ABSTRACT

In the present investigation, the seed parent of castor hybrid DCH-519 i.e., M-574 was studied in order to know the effect of nitrogen and growth regulator (ethrel) on sex expression and hybrid seed quality. The parental lines of castor hybrid DCH-519 hybrid i.e., M-574 (female line) and DCS-78 (male line) were sown in 4:1 ratio in the second fortnight of October at Seed Research and Technology Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design (RBD) in three replications during rabi, 2008-09.

Seven treatments were imposed namely, 40 kg N/ha (T₁), 60 kg N/ha (T₂), 80 kg N/ha (T₃), 100 kg N/ha (T₄), 120 kg N/ha (T₅), 40 kg N + ethrel 200 ppm/ha
The following characters were studied both in the field level and at laboratory level – number of pistillate plants per plot, number of ISF in different order spikes, total plant stand per plot, days to initiation of first raceme, days to 50 per cent flowering of first raceme, days to maturity of first raceme, plant height (cm) upto primary spike, number of nodes upto primary spike, effective length of primary spike (cm), 100-seed weight (g), seed yield/plant (g), and genetic purity(%) were studied in the field level and the observations on oil content (%), germination per cent, seedling vigour index on length and dry weight basis and field emergence index were made at laboratory level. Among all the seven treatments, 40 kg N/ha was treated as control. The data was analyzed to know the extent of influence of nitrogen and growth regulator on sex expression.

The treatments differed significantly with respect to expression of pistillateness and ISF in primary and secondary order spikes. Among different nitrogen treatments, the seed parent that received 100 kg N/ha recorded less number of ISF and maximum number of pistillate plants and which was found to be an optimum dose to take up hybrid seed production. Ethrel treatment at a concentration of 200 and 400 ppm along with 40 kg N/ha enhanced the expression of pistillate flowers by suppression of interspersed staminate flowers in the seed parent in the primary and secondary spike orders. The primary order spike produced more number of ISF over secondary order spike in all the treatments.

Among the nitrogen treatments, 100 kg N/ha resulted in early flowering (44 days) and maturity (125 days) when compared to all other nitrogen treatments. Ethrel treatment recorded maximum spike length (60.33 cm), 100-seed weight (28.70 g), oil content (52.18 %) and maximum seed yield (65.33 g) at a very short plant height (46.00 cm).
Seed quality parameters like germination per cent, seedling vigour index and field emergence index were recorded high in the hybrid seed obtained from ethrel treatments. Ethrel treatment @ 200 ppm along with 40 kg N/ha resulted in high genetic purity (94.00%) of hybrid seed due to suppression of ISF and maintenance of stable pistillate plants, while the seed obtained from the plots that received 40 and 60 kg N/ha recorded very low genetic purity (75.25 - 80.75 %) as a result of more number of ISF in the seed parent. It was concluded that ethrel @ 40kg N/ha+ ethrel 200 ppm /ha was found to be very effective for obtaining better quality seed by suppression of ISF in seed parent M-574 of castor hybrid DCH-519.
CHAPTER 1

INTRODUCTION

Castor (