedlings were selected randomly in each treatment from all the replications on the seventh day of germination. The total seedling length was estimated by adding the total root length and shoot length.

3.6.20 Seedling vigour index I

Seedling vigour index was calculated as per the method suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

Seedling vigour index I = Seed germination (%) × Seedling length (cm)

3.6.21 Seedling dry weight (g)

Ten normal seedlings used to estimated seedling dry weight were kept in hot air oven at 85+10 ^{o}c for 24 hours. Later they were removed and cooled in a desiccator for 30 minutes before weighing on an electronic balance. The mean dry weight of the seedlings was recorded and expressed in grams

3.6.22 Seedling vigour index II

Seedling vigour index II was calculated as per the method suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

Seedling vigour index II = Seed germination (%) × Seedling dry weight (g)

3.6.23 Electrical conductivity of seed leachates (dSm^{-1})

The test is based on the leakage of solutes from the cell membrane of the seeds into de-ionized distilled water. The amount of electrolyte leakage was assessed by measuring the electrical conductivity of the seed soaked water with a conductivity meter.

Twenty five undamaged seeds in three replications were taken and the seeds were soaked in 25 ml of distilled water at 25 $\pm$ 1 ºC for 24 h. The electrical conductivity of seed leachates was measured by using digital EC meter at ambient conditions and the average mean of EC was calculated by using the formula illustrated as follows and expressed in dSm^{-1} (Dadlani and Agarwal, 1983).

3.6.24 Speed of germination

Fifty seeds in two replications of 25 seeds from each treatment were placed in petridish containing moistened filter paper. These petridishes were placed in germinator and daily data on germination was recorded. The speed of germination was calculated by adding the quotients of daily counts divided by number of days of germination (Maguire, 1962).

$$\text{Speed of germination} = \frac{N_1}{T_1} + \frac{N_2}{T_2} + \frac{N_3}{T_3} .... \frac{Nx}{Tx}$$

Where `N' is number of seeds germinated at days `T'

3.6.25 Total fungal colonies

Seed health status of dhaincha was estimated under laboratory conditions by using standard blotter method (Anonymous, 1996).

Three layers of blotter papers of 90 mm diameter were dipped in a beaker containing sterile distilled water and were removed by forceps and plated in sterilized petriplate and the blotters were wetted with sterile distilled water (Plate 13). Four hundred seeds from each treatment were plated and incubated at 25 ± 1^0c under alternating cycles of 10 hours light and 12 hours darkness for 7 days in BOD incubator. The plates were examined under stereo binocular microscope on 7^{th} day of incubation and the percentage of total number of fungal colonies were observed under binocular microscope

3.7 Statistical analysis

The data recorded on various parameters during the course of investigation were statistically analyzed duly following the analysis of variance technique for split plot design. The statistical significance was tested with F test at 0.05 level of probability and where ever the F value was found significant, critical difference (CD) was worked out to test the level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the experiment entitled **"Standardization of seed production techniques in Dhaincha (*Sesbania aculeata*)"** conducted during *kharif*, 2015 at Seed Research & Technology Center, Rajendranagar, Hyderabad are presented in this chapter. Experimental data was statistically analysed, apportioned under various heads and furnished in tables and illustrated wherever necessary. The results of the experiment are discussed critically with cause and effect relationship under following headings.

1. Plant height (cm)
2. Days to first flowering
3. Days to 50% flowering
4. Days to maturity
5. Number of branches plant^{-1}
6. Number of pods plant^{-1}
7. Pod length (cm)
8. Number of seeds pod^{-1}
9. Pod yield plant^{-1} (g)
10. Seed yield plant^{-1} (g)
11. Seed yield ha^{-1} (q)
12. Seed recovery (%)
13. 100 seed weight (g) – First picking
14. 100 seed weight (g) – Second picking
15. Seed moisture content (%)
16. Germination (%)
17. Root length (cm)
18. Shoot length (cm)
19. Total seedling length (cm)
20. Seedling vigour index I
21. Seedling dry weight (g)
22. Seedling vigour index II

23. Speed of germination

24. Electrical conductivity of seed leachates (µS cm^{-1})

25. Total fungal colonies

4.1 Plant height (cm)

Data (Table 4.1) on pinching and foliar spray revealed that plant height was significantly influenced by both pinching and foliar sprays.

Increase in plant height (Plate 14) was observed in the treatment without pinching (254.9 cm) and it was significantly higher than with pinching (231.5 cm). Though dhaincha crop exhibited reduction in plant height (250.7 cm) with the spray of cycocel @ 75 ppm it was statistically at par with pinching and without pinching treatments (Fig. 4.1). Thus reduction in plant height is due to retardation of transverse cell division particularly in cambium which is the zone of meristematic activity at base of the inter node (Grossman, 1990). Similar findings were also reported in China aster (Aswath *et al*., 1994) and in African marigold (Kandelwal *et al*., 2003).

Significant decrease in plant height due to pinching (9.18%) could be attributed to relative behaviour of sink and source (Abdali Mashhadin *et al*., 2014). These results are in conformity with the findings of Mishra and Nayak (1997) in jute crop. The reduction might be due to the fact that cycocel acts in the sub-apical system, inhibits cell division, prevents cell elongation due to its anti-gibberellic nature and consequently the plant becomes dwarf as the internodes fail to elongate (Hamer *et al*., 1975, Rajyalakshmi and Rajasekhar, 2014). Cycocel, an anti-gibberellin dwarfing agent leads to deficiency of gibberellin in the plants and reduces growth by blocking the conversion of gurancyl pyrophosphate to copalyl pyrophosphate (Moore, 1980).

Plant height was maximum with S_1 *i.e.* foliar spray with DAP 2% (249.9 cm) and was statistically on par with the other three foliar sprays indicating that spray of foliar nutrients exhibited numerical increase in plant height as compared to the control. Similar results of significant increase in plant height due to foliar nutrition of 2% DAP is in accordance with the findings of Ramesh and Thirumurugan (2001) in soybean, Kathiresan and Duraisamy (2001) in dhaincha and Kumar *et al*. (2008) in urdbean. Significant increase in plant height of black gram was reported with foliar application of NAA @ 40 ppm at 50% flowering stage (Lakshman and Rao, 1996). Shashikumar *et al*.

(2013) reported significantly higher plant height with foliar spray of 40 ppm NAA + 0.5% chelated micronutrient + 2% DAP. Increase in plant height with foliar application could be attributed to the fact that foliar application of nutrients enhance plant vigour and strengthen the stalk (Das, 1999).

Among the interaction effects, the treatment M_2S_3 *i.e.* without pinching and foliar spray of NAA @ 40 ppm recorded maximum plant height of 269 cm and was significantly different from M_1S_2 *i.e.* with pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (230.3 cm), M_1S_3 *i.e.* pinching + foliar spray with NAA 40 ppm (234.6 cm) and M_1S_4 *i.e.* with pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (232.1 cm).

4.2 Days to first flowering

Analysis of the data (Table 4.2) on days to first flowering in dhaincha revealed that dhaincha crop without pinching treatment (30.3 days) and spray of cycocel @ 75 ppm (30.5 days) took less number of days for appearance of first flower (Fig. 4.2). It differed significantly from pinching treatment (34.1 days) indicating that pinching treatment significantly prolonged the days for appearance of the first flower by about 4 days. This can be attributed to reduced GA activity in response to disbudding treatments. Suppressive as well as beneficiary effects of pinching in terms of delayed flowering and increase number of flowering stems have been reported by several researchers (Sawwan and Samawi, 2000; Pathania *et al.,* 2000). Chemicals especially cycocel seem to offset juvenility factor, which in turn to earlier development of reproductive primordial, whereas, pinching promoted vegetative growth resulting in delayed flowering (Ahmad *et al.,* 2007)

In the present study, reproductive efficiency of dhaincha was significantly influenced by various foliar spray treatments. Among the different foliar applications, the treatment S_5: without any foliar nutrition took 32.7 days for initiation of flowering and is at par with S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (31.9 days) and S_1 *i.e.* foliar spray with DAP 2% (31.7 days) and differed significantly from S_3 *i.e.* foliar spray with NAA 40 ppm (31.1 days) and S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (30.8 days). Foliar application of nutrients enhanced the plant vegetative growth and improved the ability of plant for synthesis and storage of metabolites. The favourable effect of foliar application of fertilizers might be due to on account of improved photosynthetic efficiency.

Interaction effect due to pinching/chemical and foliar nutrition indicated that M_1S_5 *i.e.* with pinching + without any foliar nutrition took maximum number of days (36 days) for the appearance of fist flower and is statistically at par with M_1S_2 *i.e.* with pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%). However it is significantly different from other interactive effects.

4.3 Days to 50% flowering

Analysis of variance due to pinching/chemical and foliar nutrition indicated that days to 50% flowering was significantly influenced by pinching/chemical (Table 4.3).

In dhaincha, pinching treatment significantly prolonged days to physiological maturation. Dhaincha crop due to pinching treatment took maximum number of days for 50% of the plants to flower (40.1days) and is significantly different from cycocel spray @ 75 ppm (37.1 days) and without pinching treatment (35.7 days). Though not statistically significant, M_2 treatment *i.e.* without pinching matured 2 days earlier than M_3 *i.e.* foliar application of cycocel @ 75 ppm, which took 37.1 days to attain 50% flowering (Fig. 4.3).

Interaction effect due to pinching and foliar nutrition indicated that M_1S_5 *i.e.* with pinching + without any foliar nutrition took maximum number of days to 50% flowering (41.7 days) and is significantly different from other interaction effects involving M_2 *i.e.* without pinching and M_3 *i.e.* cycocel spray @ 75 ppm.

4.4 Days to maturity

Perusal of data presented in the table 4.4 on days to maturity revealed that days to maturity was significantly influenced by pinching/cycocel and foliar nutritions.

Pinching treatments significantly prolonged days to physiological maturity by about 3 days (86.4 days) which could be due to reduced GA activity in response to disbudding treatments. Though M_3 *i.e.* foliar spray of cycocel @ 75 ppm treatment took more days to attain maturity (83.1 days) compared to without pinching treatments (81.7 days) they were at par with each other (Fig. 4.4).

Among the sub treatments, S_5 *i.e.* without any foliar nutrition took more days for physiological maturity (85.1 days) and is significantly different from S_1 *i.e.*foliar spray with DAP 2% (83.7 days) and S_2 *i.e.* foliar spray with micronutrient mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%) (83.7 days).

Interaction effects due to pinching and foliar nutrition revealed that interactive effects involving pinching treatment took more number of days to maturity and are significantly different from other interaction effects involving both M_2 *i.e.* without pinching and M_3 *i.e.* spray of cycocel @ 75 ppm treatments.

4.5 Number of branches plant^{-1}

Data on number of branches plant^{-1} as influenced by pinching and foliar sprays were presented in Table 4.5.

Branches plant^{-1} was significantly influenced by pinching and foliar nutrition. Increased branches plant^{-1} was recorded with pinching (16.5) and was significantly higher than without pinching (12.6). On the other hand, branches plant^{-1} was higher with the foliar spray of cycocel @ 75 ppm (14.8) and it was statistically at par with pinching and without pinching (Fig. 4.5). The per cent improvement in branches plant^{-1} due to pinching was 30.95% and 11.48% with spray of cycocel as compared to without pinching (Plate 15).

Pinching of the dhaincha crop might have diverted all the food material and led to higher biomass production resulting from more plant growth and development (Kumar and Srivastava, 2013). Removal of apical dominance might have promoted the development of lateral buds thereby resulting in increased branches plant^{-1} (Pathania *et al*., 2000).

The terminal bud clipping practice might have efficiently altered the crop architecture by activating the lateral dormant buds through arresting the terminal growth which in turn increased the lateral branches that led to greater development of source and sink features in sesame and thereby facilitating the significant increase in yield (Singh *et al*., 2013, Kokilavani *et al*., 2007 and Imayavaranban, 2000).

Among the foliar sprays, maximum number of branches plant^{-1} (15.6) was recorded with S_2 *i.e* foliar spray with micronutrient mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%) and was statistically at par with other three foliar nutritions and control indicating that spray of foliar nutrients exhibited numerical increase in branches plant^{-1} as compared to the control. The increase in branches plant^{-1} might be due to increased supply and availability of secondary elements and micronutrients like S, Zn, and B that are necessary for the growth and development of the crop.

Among the interaction effects, M_1S_1 *i.e.* with pinching and foliar spray with DAP 2% recorded highest number of branches (19.3). It is statistically on par with majority of the interaction effects except M_1S_3 *i.e.* pinching + foliar spray with NAA 40 ppm (18.4) and M_3S_2 *i.e.* foliar application of cycocel @ 75 ppm + foliar nutrition with micronutrient mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%) (18.0).

4.6 Number of pods plant^{-1}

Analysis of the data on pods plant^{-1} of dhaincha crop as influenced by pinching and foliar nutrition revealed that pods plant^{-1} was significantly influenced by both pinching and foliar sprays (Table 4.6).

Highest number of pods plant^{-1} was recorded with pinching (28.2) and it was significantly higher than without pinching (22.0). Though dhaincha crop exhibited reduction in pods plant^{-1} (24.7) with the spray of cycocel @ 75 ppm, it was statistically on par with pinching and without pinching treatments (Fig. 4.6).

The removal of terminal buds directly/indirectly by both pinching and spraying of chemical increased the number of pods plant^{-1}. Maximum increase in pod number was observed in pinched plants, which exhibited 28.18% increase and with spray of cycocel (12.27%) over control.

Results of the present experiment signify the better performance of pinching and cycocel as they reduced plant height compared to control. The effectiveness of pinching may probably be due to the change induced in the rate of cell division in the meristematic region (Ahmad *et al*., 2007) thereby reducing the plant height promoting the development of increased number of healthy branches and flowers (Pathania *et al*., 2000) resulting in increase in the pod number. Further, the effectiveness of chemicals on pod production might be due to their retarding effect on apical growth, which in turn encouraged side branches (Ahmad *et al*., 2007).

Among foliar applications, S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) significantly recorded higher number of pods plant^{-1} (27.2) and it was significantly superior with S_4 *i.e.* foliar spray of DAP 2% + micronutrient mixture (Zn + B) + NAA (24.5) and S_1 *i.e.* foliar spray with DAP 2% (22.7). The significant increase in number of pods with foliar application of zinc and boron could be attributed to increase in the number of branches plant^{-1}. These micronutrients play an important role in various physiological and biochemical processes and might contribute to the growth of the meristematic regions (Cakmak *et al*., 2000) and enhancing growth of plants in green gram (Elamathi and Pradeep, 2007). Boron plays an important role in cell division, cell differentiation, development, calcium utilization, translocation of photosynthates and growth regulators from source to sink, which in turn helps in maintaining higher leaf area, leaf area index and higher number of pods and pod weight plant^{-1} (Kalyani *et al.*, 1993). Further, boron plays an important role in preventing flower and pod drop, thereby retaining higher number of pods plant^{-1} (Seifinadergholi *et al.*, 2011). Similarly, the retention of flowers and pods can be increased by either foliar application of nutrients or plant growth regulators as reported by Sharma and Dey (1986) in green gram.

Among the interaction effects, M_1S_2 *i.e.* pinching of the dhaincha crop at 20 DAS in combination with foliar spray of micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid (0.3%) recorded maximum pods plant^{-1} (31.2) and it was significantly different from M_1S_1 *i.e.* pinching and foliar spray with DAP 2% (25.6) and M_1S_4 *i.e.* pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (26.0). The difference in pod number may be attributed to better utilization of resources from soil (Ajay Kumar, 2014).

4.7 Pod length (cm)

Perusal of the data on pod length (Table 4.7) revealed that pod length was not influenced by both pinching and foliar applications.

Though dhaincha crop recorded maximum pod length with spray of cycocel @ 75 ppm (24.2 cm), it was statistically on par with pinching (23.7 cm) and without pinching (24.1 cm) treatments (Fig. 4.7) indicating that mechanical pinching and use of cycocel had no significant impact on improving the length of the pod. These results are in contrary with the finding of Reddy *et al*. (2009) who reported significant increase in pod length in cowpea.

Pod length was maximum with S_3 *i.e.* foliar spray with NAA 40 ppm (24.3 cm) and was statistically on par with other three foliar spays and control indicating that spray of NAA @ 40 ppm exhibited numerical increase in pod length as compared to the control and other foliar applications. These results are in agreement with the findings of Ganiger *et al*., 2002 and Ajay Kumar *et al*. (2014).

Interaction effect of pod length of dhaincha crop as influenced by pinching and foliar applications revealed that M_3S_2 *i.e.* spray of cycocel in combination with foliar application of micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) and M_3S_3 *i.e.* spray of cycocel in combination with foliar application of NAA 40 ppm recorded maximum pod length of 24.5 cm and was significantly different from M_1S_2 *i.e.* pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (22.9 cm) and M_2S_4 *i.e.* without pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (23.3 cm).

4.8 Number of seeds pod^{-1}

Seeds pod^{-1} of dhaincha crop as influenced by both pinching and foliar nutrition (Table 4.8) indicated that seeds pod^{-1} was significantly influenced by pinching.

Maximum number of seeds pod^{-1} was recorded with foliar spray of cycocel @ 75 ppm (34.6) and it was significantly different from pinching (33.0). Though dhaincha crop exhibited reduction in number of seeds pod^{-1} (34.1) without pinching treatment, it was statistically on par with the treatments pinching and cycocel spray @ 75 ppm (Fig 4.8). These results are in agreement with the findings of Pourmohammad *et al.* (2014) who reported significant increase in seed number due to foliar spray with cycocel in rapeseed. However, Tripathi *et al.* (2013) reported that different topping practices in sunhemp did not exert any significant influence on number of seeds pod^{-1} and test weight.

Among the sub treatments, S_3 *i.e.* foliar spray with NAA 40 ppm (34.2) and S_1 *i.e.* foliar spray with DAP 2% recorded significantly maximum seeds pod^{-1} (34.2) and was at par with the other treatments namely S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (33.8), S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B + NAA) (33.6) and control (33.9). Similar increase in seeds pod^{-1} due to application of NAA (50 ppm) in cowpea (Ganiger *et al.*, 2002 and Jayaram and Ramaiah,, 1980)

Interaction effect of seeds pod^{-1} as influenced by pinching and foliar sprays indicated that M_3S_3 *i.e.* cycocel spray @ 75 ppm along with foliar application of NAA @ 40 ppm recorded maximum seeds pod^{-1} (35.5) and it was significantly different from S_4 *i.e.* foliar nutrition with DAP 2% + micronutrient mixture (Zn + B) + NAA of the same main treatment (33.8) and M_1S_1 *i.e.* with pinching + foliar spray with DAP 2% (33.2), M_1S_2 *i.e.* with pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (31.9), M_1S_4 *i.e.* with pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (33.4), M_1S_5 *i.e.* with pinching + without foliar nutrition (33.0). The use of growth regulators is one of the potent factors for improving the growth of the crop, flower and pod setting, seed yield and quality. The growth rate of plants are greatly influenced by the environment and growth substances, including exogenously applied growth regulators (Raghava *et al.*, 1996) which in turn stimulate growth, flower initiation and pod setting of pulse crops (Devi *et al.*, 2011). Improvement in growth characters in green gram by growth regulators application have been reported by Parmar *et al.* (2012).

4.9 Pod yield plant^{-1} (g)

Perusal of the data on pod yield plant^{-1} of dhaincha crop as influenced by pinching and foliar applications presented in Table 4.9 showed that pod yield plant^{-1} was not significantly influenced by pinching and foliar applications.

Though maximum pod yield plant^{-1} of dhaincha was recorded with pinching treatment (289.14 g) it was statistically on par with without pinching treatment (251.90 g) and spray of cycocel @ 75 ppm (243.20 g) (Fig. 4.9).

Among the different foliar applications, S_3 *i.e.* foliar spray with NAA 40 ppm has recorded significantly higher pod yield plant^{-1} (266.37 g) and it was numerically superior over S_5 *i.e.* control (264.15 g), S_2 *i.e.* foliar spray with micronutrient mixture $ZnS0_4$ 0.5% + Boric acid 0.3%, (263.86 g), S_1 *i.e.* foliar spray with DAP 2% (261.88 g) and S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (250.81 g), indicating that spray of secondary nutrients, micronutrients and growth promoting substances did not have any significant impact on enhancing pod yield plant^{-1}

Among the interaction effects, the treatment M_1S_3 *i.e.* with pinching and foliar application of NAA @ 40 ppm recorded maximum pod yield (331.33 g) followed by M_1S_5 *i.e.* with pinching + without any foliar nutrition (303.29 g) and it was statistically on par with M_1S_2 *i.e.* with pinching + foliar spray with micronutrient mixture $ZnS0_4$ 0.5% + Boric acid 0.3%, (285.88 g) and M_1S_1 *i.e.* with pinching + foliar spray with DAP 2% (277.07 g). However, it was on par with M_1S_4 *i.e.* with pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (248.12 g). With rest of the interaction effects it was significantly different from M_2S_3 *i.e.* without pinching + foliar spray with NAA @ 40 ppm (244.11 g), M_2S_4 *i.e.* without pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (237.57 g), M_3S_1 *i.e.* spray of cycocel @ 75 ppm + foliar nutrition with DAP2% (239.25 g), M_3S_3 *i.e.* spray of cycocel @ 75 ppm + foliar spray with NAA 40 ppm (233.68 g) and M_3S_5 *i.e.* foliar spray of cycocel @ 75 ppm + without any foliar nutrition (233.04 g).

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

Perusal of the data (Table 4.10) on seed yield plant^{-1} of dhaincha revealed that seed yield plant^{-1} was significantly influenced by both pinching and foliar nutrition.

Increase seed yield plant^{-1} was observed with M_1 *i.e.* with pinching (187.29 g) and was significantly superior over M_3 *i.e.* foliar spray with cycocel @ 75 ppm (149.99 g) and M_2 *i.e.* without pinching (155.81 g) (Fig. 4.10). Apical topping breaks the apical dominance and induces development of lateral branches thereby increasing the sites for pod development. The practice of topping has proved to be effective in increasing the yield levels of different crops like jute (Bhattacharjee and Mitra, 1999) and Indian mustard (Singh *et al.*, 2013). Observed yield advantage in response to the removal of buds and younger leaves may be attributed to the prolonged canopy life of the plant which enables the plant to produce adequate photo assimilates for an extended period.

Among the sub plots, S_2 *i.e.* foliar spray with micro nutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% resulted in maximum seed yield plant^{-1} (168.22 g) and it was statistically different from other three foliar sprays and control.

Interaction effect of dhaincha crop as influenced by pinching and foliar sprays indicated that M_1S_3 *i.e.* with pinching + foliar spray with NAA @ 40 ppm (217.15 g) was found superior for seed yield plant^{-1} and it was significantly different from other interaction effects involving the other two main treatments *i.e.* without pinching and foliar spray of cycocel @ 75 ppm except M_3S_4 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA treatment.

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

Yield is the ultimate economic produce of the crop which is determined by number of pods, seed weight as governed by the management practice and its native genetic potential. The data pertaining to seed yield of dhaincha crop is influenced by pinching and foliar nutrition and interaction effects are presented in Table 4.11.

Increased seed yield was recorded with pinching treatment (24.05 q ha^{-1}) and was significantly higher than with spray of cycocel @ 75 ppm (22.33 q ha^{-1}) and without pinching (20.35 q ha^{-1}) treatments. Though spray of cycocel recorded reduced seed yield ha^{-1}, it was significantly different from without pinching (20.35 q ha^{-1})

treatment (Fig. 4.1). The per cent increase in seed yield noticed with pinching was 15.38% over control and 7.70% over cycocel spray 75 ppm. The maximum yield observed under the effect of pinching might be attributed to growth characteristics which resulted in considerable improvement in yield attributing characters like pods plant^{-1} and seed yield plant^{-1} and finally reflected into yield. Further, more branches plant^{-1} under pinching treatment might have had multiplicative effect on seed yield. The increase in seed yield recorded with un pinched plants may be attributed to diversion of photosynthates and metabolites produced by leaves to strong carbohydrate sinks (pods) when compared to meristem in un pinched plants (Tripathi *et al*., 2013). The results are in confirmity with the findings of Bhattacharjee and Mitra (1999) and Jagannatham *et al*. (2008) in Mesta, Lakshmi *et al.* (1995) in Mesta, Kathiresan Duraisamy (2001) in *Sesbania*.

Among different foliar applications, maximum seed yield ha^{-1} (25.27 q ha^{-1}) was recorded with S_2 *i.e.* foliar spray with micronutrient mixture $ZnS0_4$ 0.5% + Boric acid 0.3% followed by S_3 *i.e.* foliar spray with NAA 40 ppm (23.35 q ha^{-1}). They were statistically on par with the other two foliar sprays and control *i.e.* S_1: foliar spray with DAP 2% (22.91 q ha^{-1}), S_4: foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (18.82 q ha^{-1}) and S_5: without any foliar nutrition (20.89 q ha^{-1}). The superiority in performance might be attributed to the prolonged assimilation activity of leaves thereby ensuring a considerable yield advantage (Vasilas *et al.*, 1980).

Further, the foliage applied nutrients at the critical stages of the crop were effectively absorbed by the plant and translocated to the developing pods, producing more number of pods, more filling and higher yield. Significant improvement in seed yield with spray of secondary nutrients like sulphur, micronutrients like zinc and boron indicate that these nutrients play an important role in several enzymatic processes and are necessary for growth and development of the crop. They further contribute to increased branches, pods and seed yield. This could be attributed to the fact that boron plays an important role in cell divisions, cell differentiation, development, calcium utilization, translocation of photosynthates and growth regulators from source to sink, and help in maintaining higher leaf area, leaf area index and higher number of pods plant^{-1} (Kalyani *et al.*,1993). It also helps in preventing flower drop, pod drop and there by maintaining higher number of pods plant^{-1}

Among the interaction effects due to pinching and foliar applications, M_3S_2 *i.e.*

spray of cycocel @ 75 ppm + foliar application of micronutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% recorded maximum seed yield (27.98 q ha^{-1}) and it was significantly different from other foliar sprays involving the same main treatment *i.e.* $S_{1:}$ foliar spray with DAP 2% (24.19 q $^{-1}$), S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (18.72 q ha^{-1}) and control (20.89 q $^{-1}$).

4.12 Seed recovery (%)

Scrutiny of data on per cent seed recovery (Table 4.12) revealed that it was neither influenced by pinching/cycocel treatment nor by different foliar nutritions. Interaction effect due to pinching and foliar nutrition was found non significant.

4.13 100 seed weight – First picking (g)

Perusal of the data on 100 seed weight of the produce obtained from first picking of dhaincha crop as influenced by pinching and foliar sprays revealed that 100 seed weight was significantly influenced by pinching and cycocel treatment (Table 4.13). However, the differences due to foliar nutrition were found non-significant.

An increase in 100 seed weight of dhaincha was observed with M_3 *i.e.* foliar spray of cycocel @ 75 ppm (2.20 g) and it was significantly superior over M_2 *i.e* without pinching (2.00 g) and M_1 *i.e.* with pinching (2.04 g) treatments. These results are in conformity with the findings of Pourmohammad *et al.* (2014) who reported significant increase in 1000 seed weight with foliar spray of cycocel. Other workers Tomar *et al*. (2004), Bhat and Shepherd (2007) observed significant reduction in 1000 seed weight due to pinching treatment. Reduction in individual flower size and weight under pinching might have produced smaller seeds which in turn might have reduced the 1000 seed weight. However, Mohanthy *et al*. (2015) and Sunitha *et al*. (2007) in African marigold observed that seed weight was higher in pinching treatment compared to no pinching. On the other hand, Tripathi *et al*. (2013) reported non-significant difference in test weight of sunhemp due to topping.

Among the sub plots, the treatment S_2 *i.e.* foliar spray with micronutrient mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%) recorded maximum seed weight of 2.10 g and it was statistically on par with the other three foliar sprays and control indicating that application of foliar nutrients did not have any significant impact on increasing the seed weight. These results are in agreement with the findings of Elamathi and Pradeep, (2007) and Nigamananda and Elamathi (2007) in green gram.

Interaction effect as influenced by pinching and foliar sprays showed that M_3S_2

i.e. spray of cycocel @ 75 ppm + foliar nutrition with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) recorded maximum 100 seed weight of 2.25 g and it was statistically at par with M_3 (spray of cycocel @ 75 ppm at peak flowering stage) in combination with different foliar applications. However, it was significantly different from other interaction effects involving both pinching and without pinching treatments.

4.14 100 seed weight - Second picking (g)

Data pertaining to 100 seed weight of the produce obtained from second picking of dhaincha crop as influenced by pinching/cycocel spray and foliar nutrition is depicted in Table 4.14.

An increase in 100 seed weight of dhaincha was observed with M_2 *i.e.* without pinching treatment (2.19 g) and it was significantly superior over the treatments M_3 *i.e.* foliar spray of cycocel @ 75 ppm (2.12 g) and M_2 *i.e* without pinching (2.11 g) (Fig. 4.13).

In general, seed weight of the produce obtained from second picking (2.13 g) was bold compared to the seed realized from first picking (2.08 g). Highest seed weight of 2.17 g was observed with S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) and was statistically on par with other foliar sprays *i.e.* S_1 : foliar spray with DAP 2% (2.13 g), S_3: foliar spray with NAA 40 ppm (2.10 g), S_4 : foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (2.17 g) and control (2.12 g). Bold seeds recorded with foliar application of Zn, S and boron might be due to boron which played a pivotal role in translocation of assimilates to developing sink (Elamathi and Pradeep 2007).

Interaction effect of 100 seed weight revealed that the treatment M_2S_2 *i.e.* without pinching and foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) recorded maximum 100 seed weight of 2.23 g and it was statistically on par with other foliar applications. However, it was significantly different from the treatments M_1S_5 *i.e.* pinching + without any foliar nutrition (2.06g) and M_1S_3 *i.e.* pinching + foliar spray with NAA 40 ppm (2.04 g).

4.15 Seed moisture content (%)

The data pertaining to seed moisture content with the harvested produce revealed that seed moisture content was significantly influenced by both pinching and foliar applications (Table 4.15).

Seed moisture content recorded was maximum with without pinching treatment (11.1%) and it was significantly higher than with pinching (10.7%). Though dhaincha crop exhibited reduction in moisture content (10.9%) with the spray of cycocel @ 75 ppm, it was statistically on par with without pinching treatment (Fig. 4.14).

Among the foliar nutritions, the treatment S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA and S_5 *i.e.* control has recorded significantly higher moisture (11.0%) and it was superior over S_3 *i.e.* foliar spray with NAA 40 ppm (10.9%), and S_2 : foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (10.9%) and differed statistically from S_1 *i.e.* foliar spray with DAP 2% (10.6%)

Among the interaction effects, the treatment combination M_2S_2 *i.e.* without pinching and foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) recorded maximum moisture (11.2%) and it was significantly different from any other sub treatment involving pinching.

4.16 Seed germination (%)

Germination percentage of dhaincha seed as influenced by both pinching and foliar sprays are presented in Table 4.16, indicated that germination percentage did not differ significantly among the main treatments. Though numerically more germination percentage was recorded without pinching cycocel (98.7%) it was statistically on par with cycocel spray @ 75 ppm (96.7%) and with pinching (96.6%) treatments. (Fig. 4.15).

Among the sub treatments, maximum germination percentage was recorded with S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (98.1%) and it was statistically on par with other three foliar applications. But significantly differed from S_3 *i.e.* foliar spray with NAA 40 ppm.

Interaction effect of different main and sub treatments indicated that germination percentage of the seedlings was more influenced by pinching and foliar applications. The treatment M_3S_1 *i.e.* combination of foliar spray of cycocel @ 75 ppm and foliar spray with DAP 2% recorded maximum germination of 99.1% and it was statistically on par with all other interaction effects except M_1S_3 *i.e.* with pinching and foliar spray with NAA 40 ppm.

4.17 Root length (cm)

Studies conducted on the root length (cm) of the seedlings of dhaincha as influenced by pinching and foliar nutrition are presented in Table 4.17.

Maximum root length of the seedling recorded with the seeds obtained from without pinching was 8.2 cm and it was statistically on par with pinching (7.7 cm) treatment (Fig. 4.16). However, the root length was significantly different from foliar spray of cycocel @ 75 ppm (6.9 cm).

Among different foliar applications, there was no significant improvement in the root length of the seedlings.

Among the interaction effects M_2 S_3 *i.e.* without pinching and foliar spray with NAA 40 ppm recorded maximum root length 8.6 cm and it was statistically on par with different foliar nutrition's of the same treatment. However, the treatment combination M_2S_3 *i.e.* without pinching and foliar spray with NAA 40 ppm was significantly different form M_3S_1 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with DAP 2% (7.0 cm), M_3S_2 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) (6.6 cm), M_3S_3 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with NAA 40 ppm (6.6 cm), M_3S_4 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (6.7 cm) and M_1S_5 *i.e.* with pinching + without foliar nutrition (8.2 cm).

4.18 Shoot length (cm)

Perusal of the data (Table 4.18) on shoot length of dhaincha seedlings revealed that shoot length was significantly influenced by pinching/cycocel spray.

Though dhaincha crop recorded maximum shoot length with M_2 *i.e.* without pinching (15.8 cm) it was statistically on par with pinching (15.0 cm) and significantly different from cycocel spray @75 ppm (9.8 cm) (Fig. 4.17). The per cent reduction in shoot length observed with cycocel spray was 38%. However, the reduction in shoot length noticed with pinching treatment was only 5.06%.

Application of different foliar nutrients did not make any significant difference in improving the shoot length of the seedlings.

Interaction effect of shoot length of the seedlings as influenced by pinching and foliar sprays indicated that the treatment combination M_2S_3 *i.e.* without pinching and foliar application of NAA 40 ppm recorded maximum shoot length of 16.6 cm and it was significantly different from M_2S_5 *i.e.* without pinching + without foliar nutrition and with any other treatment involving cycocel spray.

4.19 Total seedling length (cm)

Scrutiny of the data on total seedling length presented in Table 4.19 shows that total seedling length was significantly influenced by pinching/cycocel spray.

Maximum seedling length was recorded with M_2 *i.e.* without pinching (23.9 cm) treatment and it was statistically on par with M_1 *i.e.* with pinching (22.7 cm) and significantly different from M_3 *i.e.* foliar spray with cycocel @ 75 ppm (16.7) (Fig. 4.18).

Non-significant differences were noticed among the different sub treatments *i.e.* foliar application of nutrients.

Interaction effect due to pinching and foliar applications indicated that maximum seedling length was observed with the treatment combination M_2S_3 *i.e.* without pinching and foliar spray with NAA 40 ppm (25.2 cm) and it was at par with other interaction effects involving both pinching and without pinching treatments. However, it was statistically significant with other interaction effects involving cycocel spray.

4.20 Seedling vigour index I

Scrutiny of data on seedling vigour index I of the seedlings indicated that seedling vigour index I was significantly influenced by pinching and spray of growth retardant cycocel (Table 4.20). However, the seedling vigour index I was not significantly influenced by different foliar applications.

Maximum seedling vigour index I was recorded with without pinching treatment (2364), and it was statistically on par with pinching (2220). Though dhaincha crop exhibited low seedling vigour index I (1623) with foliar spray of cycocel @ 75 ppm, it was significantly different from without pinching and with pinching (Fig. 4.19).

Among different sub treatments, foliar nutrition did not make any significant difference in improvement of seedling vigour index I. Among different foliar applications, the treatment S_5 *i.e.* without any foliar nutrition (2123) recorded significantly higher seedling vigour index 1 than other three foliar treatments *viz.*, S_3

i.e. foliar spray with NAA 40 ppm (2108), S_2 *i.e.* foliar spray with micronutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% (2051), S_1 *i.e.* foliar spray with DAP 2% (2043) and S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (2034).

Interaction effect of seedling vigour index I as influenced by pinching and foliar sprays indicated that the treatment combination M_2S_3 *i.e.* without pinching + foliar spray with NAA 40 ppm recorded maximum seedling vigour index 1 of 2520 and was significantly different from M_1S_1 *i.e.* with pinching + foliar spray with DAP 2% (2145), M_1S_4 *i.e.* with pinching + foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA (2187), and all other sub treatments involving cycocel spray @ 75 ppm. It can be to noted that spray of cycocel registered low seedling vigour index. The significant reduction in seedling vigour index I with spray of cycocel 75 ppm at 20 DAS could be attributed to the significant reduction in root length, shoot length and seedling length. Further, decrease in germination percentage was noticed with M_3 treatment *i.e.* spray of cycocel @ 75 ppm. Since seedling vigour index I is the product of germination and seedling length, significant reduction could be attributed to concomitant reduction in seedling length and germination percentage as the decrease in germination percentage is one the affecting factors of the seed vigour index.

4.21 Seedling dry weight (g)

Perusal of the data on dry weight (g) of dhaincha seedlings presented in Table 4.21 indicates that seedling dry weight was significantly influenced by pinching and spray of cycocel @ 75 ppm at 20 DAS.

Among the main treatments, seedling dry weight was observed to be highest with M_3 *i.e.* foliar spray of cycocel @ 75 ppm (0.0092 g) and was significantly superior over M_2 *i.e.* without pinching (0.009 g) and M_1 *i.e.* with pinching (0.0089 g) (Fig. 4.20).

Among sub plots, application of DAP, micronutrients like Zn, B and growth promoting substance like NAA did not exhibit any significant improvement in the dry weight of the seedlings.

Interaction effect due to pinching and foliar applications showed that the treatment combination M_3S_4 *i.e.* spray of cycocel @ 75 ppm and foliar application of DAP 2% + micronutrient mixture (Zn + B) + NAA recorded maximum seedling dry weight of 0.0094 g and is at par with majority of the interaction effects except with M_1S_3 *i.e.* with pinching and foliar spray with NAA 40 ppm (0.0086 g), M_1S_5 *i.e.*

pinching in combination with no foliar nutrition (0.0086 g), M_2S_2 *i.e.* without pinching and foliar spray with micronutrient mixture $ZnSo_4$ 0.5% + Boric acid 0.3% (0.0086 g).

4.22 Seedling vigour index II

Perusal of the data on seedling vigour index II as influenced by pinching and foliar applications presented in Table 4.22 indicated that seedling vigour index II was not significantly influenced by pinching and foliar application of chemicals. Maximum seedling vigour index II was recorded with M_3 *i.e.* foliar spray with cycocel @ 75 ppm (0.899) followed by M_2 *i.e.* without pinching (0.886) and M_1 *i.e.* with pinching (0.873) (Fig. 4.21).

Among the sub treatments, increased seedling vigour index II was recorded with foliar spray with DAP 2% (0.901) and was statistically on par with other three foliar treatments and control.

The interaction among different treatment combinations of pinching/cycocel spray and foliar nutrition on seedling vigour index II was non-significant. However, the treatment combination M_1S_1 *i.e.* with pinching and foliar spray with DAP 2% and M_2S_5 exhibited maximum seedling vigour index II (0.918).

The seed quality traits like germination (%), root length and seed vigour index were significantly maximum in single pinching followed by no pinching (Mohanty *et al.*, 2015). The results are in conformity with the findings of Tomar *et al.* (2004), Bhat and Shepherd (2007) and Sunitha *et al.* (2007).

4.23 Speed of germination

Scrutiny of the data on speed of germination presented in Table 4.23 revealed that speed of germination was significantly influenced by both pinching and foliar nutrition.

Maximum speed of germination was recorded with pinching treatment (25.73) and it was significantly higher than without pinching (18.16). Though dhaincha crop exhibited reduction in speed of germination (24.12) with the spray of cycocel @ 75 ppm, it was statistically on par with pinching treatment and significantly different from without pinching (Fig. 4.22).

Among the foliar applications, S_3 *i.e.* foliar spray with NAA 40 ppm has recorded significantly higher speed of germination (23.91) followed by S_1 *i.e.* foliar spray with DAP 2% (23.77), S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn+B) + NAA (22.26) and control (22.67).

Interaction effect due to pinching and foliar applications indicated that the treatment combination M_1S_3 *i.e.* with pinching + foliar spray with NAA 40 ppm recorded maximum speed of germination (29.27) and it was on par with M_1S_1 *i.e.* with pinching + foliar spray with DAP 2% (27.67), M_1S_5 *i.e.* with pinching + control (25.58), and M_1S_2 *i.e.* with pinching + foliar spray with micronutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% (24.47) and were significantly superior over control (25.58 g).

4.24 Electrical conductivity of seed leachates (µS cm^{-1})

Scrutiny of data (Table 4.24) on electrical conductivity revealed that electrical conductivity was neither significantly influenced by pinching nor by foliar applications. Though numerically higher electrical conductivity was recorded with foliar spray of cycocel @ 75 ppm (4.2 µS cm^{-1}) it did not differ significantly from without pinching (3.9 µS cm^{-1}) and with pinching (4.0 µS cm^{-1}) treatments. Among the different foliar applications, S_5 *i.e.* control has recorded numerically higher electrical conductivity (4.2 µS cm^{-1}) and was statistically on par with other foliar applications.

Interaction effect as influenced by pinching and foliar nutrition indicated that the treatment combination M_3S_5 *i.e.* spray of cycocel @ 75 ppm and without foliar nutrition recorded maximum electrical conductivity (4.7 µS cm^{-1}) and it was significantly different from M_1S_2 *i.e.* with pinching and foliar spray with micronutrient mixture $ZnS0_4$ 0.5% + Boric acid 0.3% (3.5 µS cm^{-1}) and M_3S_2 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with micronutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% (3.6 µS cm^{-1}).

4.25 Total fungal colonies

Data on seed infection after harvest of dhaincha crop was presented in Table 4.25. Total fungal colonies of dhaincha was significantly influenced by pinching and foliar sprays.

Maximum seed infection was recorded with cycocel spray @ 75 ppm (0.6) and it was significantly higher than with pinching (0.53) and without pinching (0.3) (Fig. 4.23).

Among the foliar sprays maximum seed infection per cent (0.8) was recorded with S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA which was significantly superior over the other three treatments.

Interaction effect showed that fungal colonies of seed were more influenced by pinching and foliar application. The treatment combination M_3S_2 *i.e.* foliar spray of cycocel @ 75 ppm + micronutrient mixture $ZnSO_4$ 0.5% + Boric acid 0.3% (1.3) was maximum when compared with other treatments and control.

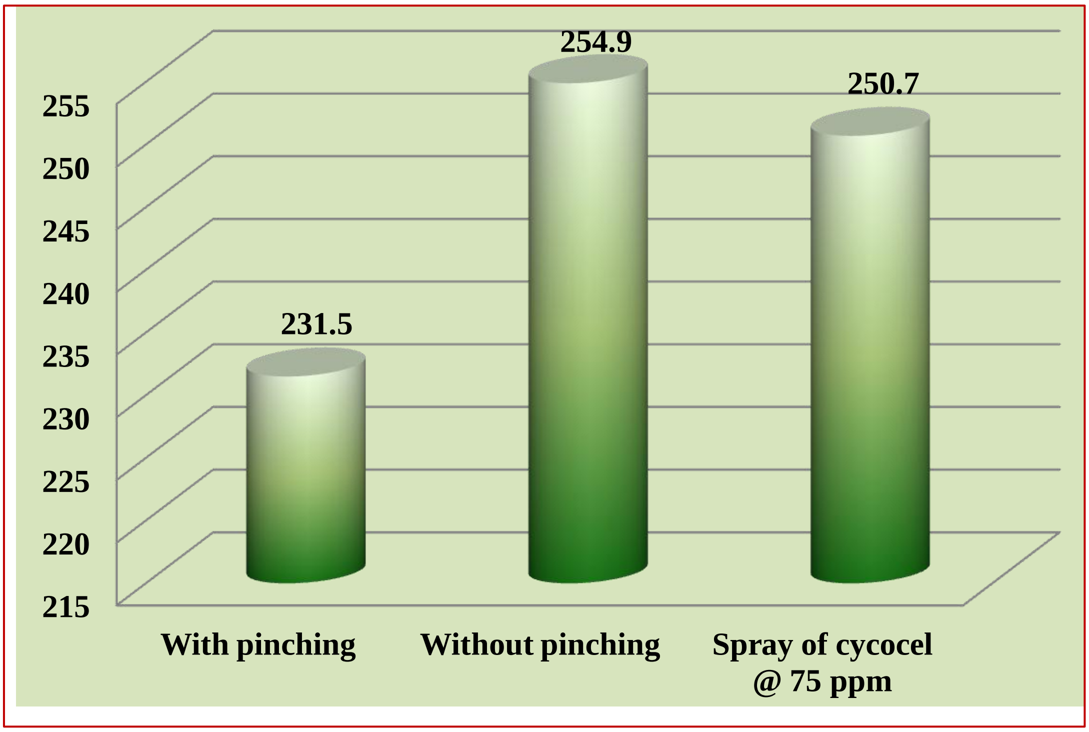

Fig. 4.1 Influence of pinching/cycocel on plant height (cm) of dhaincha during *Kharif*, 2015

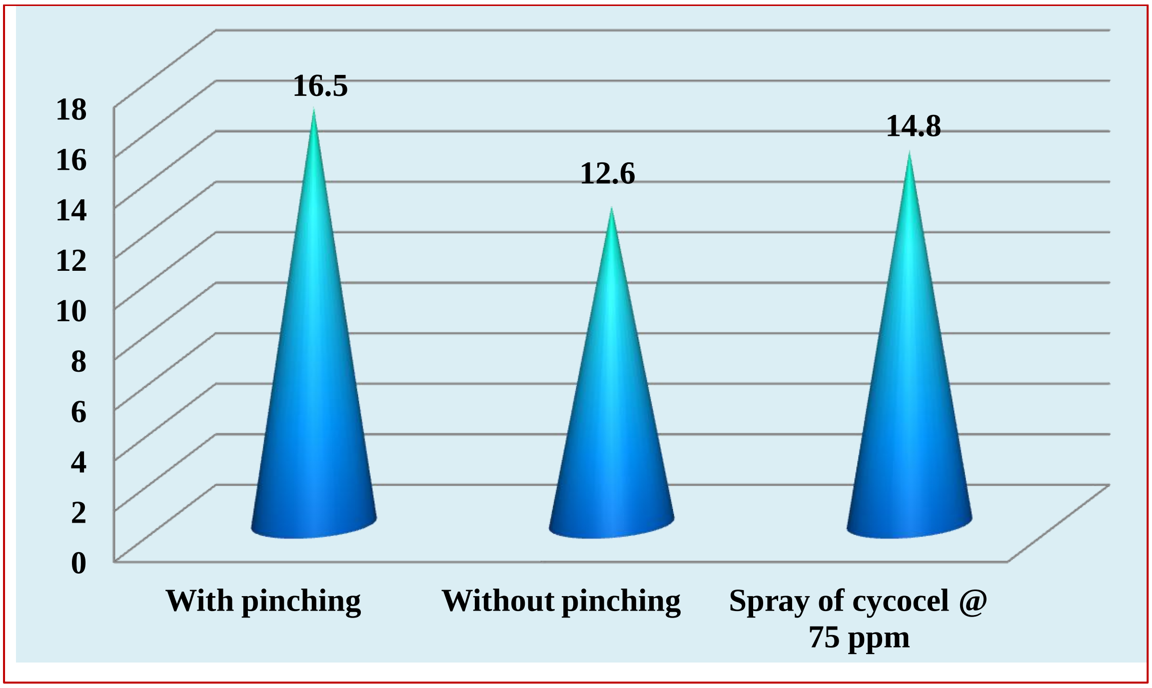

Fig. 4.5 Influence of pinching/cycocel on number of branches plant^{-1} of dhaincha during *Kharif*, 2015

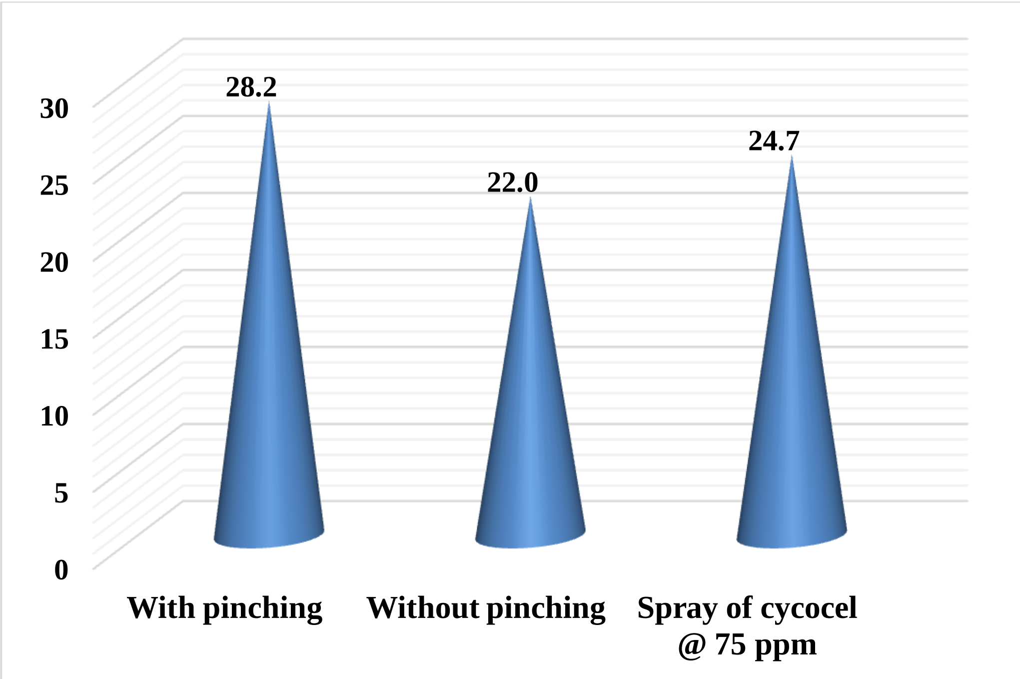

Fig. 4.6 Influence of pinching/cycocel on number of pods plant^{-1} of dhaincha during *Kharif*, 2015

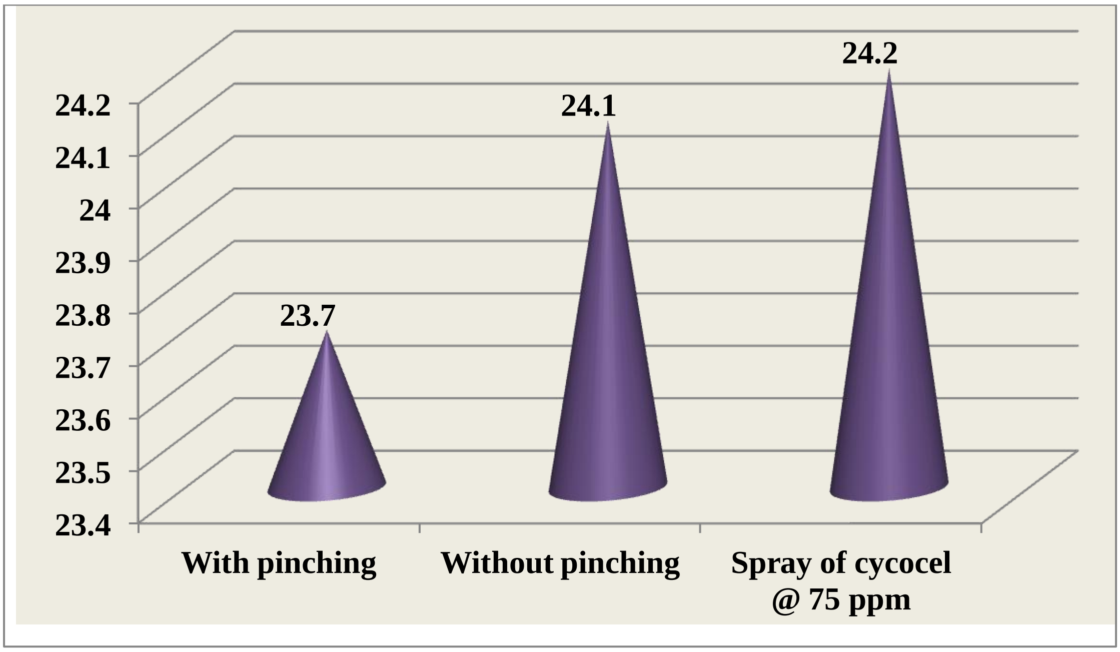

Fig. 4.7 Influence of pinching/cycocel on pod length (cm) of dhaincha during *Kharif*, 2015

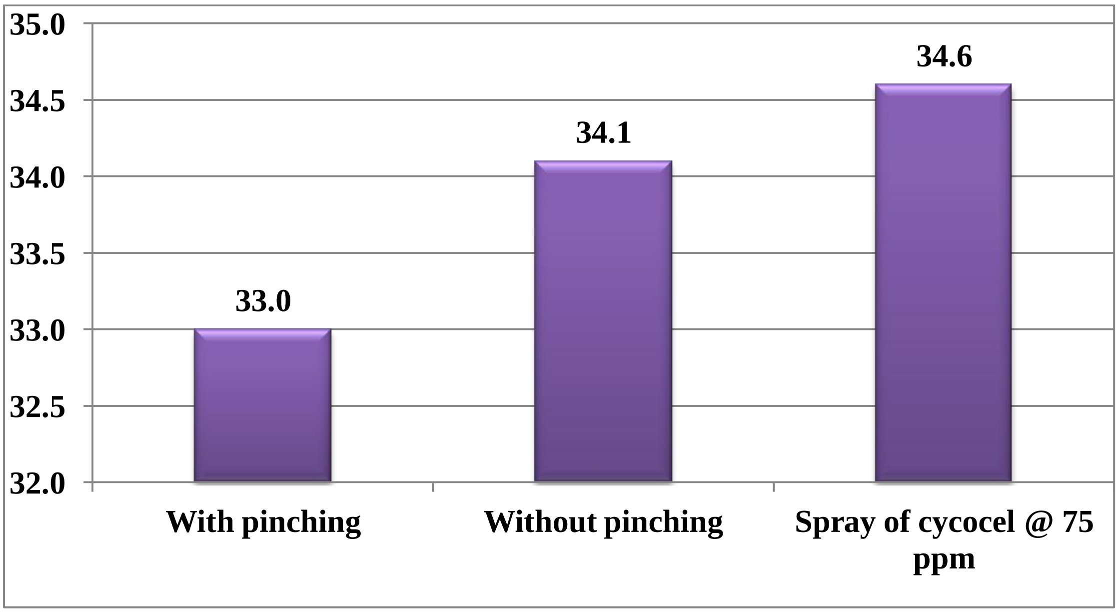

Fig. 4.8 Influence of pinching/cycocel on number of seeds pod^{-1} of dhaincha during *Kharif*, 2015

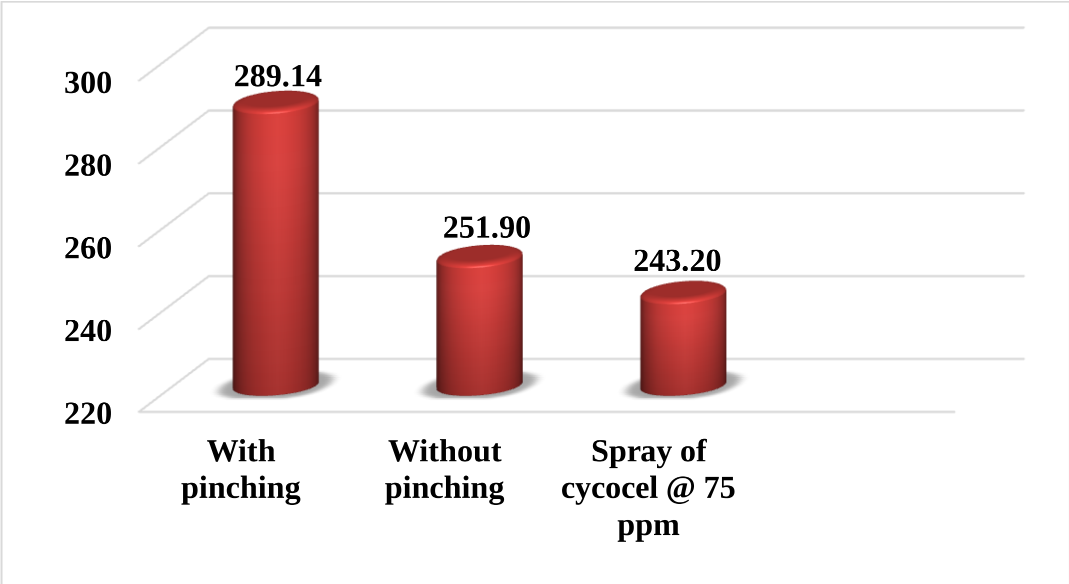

Fig. 4.9 Influence of pinching/cycocel on pod yield plant^{-1} (g) of dhaincha during *Kharif*, 2015

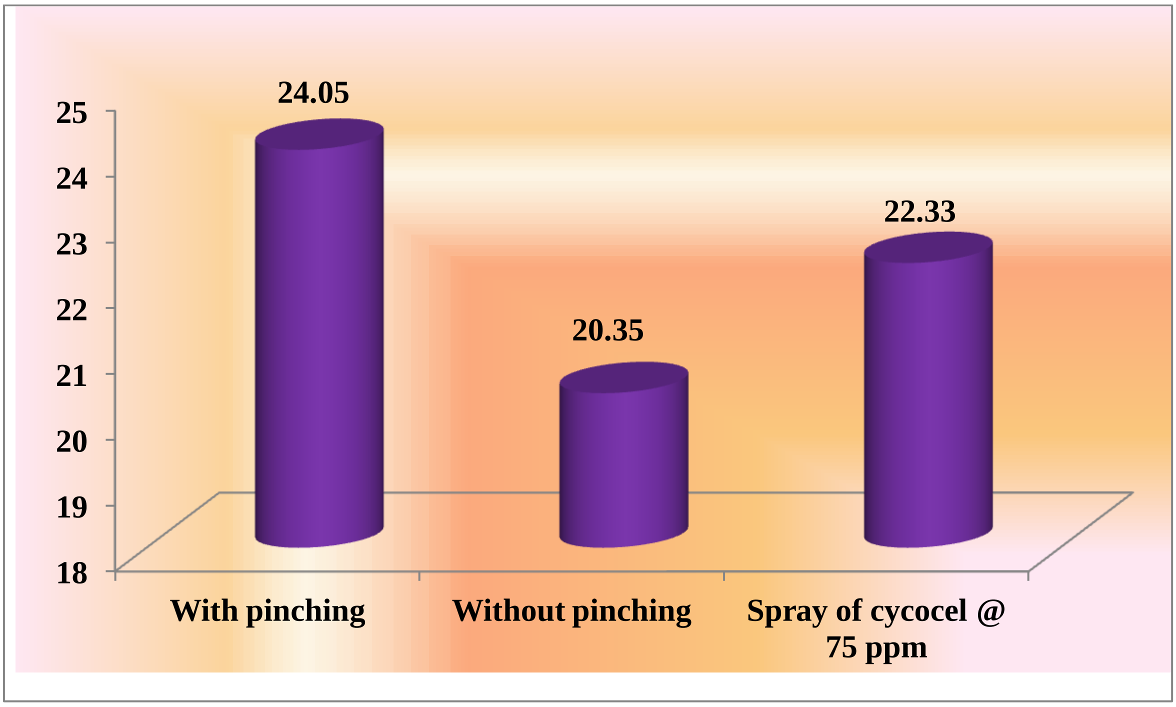

Fig. 4.11 Influence of pinching/cycocel on seed yield ha^{-1} (q) of dhaincha during *Kharif*, 2015

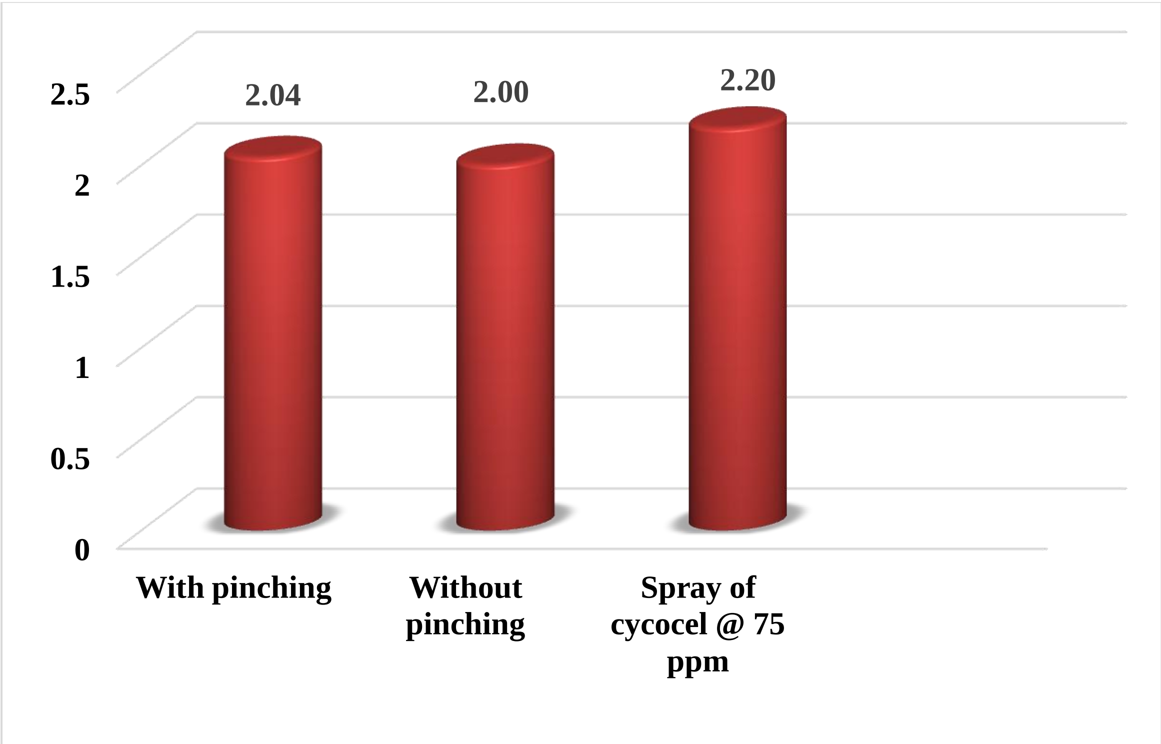

Fig. 4.12 Influence of pinching/cycocel on 100 seed weight (g) - first picking of dhaincha during *Kharif*, 2015

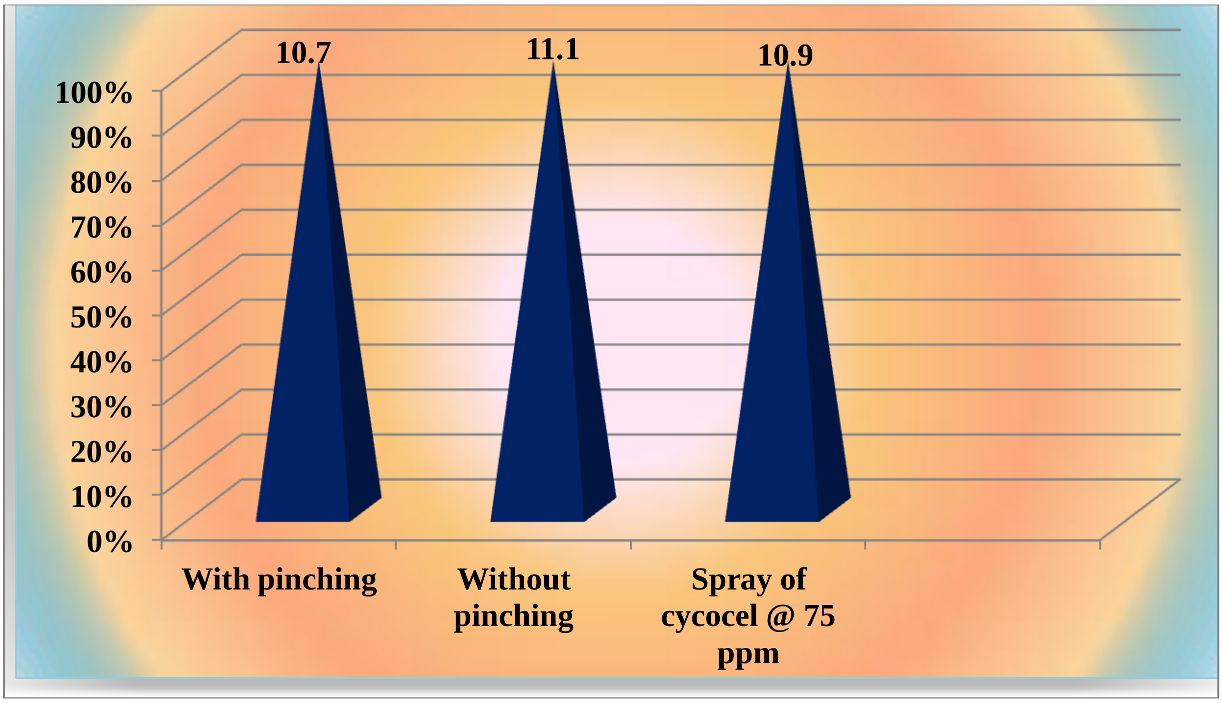

Fig. 4.14 Influence of pinching/cycocel on seed moisture content (%) of dhaincha during *Kharif*, 2015

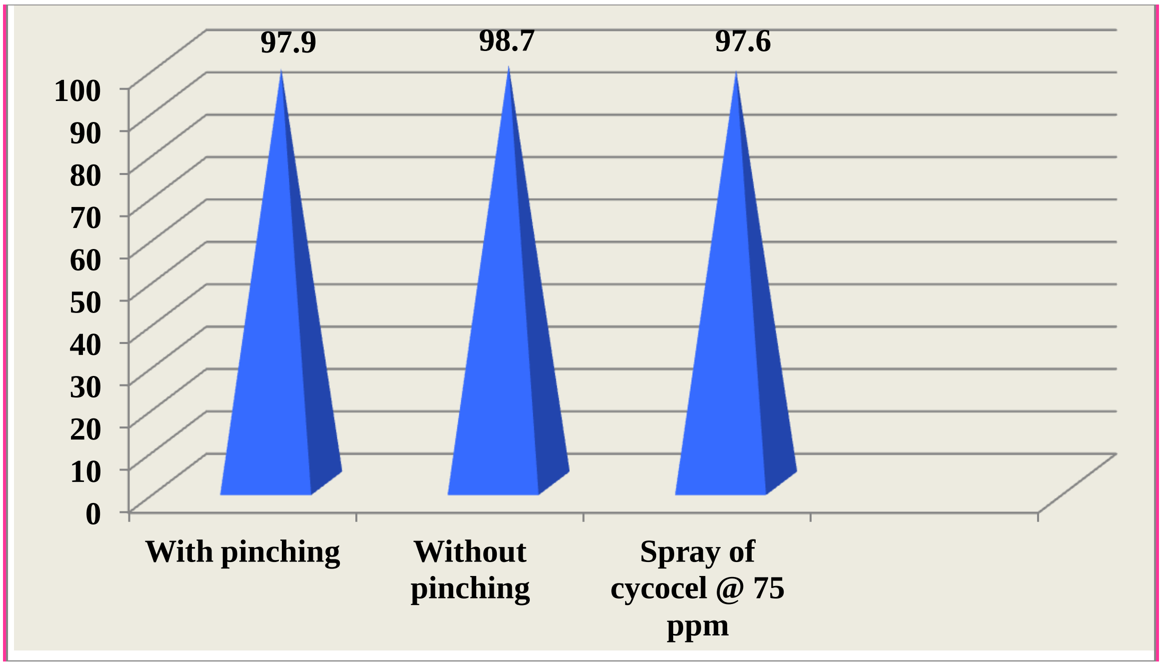

Fig. 4.15 Influence of pinching/cycocel on seed germination (%) of dhaincha seed during *Kharif*, 2015

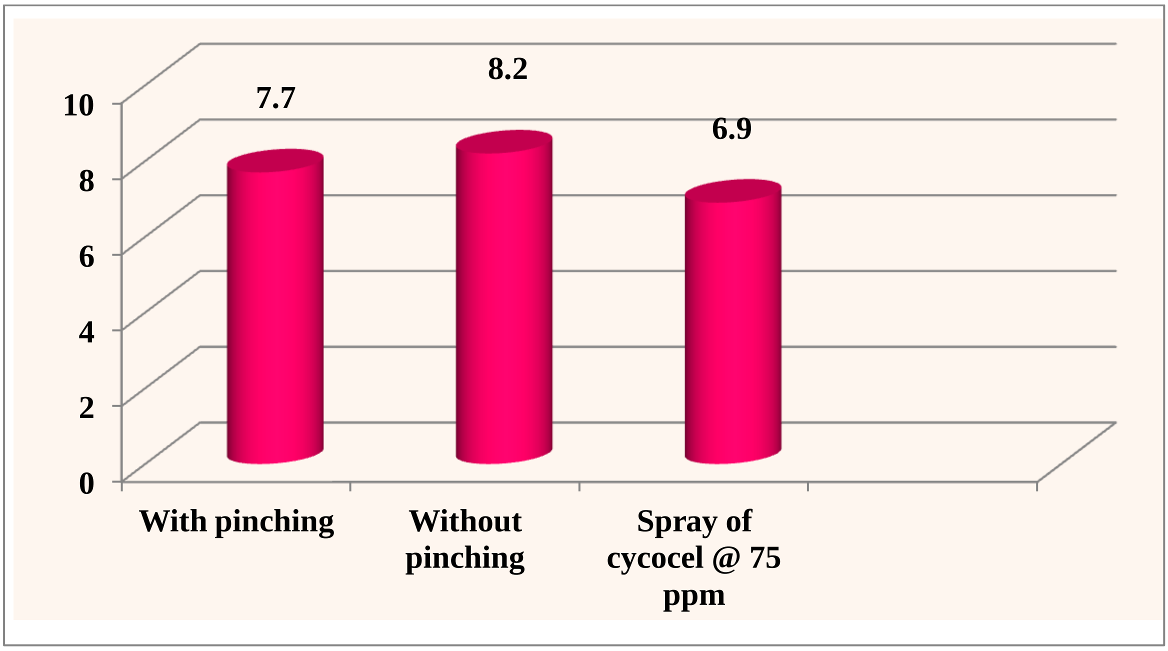

Fig. 4.16 Influence of pinching/cycocel on root length (cm) of dhaincha seedling during *Kharif*, 2015

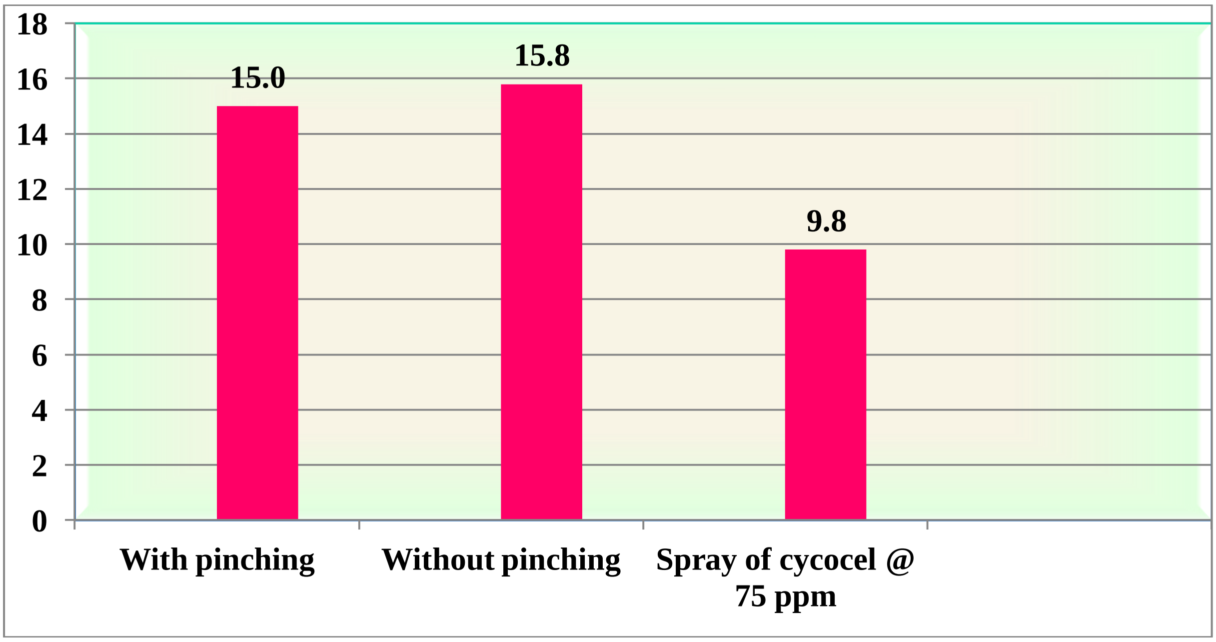

Fig. 4.17 Influence of pinching/cycocel on shoot length (cm) of dhaincha seedling during *Kharif*, 2015

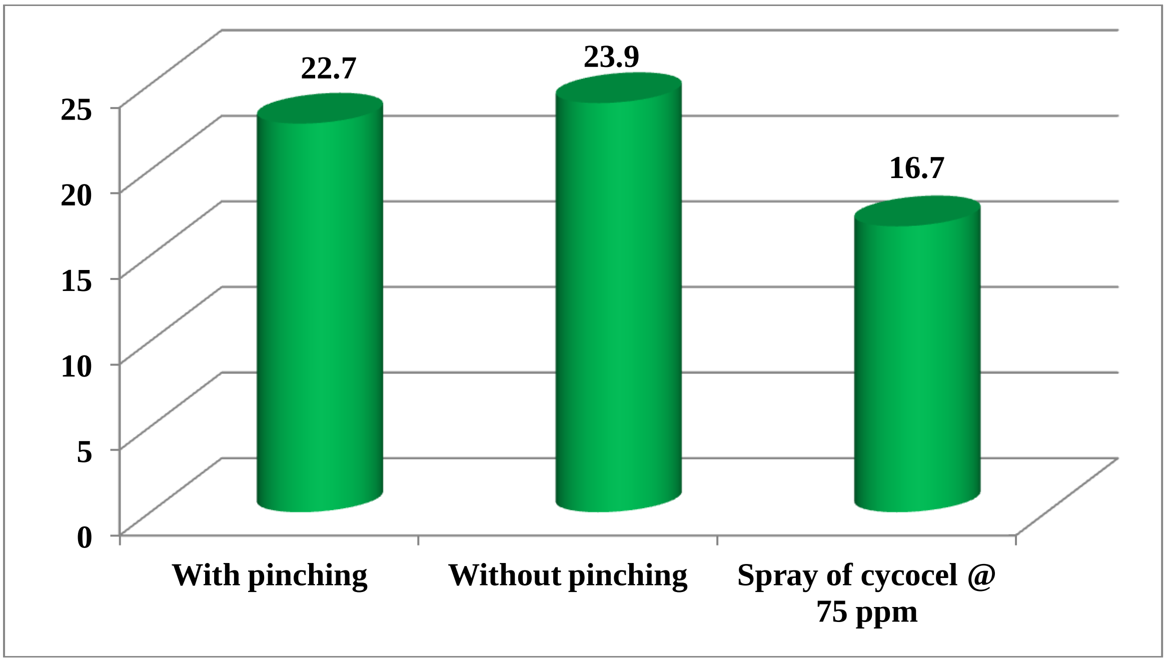

Fig. 4.18 Influence of pinching/cycocel on total seedling length (cm) of dhaincha during *Kharif*, 2015

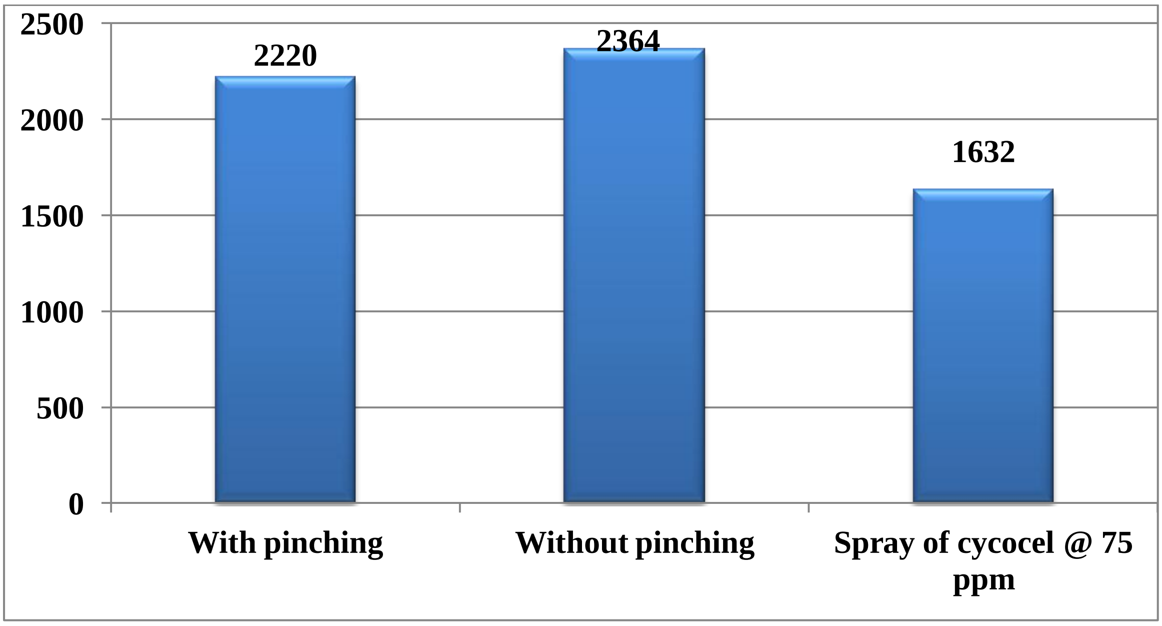

Fig. 4.19 Influence of pinching/cycocel on seedling vigour index I of dhaincha during *Kharif*, 2015

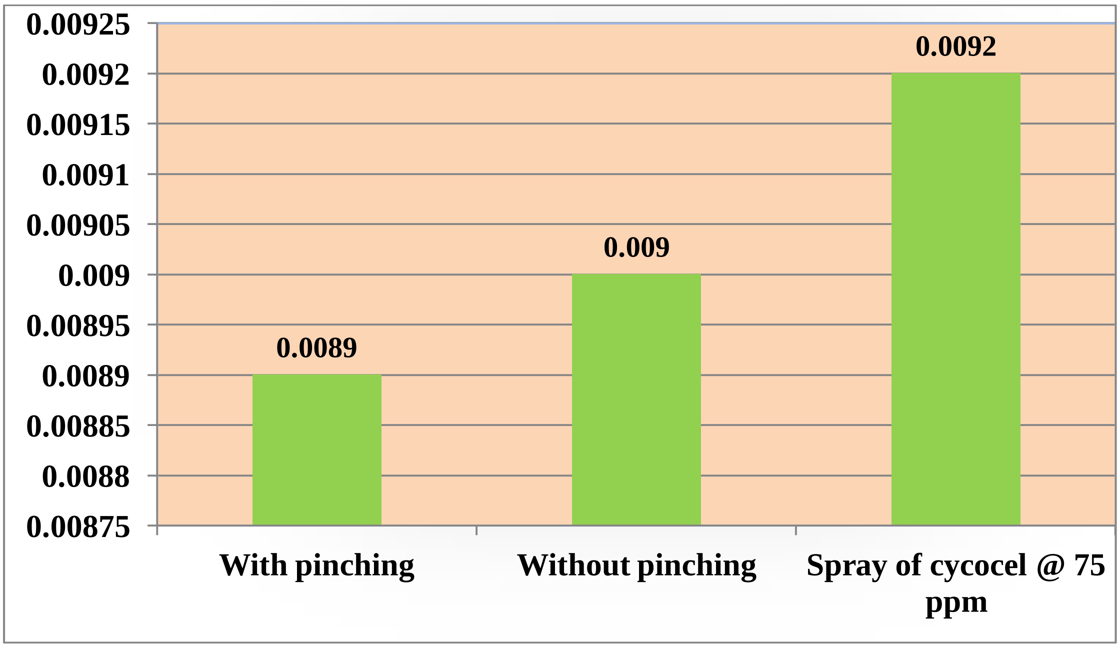

Fig. 4.20 Influence of pinching/cycocel on seedling dry weight (g) of dhaincha during *Kharif*, 2015

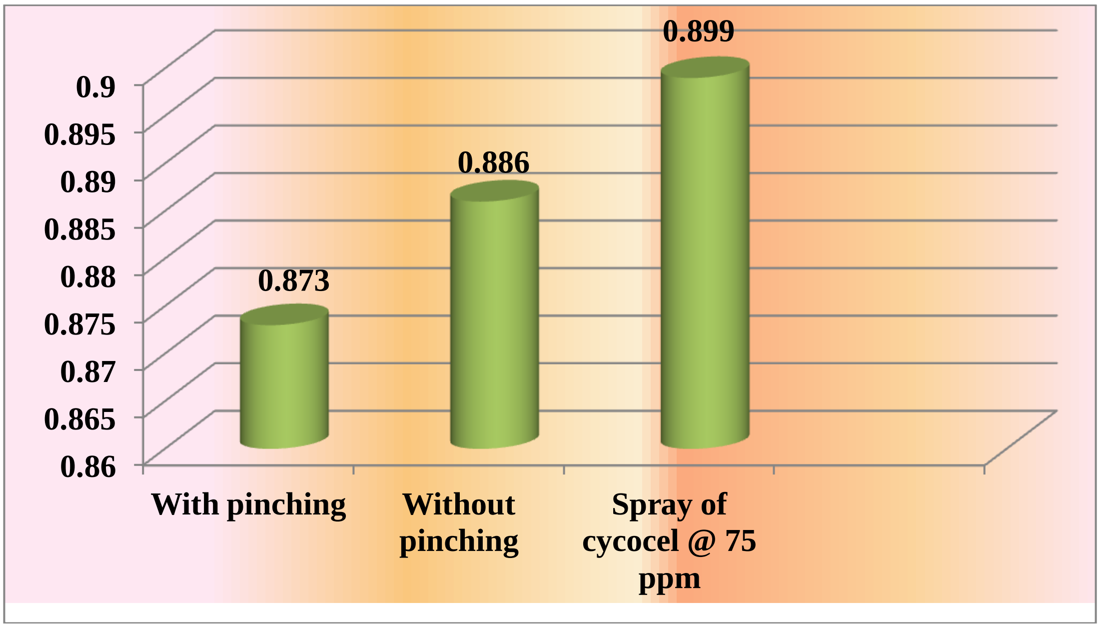

Fig. 4.21 Influence of pinching/cycocel on seedling vigour index II of dhaincha during *Kharif*, 2015

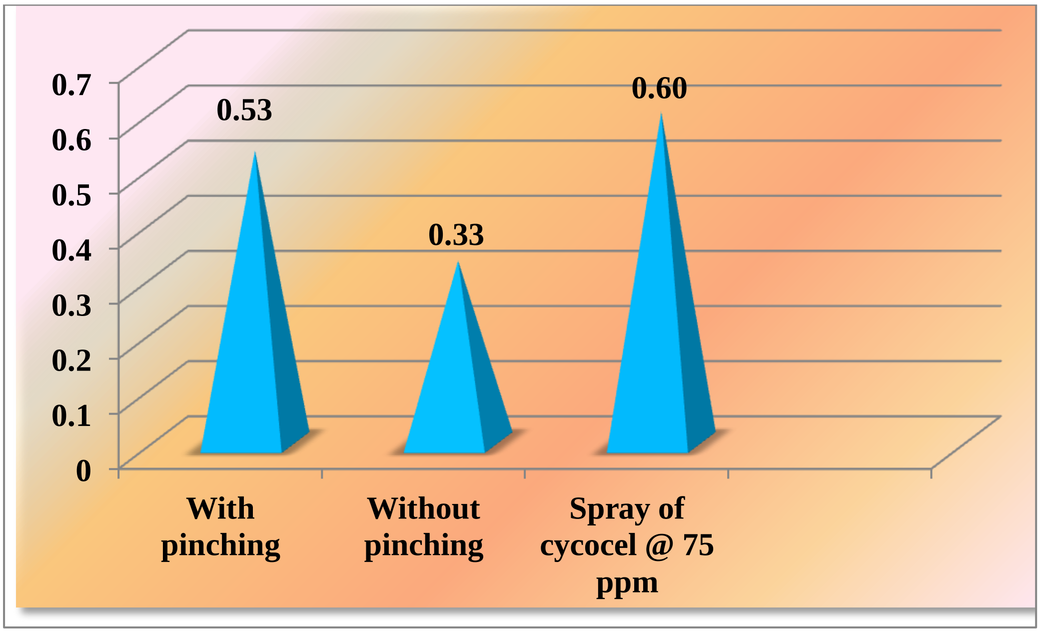

Fig. 4.23 Influence of pinching/cycocel on total fungal colonies of seed of dhaincha during *Kharif*, 2015

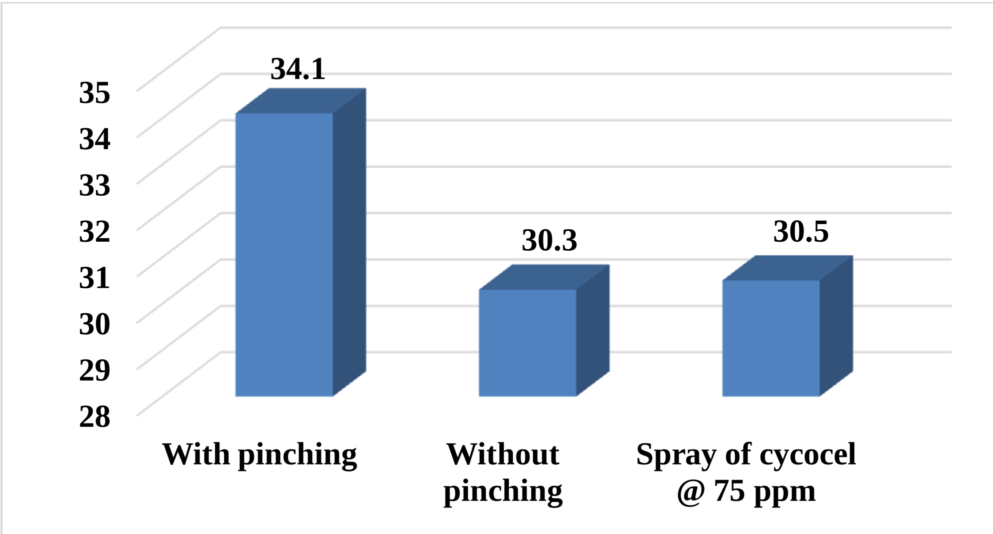

Fig. 4.2 Influence of pinching/cycocel on days to first flowering of dhaincha during *Kharif*, 2015

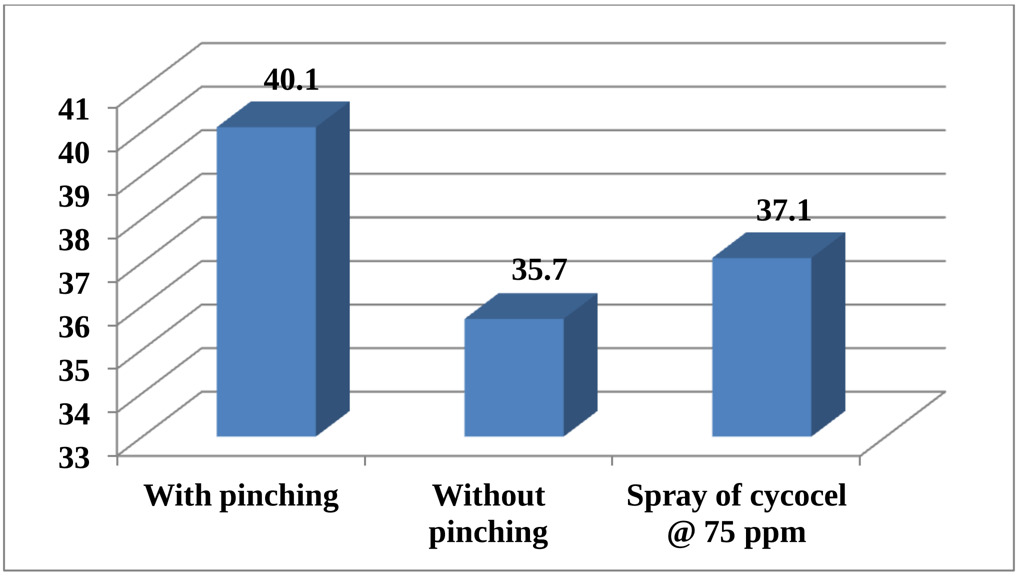

Fig. 4.3 Influence of pinching/cycocel on days to 50% flowering of dhaincha during *Kharif*, 2015

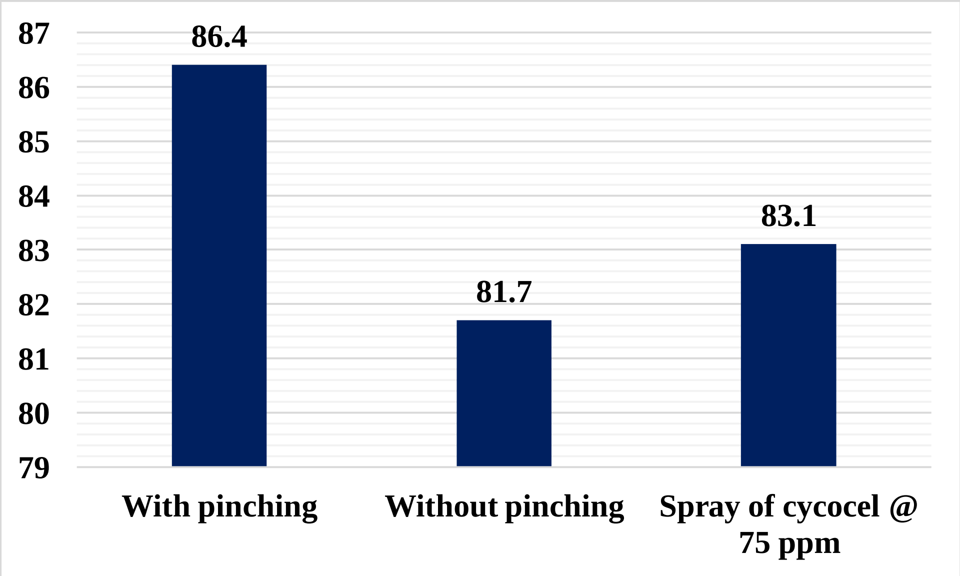

Fig. 4.4 Influence of pinching/cycocel on days to maturity of dhaincha during *Kharif*, 2015

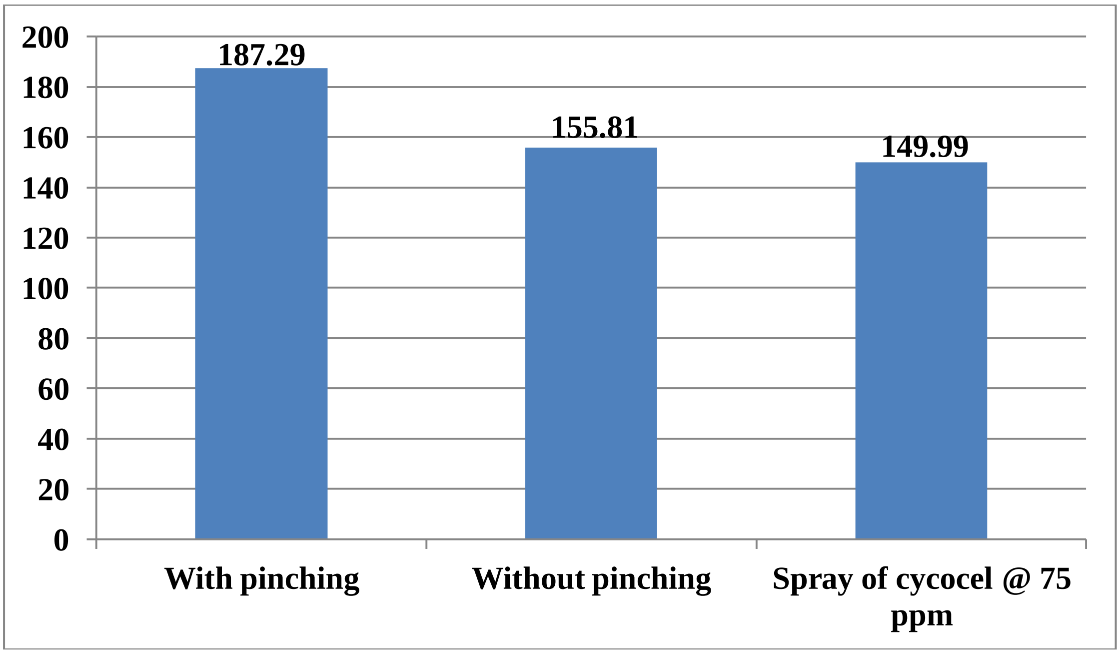

Fig. 4.10 Influence of pinching/cycocel on seed yield plant^{-1} (g) of dhaincha during *Kharif*, 2015

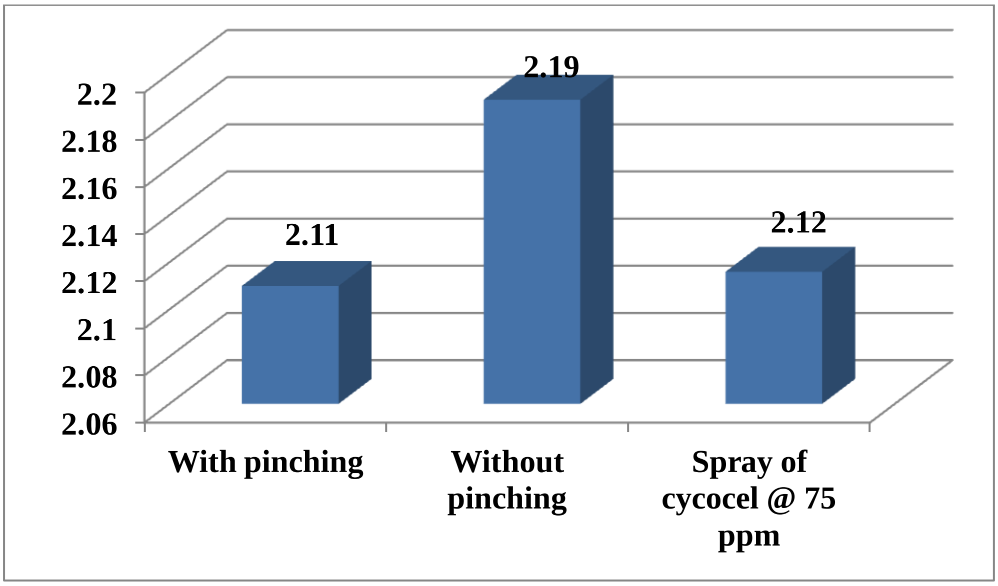

Fig. 4.13 Influence of pinching/cycocel on 100 seed weight (g) - second picking of dhaincha during *Kharif*, 2015-16

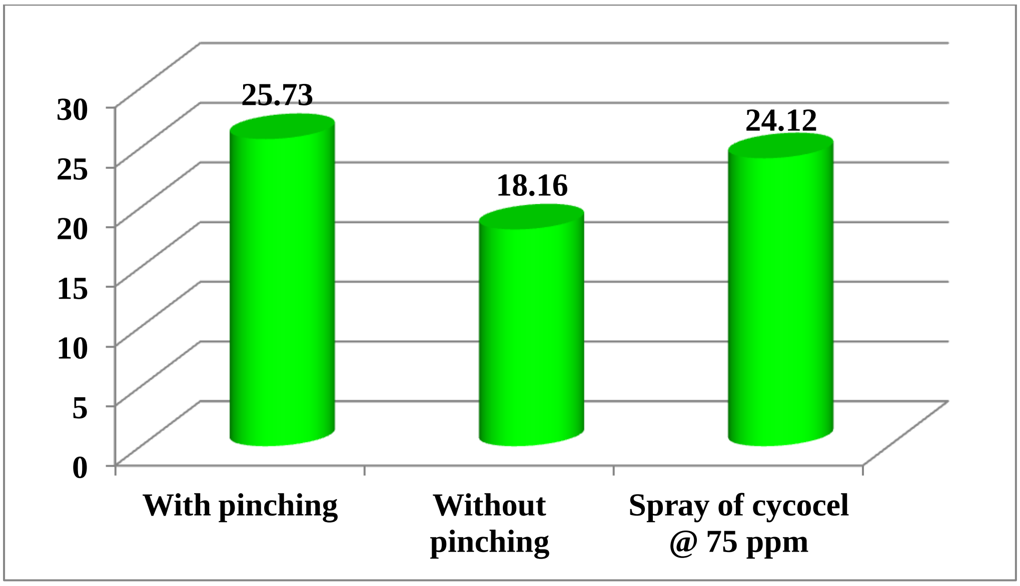

Fig. 4.22 Influence of pinching/cycocel on speed of germination of dhaincha seed during *Kharif*, 2015

Plate 1. Over view of the experimental plot

Plate 2. Pinching of Dhaincha crop at 20 DAS

Plate 3. Treatment – with pinching

Plate 4. Treatment - without pinching

Plate 5. Foliar spray of Cycocel @ 75 ppm at peak flowering stage

Plate 6. Treatment - foliar spray of cycocel @ 75 ppm

Plate 7. Picking of Dhaincha pods

Plate 8. Separation of seeds from pods after threshing

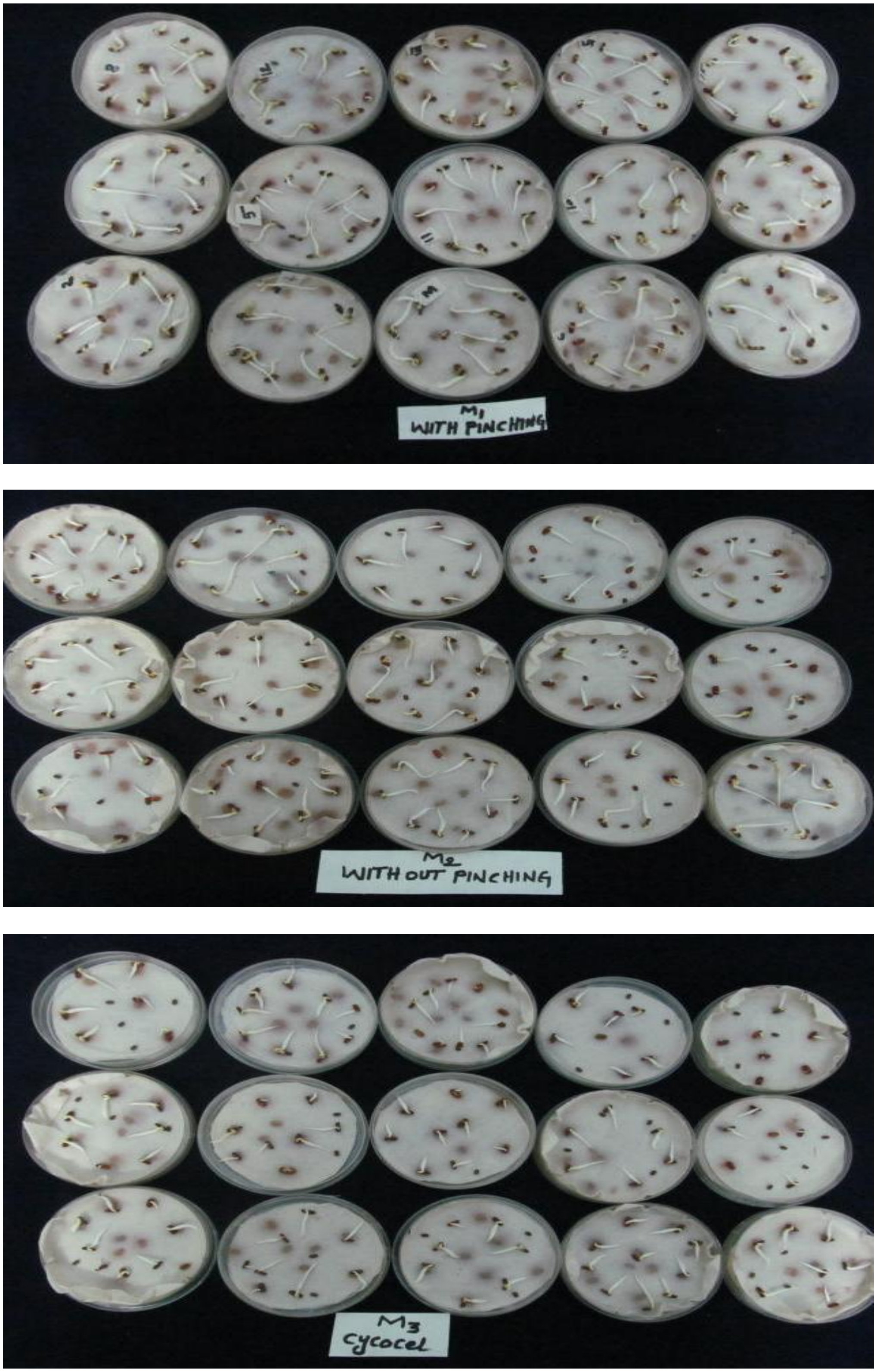

Plate 13. Seed health testing of dhaincha

Plate 14. Reduction in plant height due to pinching treatment

Plate 15. Increased number of branches plant^{-1} due to pinching treatment

Table 5.1 Influence of pinching/cycocel and foliar nutrition on total seed yield of dhaincha during Kharif, 2015-16

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	5.341	102.56	90.66	100.06
S_2	Foliar spray with MN Mixture (ZnSO4 0.5% + Boric acid 0.3%)	6.380	88.04	111.34	95.65
S_3	Foliar spray with NAA 40 ppm	5.928	91.93	90.62	98.91
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	5.850	81.86	95.66	93.88
S_5	Control	6.266	116.09	77.80	106.08
Mean		5.037	96.09	93.21	98.91
		S.Em	**S.Ed**	**C.D.**	**C.V.**
Ai.-Aj.		0.122	0.0173	0.479	10.2
Bi.-Bj.		0.1787	0.265	0.546	
AiBi-AiBj		0.324	0.458	0.946	
AiBi-AjBi		0.315	0.455	0.966	

Table 4.1 Influence of pinching/cycocel and foliar nutrition on plant height (cm) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	246.4	249.9	253.4	**249.9**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid)	230.3	246.4	253.8	**243.5**
S_3	Foliar spray with NAA 40 ppm	234.6	269.0	239.7	**247.7**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	232.1	244.6	265.9	**247.6**
S_5	Control	214.2	264.5	240.6	**239.8**
Mean		**231.5**	**254.9**	**250.7**	**245.7**
		S.Em $\pm$	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		5.7	8.2	22.7	6.3
Bi.-Bj.		5.2	7.3	15.1	
AiBi-AiBj		9.0	12.7	26.2	
AiBi-AjBi		9.9	14.0	32.2	

Table 4.2 Influence of pinching/cycocel and foliar nutrition on days to first flowering of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	34.0	30.7	30.3	**31.7**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	34.3	30.7	30.7	**31.9**
S_3	Foliar spray with NAA 40 ppm	33.3	29.7	30.3	**31.1**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	33.0	29.7	29.7	**30.8**
S_5	Control	36.0	30.0	31.3	**32.7**
Mean		**34.1**	**30.3**	**30.5**	**31.6**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.41	0.58	1.60	3.22
Bi.-Bj.		0.34	0.48	1.98	
AiBi-AiBj		0.59	0.83	1.71	
AiBi-AjBi		0.66	0.94	2.19	

Table 4.3 Influence of pinching/cycocel and foliar nutrition on days to 50% flowering of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	40.7	35.7	36.3	**37.6**
S_2	Foliar spray with MN Mixture ($ZnSO_4$0.5% + Boric acid 0.3%)	40.7	37.7	36.7	**38.3**
S_3	Foliar spray with NAA 40 ppm	39.3	34.7	38.0	**37.3**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	38.0	34.7	36.3	**36.3**
S_5	Control	41.7	35.7	38.0	**38.4**
Mean		**40.1**	**35.7**	**37.1**	**37.6**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V (%)**
Ai.-Aj.		0.4	0.6	2.8	3.0
Bi.-Bj.		0.4	0.5	N.S.	
AiBi-AiBj		0.7	0.9	2.1	
AiBi-AjBi		0.7	1.0	2.3	

Table 4.4 Influence of pinching/cycocel and foliar nutrition on days to maturity of dhaincha during *Kharif*, 2015

Treatments		M_1	M_2	M_3	Mean
		With pinching	**Without pinching**	**Spray of cycocel @ 75 ppm**	
S_1	Foliar spray with DAP 2%	85.7	82.0	83.3	**83.7**
S_2	Foliar spray with MN Mixture (ZnSO4 0.5% + Boric acid 0.3%)	85.7	82.0	83.3	**83.7**
S_3	Foliar spray with NAA 40 ppm	86.7	80.7	82.0	**83.1**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	86.3	80.3	82.7	**83.1**
S_5	Control	87.7	83.3	84.3	**85.1**
Mean		**86.4**	**81.7**	**83.1**	**83.7**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V.(%)**
Ai.-Aj.		0.4	0.6	1.8	1.9
Bi.-Bj.		0.5	0.7	1.6	
AiBi-AiBj		1.9	1.3	2.8	
AiBi-AjBi		1.9	1.3	3.0	

Table 4.5 Influence of pinching/cycocel and foliar nutrition on number of branches plant^{-1} of dhaincha during *Kharif*, 2015

Treatments		M_1	M_2	M_3	Mean
		With pinching	Without pinching	Spray of cycocel @ 75 ppm	
S_1	Foliar spray with DAP 2%	19.3	12.4	14.3	**15.3**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	14.9	13.8	18.0	**15.6**
S_3	Foliar spray with NAA 40 ppm	18.4	12.6	13.7	**14.9**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	15.4	10.7	14.9	**13.6**
S_5	Control	14.3	13.7	13.2	**13.8**
Mean		**16.5**	**12.6**	**14.8**	**14.6**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.7	0.9	2.6	13.9
Bi.-Bj.		0.7	1.0	2.0	
AiBi-AiBj		1.2	1.7	3.4	
AiBi-AjBi		1.2	1.8	4.0	

Table 4.6 Influence of pinching/cycocel and foliar nutrition on number of pods plant^{-1} of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	25.6	20.8	21.7	**22.7**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	31.2	27.3	23.0	**27.2**
S_3	Foliar spray with NAA 40 ppm	28.7	23.6	22.1	**24.8**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	26.0	19.7	27.7	**24.5**
S_5	Control	29.7	18.6	29.2	**25.9**
	Mean	**28.2**	**22.0**	**24.7**	**25.0**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		1.1	1.4	4.0	9.7
Bi.-Bj.		0.8	1.1	2.4	
AiBi-AiBj		1.4	2.0	4.1	
AiBi-AjBi		1.6	2.3	5.4	

Table 4.7 Influence of pinching/cycocel and foliar nutrition on pod length (cm) of dhaincha during *Kharif*, 2015

Treatments		M_1	M_2	M_3	Mean
		With pinching	**Without pinching**	**Spray of cycocel @ 75 ppm**	
S_1	Foliar spray with DAP 2%	23.9	24.5	23.8	**24.1**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	22.9	24.3	24.5	**23.9**
S_3	Foliar spray with NAA 40 ppm	24.4	24.0	24.5	**24.3**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	24.0	23.3	23.9	**23.8**
S_5	Control	23.5	24.2	24.1	**24.0**
	Mean	**23.7**	**24.1**	**24.2**	**24.0**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.3	0.4	N.S.	2.6
Bi.-Bj.		0.2	0.3	N.S.	
AiBi-AiBj		0.4	0.5	1.1	
AiBi-AjBi		0.4	0.6	1.4	

Table 4.8 Influence of pinching/cycocel and foliar nutrition on number of seeds pod^{-1} of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	33.2	34.8	34.5	**34.2**
S_2	Foliar spray with MN Mixture ($ZnSO_4$0.5% + Boric acid 0.3%)	31.9	34.8	34.7	**33.8**
S_3	Foliar spray with NAA 40 ppm	33.7	33.3	35.5	**34.2**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn+B)+ NAA	33.4	33.7	33.8	**33.6**
S_5	Control	33.0	34.1	34.5	**33.9**
	Mean	**33.0**	**34.1**	**34.6**	**33.9**
		S.Em $\pm$	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.3	0.5	1.3	2.8
Bi.-Bj.		0.3	0.4	N.S.	
AiBi-AiBj		0.5	0.8	1.6	
AiBi-AjBi		0.6	0.8	1.9	

Table 4.9 Influence of pinching/cycocel and foliar nutrition on pod yield plant^{-1} (g) of dhaincha during *Kharif*, 2015

Treatments		M_1	M_2	M_3	Mean
		With pinching	**Without pinching**	**Spray of cycocel @ 75 ppm**	
S_1	Foliar spray with DAP 2%	277.07	269.31	239.25	**261.88**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	285.88	252.40	253.31	**263.86**
S_3	Foliar spray with NAA 40 ppm	331.33	244.11	223.68	**266.37**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	248.12	237.57	266.73	**250.81**
S_5	Control	303.29	256.12	233.04	**264.15**
Mean		**289.14**	**251.90**	**243.20**	**261.41**
		S.Em $\pm$	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		17.0	24.0	66.90	14.48
Bi.-Bj.		12.6	17.8	36.84	
AiBi-AiBj		21.8	30.9	63.82	
AiBi-AjBi		25.9	36.6	86.99	

Table 4.10 Influence of pinching/cycocel and foliar nutrition on seed yield plant^{-1}(g) of dhaincha during *Kharif*, 2015

Treatments		M_1	M_2	M_3	Mean
		With pinching	**Without pinching**	**Spray of cycocel @ 75 ppm**	
S_1	Foliar spray with DAP 2%	170.11	166.76	148.59	161.82
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	198.31	164.37	141.98	168.22
S_3	Foliar spray with NAA 40 ppm	217.15	152.13	133.07	167.46
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	171.94	155.71	171.08	166.24
S_5	Control	178.95	155.81	155.24	158.07
Mean		**187.29**	**155.81**	**149.99**	**164.36**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		8.10	11.46	31.83	18.26
Bi.-Bj.		10.00	14.15	29.21	
AiBi-AiBj		17.33	24.51	50.59	
AiBi-AjBi		17.49	25.74	54.85	

Table 4.11 Influence of pinching/cycocel and foliar nutrition on seed yield ha^{-1} (q) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	21.58	22.95	24.19	**22.91**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	25.78	22.05	27.98	**25.27**
S_3	Foliar spray with NAA 40 ppm	23.95	21.13	24.96	**23.35**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	23.64	14.09	18.72	**18.82**
S_5	Control	25.32	21.56	15.79	**20.89**
Mean		**24.05**	**20.35**	**22.3**	**22.24**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.49	0.69	1.93	10.20
Bi.-Bj.		0.75	1.06	2.20	
AiBi-AiBj		1.30	1.85	3.82	
AiBi-AjBi		1.27	1.79	3.90	

Table 4.12 Influence of pinching/cycocel and foliar nutrition on seed recovery (%) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	62.1	61.6	62.2	**61.9**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	69.3	64.5	57.1	**63.6**
S_3	Foliar spray with NAA 40 ppm	64.6	62.0	60.0	**62.2**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	58.1	66.3	64.1	**62.8**
S_5	Control	59.6	56.7	66.9	**61.1**
Mean		**62.7**	**62.2**	**62.1**	**62.3**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.6	0.8	N.S.	12.4
Bi.-Bj.		2.6	3.7	N.S.	
AiBi-AiBj		4.5	6.4	N.S.	
AiBi-AjBi		4.1	5.7	N.S.	

Table 4.13 Influence of pinching/cycocel and foliar nutrition on 100 seed weight (g) – first picking of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	2.02	2.01	2.22	**2.08**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	2.00	2.05	2.25	**2.10**
S_3	Foliar spray with NAA 40 ppm	2.05	2.02	2.22	**2.10**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	2.07	1.92	2.14	**2.04**
S_5	Control	2.08	2.01	2.19	**2.09**
	Mean	**2.04**	**2.00**	**2.20**	**2.08**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.21	0.03	0.09	4.71
Bi.-Bj.		0.03	0.05	0.10	
AiBi-AiBj		0.06	0.08	N.S.	
AiBi-AjBi		0.06	0.08	N.S.	

Table 4.14 Influence of pinching/cycocel and foliar nutrition on 100 seed weight (g) – second picking of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	2.10	2.15	2.12	**2.13**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	2.15	2.23	2.15	**2.18**
S_3	Foliar spray with NAA 40 ppm	2.11	2.15	2.04	**2.10**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	2.13	2.20	2.19	**2.17**
S_5	Control	2.06	2.21	2.09	**2.12**
	Mean	**2.11**	**2.19**	**2.12**	**2.14**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.01	0.02	0.05	5.00
Bi.-Bj.		0.03	0.05	0.10	
AiBi-AiBj		0.06	0.09	0.18	
AiBi-AjBi		0.06	0.08	0.16	

Table 4.15 Influence of pinching/cycocel and foliar nutrition on seed moisture content (%) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	10.4	10.9	10.7	**10.6**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	10.6	11.2	11.0	**10.9**
S_3	Foliar spray with NAA 40 ppm	10.6	11.1	10.9	**10.9**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	10.8	11.2	10.9	**11.0**
S_5	Control	10.8	11.2	11.0	**11.0**
Mean		**10.7**	**11.1**	**10.9**	**10.9**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.06	0.08	0.24	1.44
Bi.-Bj.		0.05	0.07	0.15	
AiBi-AiBj		0.09	0.12	0.23	
AiBi-AjBi		0.1	0.14	0.33	

Table 4.16 Influence of pinching/cycocel and foliar nutrition on seed germination (%) of dhaincha seeds during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	98.7	98.7	100.0	**99.1**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	96.0	100.0	94.7	**96.9**
S_3	Foliar spray with NAA 40 ppm	100.0	100.0	98.7	**99.6**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	97.3	96.0	96.0	**96.4**
S_5	Control	97.3	98.7	98.7	**98.2**
Mean		**97.9**	**98.7**	**97.6**	**98.0**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		1.3	1.9	N.S.	5.3
Bi.-Bj.		1.4	2.0	4.2	
AiBi-AiBj		2.4	3.5	7.3	
AiBi-AjBi		2.6	3.6	8.3	

Table 4.17 Influence of pinching/cycocel and foliar nutrition on root length (cm) of dhaincha seedling during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	7.7	7.9	7.0	**7.6**
S_2	Foliar spray with MN Mixture (ZnSO4 0.5% + Boric acid 0.3%)	7.7	8.2	6.6	**7.5**
S_3	Foliar spray with NAA 40 ppm	7.9	8.6	6.6	**7.7**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	7.7	8.1	6.7	**7.5**
S_5	Control	7.6	8.2	7.6	**7.8**
Mean		**7.7**	**8.2**	**6.9**	**7.6**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.3	0.4	1.0	7.3
Bi.-Bj.		0.2	0.3	N.S.	
AiBi-AiBj		0.3	0.5	0.94	
AiBi-AjBi		0.4	0.6	1.33	

Table 4.18 Influence of pinching/cycocel and foliar nutrition on shoot length (cm) of dhaincha seedlings during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	14.0	15.2	9.9	**13.1**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	15.6	15.4	9.7	**13.6**
S_3	Foliar spray with NAA 40 ppm	14.5	16.6	9.2	**13.5**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	14.8	16.5	9.4	**13.6**
S_5	Control	16.0	15.0	10.5	**13.8**
Mean		**15.0**	**15.8**	**9.8**	**13.5**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.6	0.8	20.2	10.4
Bi.-Bj.		0.5	0.7	N.S.	
AiBi-AiBj		0.8	1.1	2.3	
AiBi-AjBi		0.9	1.2	3.0	

Table 4.19 Influence of pinching/cycocel and foliar nutrition on total seedling length (cm) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	21.7	23.1	17.0	20.6
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	23.2	23.6	16.3	21.0
S_3	Foliar spray with NAA 40 ppm	22.4	25.2	15.8	21.1
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	22.5	24.6	16.2	21.1
S_5	Control	23.5	23.2	18.1	21.6
Mean		22.7	23.9	16.7	21.1
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.7	1.1	2.9	7.9
Bi.-Bj.		0.6	0.8	N.S.	
AiBi-AiBj		1.0	1.4	2.8	
AiBi-AjBi		1.3	1.6	3.8	

Table 4.20 Influence of pinching/cycocel and foliar nutrition on seedling vigour index I of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	2145	2285	1699	**2043**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	2232	2357	1564	**2051**
S_3	Foliar spray with NAA 40 ppm	2240	2520	1563	**2108**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	2187	2364	1550	**2034**
S_5	Control	2294	2292	1783	**2123**
Mean		**2220** $\pm$	**2364**	**1632**	**2072**
		S.Em	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		89	126	351	9.13
Bi.-Bj.		63	89	N.S.	
AiBi-AiBj		109	154	319	
AiBi-AjBi		132	187	447	

Table 4.21 Influence of pinching/cycocel and foliar nutrition on seedling dry weight (g) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	0.0093	0.0088	0.0092	**0.0091**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	0.0093	0.0086	0.0090	**0.0090**
S_3	Foliar spray with NAA 40 ppm	0.0086	0.0091	0.0093	**0.0090**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	0.0087	0.0091	0.0094	**0.0091**
S_5	Control	0.0086	0.0093	0.0092	**0.0090**
Mean		**0.0089**	**0.0090**	**0.0092**	**0.0090**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.00006	0.00008	0.00023	4.31
Bi.-Bj.		0.00013	0.00018	N.S.	
AiBi-AiBj		0.00022	0.00032	0.00066	
AiBi-AjBi		0.00021	0.0003	0.00063	

Table 4.22 Influence of pinching/cycocel and foliar nutrition on seedling vigour index II of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	0.918	0.865	0.920	**0.901**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	0.894	0.863	0.851	**0.869**
S_3	Foliar spray with NAA 40 ppm	0.863	0.910	0.914	**0.896**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	0.849	0.874	0.903	**0.875**
S_5	Control	0.840	0.918	0.905	**0.888**
Mean		**0.873**	**0.886**	**0.899**	**0.886**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.013	0.019	N.S.	5.36
Bi.-Bj.		0.016	0.022	N.S.	
AiBi-AiBj		0.027	0.039	N.S.	
AiBi-AjBi		0.028	0.040	N.S.	

Table 4.24 Influence of pinching/cycocel and foliar nutrition on electrical conductivity of seed leachates (µS cm^{-1}) of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	4.32	3.62	4.45	**4.13**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	3.88	3.50	3.68	**3.69**
S_3	Foliar spray with NAA 40 ppm	4.32	4.02	4.08	**4.14**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	3.76	4.65	4.12	**4.17**
S_5	Control	4.18	3.88	4.78	**4.28**
Mean		**4.0**	**3.93**	**4.22**	**4.08**
		S.Em ±	**S.Ed**	**C.D(P=0.05)**	**C.V(%)**
Ai.-Aj.		0.23	0.32	N.S.	14.94
Bi.-Bj.		0.20	0.28	N.S.	
AiBi-AiBj		0.35	0.49	1.03	
AiBi-AjBi		0.39	0.55	1.28	

Table 4.23 Influence of pinching/cycocel and foliar nutrition on speed of germination of dhaincha seed during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	27.67	18.50	25.13	**23.77**
S_2	Foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%)	24.47	17.47	19.92	**20.62**
S_3	Foliar spray with NAA 40 ppm	29.27	17.45	25.02	**23.91**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	21.68	19.93	25.15	**22.26**
S_5	Control	25.58	17.43	25.37	**22.79**
Mean		**25.73**	**18.16**	**24.12**	**22.67**
		S.Em ±	**S.Ed**	**C.D.**	**C.V.**
Ai.-Aj.		0.98	1.39	3.88	14.07
Bi.-Bj.		1.06	1.50	3.10	
AiBi-AiBj		1.84	2.60	5.37	
AiBi-AjBi		1.92	2.71	6.11	

Table 6.6 Influence of pinching/cycocel and foliar nutrition on field emergence of dhaincha during Kharif, 2015-16

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	62.2	42.2	54.4	**53.0**
S_2	Foliar spray with MN Mixture (ZnSO4 0.5% + Boric acid 0.3%)	66.7	40.0	57.8	**54.8**
S_3	Foliar spray with NAA 40 ppm	68.9	62.2	48.9	**60.0**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	56.7	42.2	35.6	**44.8**
S_5	Control	58.9	60.0	30.0	**49.6**
Mean		**62.7**	**49.3**	**45.3**	**52.4**
		S.Em	**S.Ed**	**C.D.**	**C.V.**
Ai.-Aj.		7.79	11.02	30.59	24.171
Bi.-Bj.		4.22	5.97	12.33	
AiBi-AiBj		7.31	10.34	21.35	
AiBi-AjBi		10.17	14.39	35.71	

Table 4.25 Influence of pinching/cycocel and foliar nutrition on total fungal colonies of seed of dhaincha during *Kharif*, 2015

Treatments		M_1 With pinching	M_2 Without pinching	M_3 Spray of cycocel @ 75 ppm	Mean
S_1	Foliar spray with DAP 2%	0.33	0.33	0.00	**0.22**
S_2	Foliar spray with MN Mixture (ZnSO4 0.5% + Boric acid 0.3%)	1.00	0.00	1.33	**0.78**
S_3	Foliar spray with NAA 40 ppm	0.00	0.00	0.33	**0.11**
S_4	Foliar spray with DAP 2%+ MN Mixture (Zn + B) + NAA	0.67	1.00	1.00	**0.89**
S_5	Control	0.67	0.33	0.33	**0.44**
Mean		**0.53**	**0.33**	**0.60**	**0.49**
		S.Em ±	**S.Ed**	**C.D.**	**C.V.**
Ai.-Aj.		0.46	0.65	1.80	30.0
Bi.-Bj.		0.49	0.70	1.44	
AiBi-AiBj		0.85	1.21	2.50	
AiBi-AjBi		0.89	1.26	2.81	

Chapter –V

SUMMARY AND CONCLUSIONS

A field experiment entitled **"Standardization of seed production techniques in Dhaincha (*Sesbania aculeata*)"** was conducted during *kharif*, 2015 at Seed Research & Technology Center, Rajendranagar, Hyderabad. The experiment was laid out in Split plot design with three main treatments (with pinching at 20 DAS, without pinching and spray of cycocel @ 75 ppm at peak flowering stage) and five sub treatments (foliar spray with DAP 2%, foliar spray with MN Mixture ($ZnSO_4$ 0.5% + Boric acid 0.3%), foliar spray with NAA @ 40 ppm, foliar spray with DAP 2% + MN Mixture (Zn + B) + NAA and control) in three replications.

Observations on seed yield and yield attributing characters like plant height (cm), days to first flowering, days to 50% flowering, days to maturity, number of branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, pod yield plant^{-1} (g), seed yield plant^{-1} (g), seed yield ha^{-1} (q), seed recovery percentage and 100 seed weight (g) were recorded. Seed of the harvested produce was for tested seed quality parameters like germination (%), root length (cm), shoot length (cm), total seedling length (cm), seedling vigour index I, seedling dry weight (g), seedling vigour index II, speed of germination, electrical conductivity of seed leachates (µS cm^{-1}) and total fungal colonies.

The salient features of the experimental findings are summarized as below

Pinching treatment significantly prolonged the time taken for the appearance of the first flower by about four days and days to 50% flowering and maturity by three days. Among the seed yield and yield attributing characters, pinching of dhaincha crop at 20 DAS exerted profound influence on reducing the height of the plant and improving the number of branches plant^{-1}, number of pods plant^{-1}, seed yield plant^{-1} and seed yield ha^{-1}. Without pinching treatment resulted in significantly taller plants as compared to pinching and spray of cycocel @ 75 ppm. The per cent improvement in branches plant^{-1} due to pinching and cycocel spray @ 75 ppm was 30.95% and 11.48%, respectively as compare to without pinching. Similarly the per cent increase in seed yield due to pinching was 15.38% (over control) and 7.70% (over spray of cycocel @ 75 ppm). On the other hand, foliar spray of cycocel @ 75 ppm resulted in significant improvement in 100 seed weight. With respect to number of seeds pod^{-1}, foliar spray of cycocel @ 75 ppm and pinching treatment were found superior. Use of growth retardant, cycocel and pinching practice does not have any significant impact on improving the length of the pod, seed recovery (%) and pod yield $plant^{-1}$.

Among the seed quality parameters, neither pinching/without pinching nor use of growth retardant cycocel significantly improved the germination percentage of dhaincha seed .

Non significant differences between pinching and without pinching treatments, was observed with respect to root length, shoot length, total seedling length and seedling vigour index-I. However, the use of growth retardant cycocel significantly contributed to improvement of seedling dry weight and seedling vigour index-II. Seed infection was also found to be maximum.

Electrical conductivity of seed leachates was neither influenced by pinching treatment nor by foliar nutrition. Pinching contributed to significant increase in speed of germination and field emergence of dhaincha seeds.

Among different foliar nutritions, dhaincha crop without any foliar spray resulted in number of maximum days for initiation of first flower (32.7 days) and days to maturity (85 days). Non significant differences among different foliar nutritions were noticed with respective to plant height, branches $plant^{-1}$, pod length, seed pod^{-1}, seed recovery (%) and pod yield $plant^{-1}$. The treatment S_2 *i.e.* foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) contributed to significant increase in pods $plant^{-1}$, 100 seed weight and seed yield. Among the seed quality traits, the treatment S_4 *i.e.* foliar spray with DAP 2% + micronutrient mixture (Zn + B) + NAA was found superior as it resulted in maximum germination percentage, while S_3 *i.e.* foliar spray with NAA 40 ppm was found promising for speed of germination and field emergence.

Among the interaction effects, the treatment combination M_1S_5 *i.e.* pinching + without foliar nutrition took maximum number of days for the appearance of first flower (36 days), 50% flowering (41.7 days) and maturity. The treatment combination M_1S_2 *i.e.* pinching + foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) recorded maximum pods plant^{-1} (31.2) and pod yield plant^{-1}. While, M_1S_3 *i.e.* pinching + foliar spray with NAA 40 ppm was found superior for pod yield plant^{-1} and seed yield plant^{-1}. The combination M_3S_1 *i.e.* foliar spray of cycocel @ 75 ppm + foliar spray with DAP 2% was found superior for germination while the interactive effect involving M_2S_3 *i.e.* without pinching + foliar spray with NAA 40 ppm was found promising for seedling characters like root length, shoot length and seedling length, while M_1S_3 i.e., pinching + foliar spray with NAA 40 ppm had better emergence under field conditions.

Under the existing situations / conditions, pinching of the dhaincha crop at 20 DAS in combination with foliar spray of NAA @ 40 ppm and pinching at 20DAS coupled with foliar spray with micronutrient mixture ($ZnS0_4$ 0.5% + Boric acid 0.3%) may be considered as an effective technique for obtaining maximum quality seed.

Future line of work

1. Identification of new plant ideotypes with determinate growth habit, uniform maturity and non shattering nature is of utmost importance in the crop.
2. In the changing climate scenario, changes in environmental conditions (sunshine and temperature) have a modifying effect on the growth and development of dhaincha plant. Therefore identification of suitable planting date with optimum agronomic package (planting dates and fertilizer dates) help in quality seed production.
3. Standardization of seed production technology involving manipulation of crop architecture using combination of pinching and use of plant growth regulators for higher seed production is required.
4. Development of seed certification standards in dhaincha and upgrading the quality for improving the planting condition of seed and applying chemical protectants to seed.
5. Dhaincha crop when used for seed and as pasture cultivation, efforts are needed in this line to make it available to small and marginal farmers.
6. As a green manure crop it is gaining importance in soil health improvement. Hence, such studies improve the quality of seed to sustain the economic status of the farmers and soil health status.

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Appendix I

Daily meteorological data recorded at ARI, Rajendranagar for the month of June, 2015

Date	Temperature		R. H. (%)		Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	Evaporation (mm)	Mean Temp. (^{o}C)
	Max.	Min.	I	II						
1	42.0	27.0	58	47	0.0	0	8.9	5.8	9.3	34.5
2	36.0	27.0	60	27	0.0	0	3.2	2.3	8.5	31.5
3	40.5	27.0	56	33	0.0	0	8.8	5.8	8.8	33.8
4	37.5	28.0	54	32	0.0	0	10.2	0.5	9.9	32.8
5	38.0	27.0	93	43	38.8	1	8.9	2.4	9.5	32.5
6	35.0	25.0	77	47	1.0	0	8.0	1.8	7.1	30.0
7	35.5	26.0	77	52	0.0	0	4.9	1.6	6.5	30.8
8	34.0	26.0	71	57	0.0	0	1.7	1.6	6.0	30.0
9	35.0	26.0	77	47	0.0	0	6.5	5.5	6.1	30.5
10	35.0	26.0	72	44	0.0	0	4.5	6.1	6.7	30.5
11	36.5	29.0	78	54	0.0	0	9.0	2.6	7.0	32.8
12	37.0	26.4	77	51	2.2	0	7.0	5.5	6.6	31.7
13	34.0	23.5	92	51	22.4	1	1.6	4.3	5.4	28.8
14	33.0	22.0	92	66	58.6	1	5.1	3.7	4.2	27.5
15	30.0	24.0	85	72	0.0	0	5.4	7.9	4.1	27.0
16	30.0	24.0	84	60	0.0	0	3.7	8.0	4.1	27.0
17	30.0	23.5	95	61	8.0	1	0.0	6.4	4.7	26.8
18	31.0	24.5	84	65	0.0	0	0.6	8.7	4.2	27.8
19	31.0	23.0	92	60	15.0	1	0.3	11.6	3.8	27.0
20	30.0	23.5	84	71	0.0	0	1.0	15.9	4.5	26.8
21	28.5	23.1	84	86	4.4	1	0.0	11.3	3.3	25.8
22	25.0	23.0	77	71	6.6	1	0.0	12.7	3.9	24.0
23	30.0	24.0	84	50	0.0	0	0.0	12.6	4.5	27.0
24	33.0	25.0	84	56	0.0	0	5.0	12.4	5.5	29.0
25	33.0	25.0	84	61	0.0	0	5.3	14.6	5.0	29.0
26	33.0	23.0	86	50	0.0	0	7.4	16.1	5.2	28.0
27	33.0	23.0	71	55	0.0	0	8.2	14.5	5.5	28.0
28	31.0	24.0	78	47	0.0	0	6.0	11.4	5.6	27.5
29	33.0	26.0	70	46	0.0	0	7.6	7.2	6.0	29.5
30	35.4	23.2	78	46	3.0	1	6.7	6.1	5.1	29.3
Total	**1005.9**	**747.7**	**2354**	**1608**	**160.0**	**8**	**145.5**	**226.9**	**176.6**	**876.8**
Mean	**33.5**	**24.9**	**78.5**	**53.6**	**-**	**-**	**4.9**	**7.6**	**5.9**	**29.2**

Appendix II

Daily meteorological data recorded at ARI, Rajendranagar for the month of July, 2015

Date	Temperature		R. H. (%)		Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	Evaporation (mm)	Mean Temp. (^oC)
	Max.	Min.	I	II						
1	34.0	25.0	77	51	0.0	0	10.0	8.7	5.7	29.5
2	34.5	23.5	84	72	0.0	0	9.6	7.2	5.8	29.0
3	30.5	24.5	73	40	0.0	0	0.5	5.5	3.6	27.5
4	34.5	24.0	73	39	0.0	0	9.1	7.6	6.4	29.3
5	36.0	24.0	70	40	0.0	0	10.6	9.5	8.3	30.0
6	35.5	24.0	70	43	0.0	0	10.7	13.4	10.0	29.8
7	35.0	24.0	77	42	0.0	0	10.6	12.7	9.1	29.5
8	34.5	25.0	73	49	0.0	0	10.0	11.3	8.4	29.8
9	33.5	24.5	77	52	0.0	0	4.0	10.3	6.4	29.0
10	34.0	25.0	77	47	0.0	0	2.3	14.2	7.2	29.5
11	35.5	23.5	77	44	0.0	0	6.2	14.5	8.5	29.5
12	34.5	24.0	77	45	0.0	0	6.4	11.7	8.1	29.3
13	36.0	25.5	71	52	0.0	0	9.6	7.6	7.5	30.8
14	35.0	25.0	77	45	2.0	0	10.4	6.3	8.2	30.0
15	35.0	23.0	97	78	14.2	1	6.0	5.8	5.0	29.0
16	31.0	24.0	79	58	2.2	0	2.9	6.0	3.6	27.5
17	32.5	23.5	84	59	0.0	0	7.4	7.9	5.8	28.0
18	33.0	23.0	84	56	0.0	0	10.1	10.6	7.1	28.0
19	32.5	23.5	81	53	0.0	0	7.4	10.1	5.8	28.0
20	32.5	23.5	84	56	0.0	0	5.5	13.0	6.4	28.0
21	32.5	22.5	79	55	3.2	1	5.7	9.8	6.4	27.5
22	31.5	24.0	84	61	0.0	0	5.5	13.7	6.2	27.8
23	31.0	24.5	77	56	0.0	0	2.0	11.4	5.0	27.8
24	32.0	23.5	79	47	0.0	0	0.5	8.7	5.0	27.8
25	34.0	23.5	79	49	0.0	0	7.6	10.5	7.1	28.8
26	33.0	23.0	84	50	3.6	1	9.0	12.2	7.4	28.0
27	32.5	23.5	77	42	0.0	0	5.0	10.6	7.5	28.0
28	34.0	23.0	77	36	0.0	0	9.4	9.7	8.2	28.5
29	36.0	22.5	73	41	0.0	0	11.2	12.4	9.5	29.3
30	34.0	23.0	81	52	0.0	0	9.5	15.1	10.1	28.5
31	31.0	23.0	77	46	0.0	0	3.9	10.1	6.2	27.0
Total	**1041.0**	**738.0**	**2429**	**1556**	**25.2**	**3**	**218.6**	**318.1**	**215.5**	**860.0**
Mean	**33.6**	**23.8**	**78.4**	**50.2**	**-**	**-**	**7.1**	**10.3**	**7.0**	**28.7**

Appendix VI

Daily meteorological data recorded at ARI, Rajendranagar for the month of November, 2015

Date	Temperature Max.	Temperature Min.	R. H. (%) I	R. H. (%) II	Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	Evaporation (mm)	Mean Temp. (°C)
1	31.0	20.0	100	47	16.5	1	8.0	1.9	3.7	25.5
2	32.0	19.5	100	44	0.0	0	7.8	0.6	4.0	25.8
3	32.0	21.5	95	51	0.0	0	9.2	0.3	3.2	26.8
4	31.0	19.0	96	44	0.0	0	5.9	1.0	3.2	25.0
5	32.0	18.5	95	52	0.0	0	7.6	1.1	4.7	25.3
6	31.5	18.0	91	48	0.0	0	7.9	0.8	3.8	24.8
7	32.0	16.5	90	70	0.0	0	8.7	1.4	4.6	24.3
8	31.5	19.0	96	83	0.0	0	8.0	1.9	4.2	25.3
9	31.5	14.5	86	86	0.0	0	9.0	3.2	5.6	23.0
10	30.5	17.0	85	90	0.0	0	4.5	3.7	4.3	23.8
11	30.0	18.0	91	86	0.0	0	5.7	3.9	3.8	24.0
12	31.0	15.0	84	86	0.0	0	9.4	4.2	6.3	23.0
13	31.0	13.5	94	48	0.0	0	9.3	2.1	3.9	22.3
14	32.0	14.5	79	49	0.0	0	8.0	1.8	3.8	23.3
15	30.5	15.0	83	33	0.0	0	7.8	2.3	4.8	22.8
16	31.0	19.0	87	56	0.0	0	6.8	1.6	3.6	25.0
17	25.5	17.0	79	52	0.0	0	0.0	1.8	2.4	21.3
18	29.0	16.5	90	46	0.0	0	5.8	2.9	3.5	22.8
19	30.0	19.0	58	53	0.0	0	9.3	3.5	5.3	24.5
20	29.0	19.5	88	81	0.8	0	5.5	3.2	3.8	24.3
21	25.5	19.5	75	53	0.0	0	0.5	0.5	2.8	22.5
22	30.0	20.5	83	51	0.0	0	7.7	1.3	3.4	25.3
23	30.0	19.5	91	45	0.0	0	6.2	0.5	4.2	24.8
24	30.5	19.0	96	48	0.0	0	9.1	0.8	4.2	24.8
25	30.5	16.5	90	46	0.0	0	7.7	0.0	3.3	23.5
26	29.5	14.0	89	40	0.0	0	8.9	0.5	3.8	21.8
27	30.5	14.5	90	35	0.0	0	9.0	0.2	3.5	22.5
28	32.0	16.0	90	36	0.0	0	9.2	0.2	3.5	24.0
29	31.0	17.5	86	38	0.0	0	8.9	0.6	3.9	24.3
30	30.0	22.5	83	62	0.0	0	9.1	1.9	6.0	26.3
Total	**913.5**	**530.0**	**####**	**####**	**17.3**	**1.0**	**220.5**	**49.7**	**121.1**	**721.8**
Mean	**30.5**	**17.7**	**88.0**	**55.3**	**0.6**	**0.0**	**7.4**	**1.7**	**4.0**	**24.1**

Appendix V

Daily meteorological data recorded at ARI, Rajendranagar for the month of October, 2015

Date	Temperature		R. H. (%)		Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	:vaporatio (mm)	Mean Temp. (oC)
	Max.	Min.	I	II						
1	30.0	22.5	97	64	0.0	0	4.4	0.3	2.9	26.3
2	31.0	22.0	92	61	0.8	0	5.4	0.2	3.0	26.5
3	31.5	21.5	97	72	0.0	0	5.6	0.0	3.0	26.5
4	32.0	21.5	100	67	31.0	1	5.8	0.2	3.8	26.8
5	31.5	21.5	97	46	2.8	1	2.5	0.2	3.0	26.5
6	31.0	21.0	95	40	0.0	0	8.4	0.2	4.2	26.0
7	32.5	18.0	94	35	0.0	0	8.8	0.3	4.1	25.3
8	32.5	17.0	96	41	0.0	0	9.0	0.2	4.4	24.8
9	33.0	19.0	91	32	0.0	0	8.5	0.2	4.2	26.0
10	34.0	23.0	81	50	0.0	0	8.1	0.0	5.2	28.5
11	33.0	22.0	84	49	0.0	0	8.0	0.5	4.5	27.5
12	33.0	20.5	91	31	0.0	0	4.0	0.0	3.8	26.8
13	34.0	18.5	91	26	0.0	0	8.7	0.0	4.7	26.3
14	34.0	17.0	85	33	0.0	0	8.9	0.0	4.7	25.5
15	34.0	18.0	91	35	0.0	0	7.4	0.0	3.4	26.0
16	34.0	20.0	100	48	0.0	0	7.5	0.0	4.0	27.0
17	32.0	21.0	91	58	0.0	0	9.0	0.2	4.8	26.5
18	31.0	21.0	87	50	0.0	0	6.9	0.6	3.5	26.0
19	32.5	20.0	91	35	0.0	0	9.0	0.3	4.0	26.3
20	32.5	17.0	91	34	0.0	0	9.4	0.5	5.6	24.8
21	33.5	17.0	91	34	0.0	0	9.3	2.7	6.0	25.3
22	33.0	18.5	91	34	0.0	0	9.5	2.1	5.0	25.8
23	33.0	18.5	91	39	0.0	0	9.6	1.8	3.6	25.8
24	33.0	17.5	91	45	0.0	0	9.3	1.6	5.2	25.3
25	32.5	19.5	88	50	0.0	0	9.0	1.8	5.2	26.0
26	32.0	18.5	91	47	0.0	0	8.7	2.1	5.2	25.3
27	31.5	17.0	91	33	0.0	0	7.6	2.1	5.0	24.3
28	32.0	17.5	82	57	0.0	0	8.9	1.1	3.6	24.8
29	31.0	22.5	91	66	0.0	0	8.1	2.9	4.2	26.8
30	31.0	21.5	87	52	1.8	0	5.9	0.8	2.5	26.3
31	31.0	21.0	73	52	0.0	0	6.4	1.9	4.2	26.0
Total	1002.5	611.0	2809.0	1416.0	36.4	2.0	237.6	24.8	130.5	806.8
Mean	32.3	19.7	90.6	45.7	1.2	0.1	7.7	0.8	4.2	26.0

Appendix III

Daily meteorological data recorded at ARI, Rajendranagar for the month of August, 2015

Date	Temperature		R. H. (%)		Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	Evaporation (mm)	Mean Temp. (oC)
	Max.	Min.	I	II						
1	33.0	22.5	87	51	3.8	1	8.2	9.3	7.0	27.8
2	34.0	23.0	79	46	0.0	0	9.4	6.4	6.8	28.5
3	33.5	22.0	79	49	3.6	1	7.4	5.0	6.6	27.8
4	33.0	24.0	77	49	0.0	0	4.8	5.1	5.5	28.5
5	31.0	23.5	81	41	0.6	0	0.6	9.8	5.8	27.3
6	32.5	22.0	87	71	2.6	1	7.0	8.4	5.9	27.3
7	32.0	24.0	84	47	0.0	0	6.6	10.0	5.0	28.0
8	33.0	24.0	84	66	8.0	1	5.0	7.2	5.7	28.5
9	30.0	25.0	84	59	0.0	0	3.5	6.0	6.2	27.5
10	29.0	25.0	92	82	0.0	0	1.0	2.9	5.5	27.0
11	32.5	24.0	92	63	0.0	0	2.3	3.2	3.3	28.3
12	31.0	22.5	87	74	0.2	0	1.8	6.0	3.5	26.8
13	28.0	21.5	87	79	4.0	1	0.6	7.7	3.6	24.8
14	27.0	22.5	84	87	1.8	0	0.0	5.3	2.8	24.8
15	31.0	22.5	92	56	4.6	1	7.8	4.8	3.9	26.8
16	35.0	22.0	92	80	13.6	1	8.7	4.8	4.4	28.5
17	28.0	22.5	92	59	6.0	1	0.0	0.8	4.0	25.3
18	32.0	23.5	92	70	0.0	0	6.5	1.6	3.2	27.8
19	32.0	22.5	89	52	0.0	0	2.0	0.6	2.8	27.3
20	34.0	21.5	100	72	41.8	1	8.5	1.6	4.0	27.8
21	30.5	22.0	95	75	2.0	0	1.1	2.6	3.5	26.3
22	31.0	21.5	92	62	5.6	1	2.9	4.8	5.6	26.3
23	32.0	24.0	92	82	0.0	0	3.7	3.9	6.1	28.0
24	30.0	24.0	87	55	0.0	0	9.4	3.7	6.2	27.0
25	31.0	23.0	84	50	0.0	0	10.4	2.7	6.0	27.0
26	32.0	23.0	84	56	0.0	0	10.4	3.7	6.2	27.5
27	32.0	20.0	87	66	0.0	0	8.5	2.1	5.7	26.0
28	30.0	22.0	87	87	1.0	0	0.8	2.6	5.4	26.0
29	29.0	22.0	84	66	13.6	1	1.9	3.5	4.7	25.5
30	30.0	22.0	92	71	14.0	1	0.0	3.7	4.6	26.0
31	28.0	23.0	78	60	0.0	0	2.2	4.0	4.9	25.5
Total	**967.0**	**706.5**	**2703**	**1983**	**126.8**	**12.0**	**143.0**	**143.8**	**154.4**	**836.8**
Mean	**31.2**	**22.8**	**87.5**	**64.1**	**-**	**-**	**4.7**	**4.7**	**5.0**	**27.0**

Appendix IV

Daily meteorological data recorded at ARI, Rajendranagar for the month of September, 2015

Date	Temperature		R. H. (%)		Rainfall (mm)	Rainy days	Sunshine (hrs.)	Wind speed (km/hr)	Evaporation (mm)	Mean Temp. (oC)
	Max.	Min.	I	II						
1	30.0	23.0	78	61	0.0	0	4.2	4.7	5.2	26.5
2	31.5	23.0	77	56	0.0	0	9.7	4.8	5.7	27.3
3	33.0	22.0	84	46	0.0	0	8.4	3.1	6.0	27.5
4	34.0	24.0	90	56	0.0	0	7.9	1.6	6.6	29.0
5	34.0	24.0	84	51	5.4	1	6.8	1.4	5.5	29.0
6	34.0	22.0	92	57	11.8	1	8.1	1.0	5.6	28.0
7	33.0	24.0	86	56	0.0	0	6.9	1.1	5.6	28.5
8	32.0	22.0	91	64	12.2	1	6.7	1.1	5.2	27.0
9	34.0	22.5	92	84	1.4	0	5.4	0.6	4.4	28.3
10	29.5	22.0	97	100	2.2	0	2.9	0.2	2.2	25.8
11	29.0	21.5	100	72	26.2	1	3.0	0.3	1.4	25.3
12	29.5	21.5	95	78	6.0	1	2.5	0.8	2.1	25.5
13	29.0	22.0	92	72	0.0	0	1.1	1.9	3.4	25.5
14	29.5	22.5	95	100	0.0	0	1.7	1.1	3.2	26.0
15	28.0	21.5	97	100	29.4	1	0.3	0.8	2.8	24.8
16	24.0	22.5	95	78	28.2	1	0.2	0.5	2.4	23.3
17	29.0	22.5	92	74	19.6	1	1.7	2.6	3.6	25.8
18	29.5	23.5	87	63	0.0	0	2.0	2.4	2.1	26.5
19	31.0	22.0	95	66	23.8	1	5.4	1.3	3.0	26.5
20	31.0	22.5	87	69	0.0	0	5.4	0.8	4.0	26.8
21	30.0	22.5	88	54	0.0	0	2.1	0.6	3.0	26.3
22	30.5	22.0	87	53	0.0	0	6.3	0.6	4.4	26.3
23	32.0	20.5	91	48	0.0	0	8.1	0.2	4.5	26.3
24	33.0	24.0	84	52	0.0	0	8.9	0.0	4.0	28.5
25	33.0	23.0	85	61	0.0	0	8.6	0.2	4.7	28.0
26	31.5	23.0	92	67	0.0	0	6.0	0.0	4.6	27.3
27	31.0	23.0	95	45	0.0	0	4.5	0.2	2.8	27.0
28	32.5	19.0	91	49	0.0	0	7.8	0.2	5.3	25.8
29	31.5	22.5	87	63	0.0	0	8.6	0.3	4.6	27.0
30	31.0	21.5	92	66	2.0	0	5.7	0.5	4.3	26.3
Total	**930.5**	**671.5**	**2698.0**	**1961.0**	**168.2**	**9.0**	**156.9**	**34.9**	**122.2**	**801.0**
Mean	**31.0**	**22.4**	**89.9**	**65.4**	**5.6**	**0.3**	**5.2**	**1.2**	**4.1**	**26.7**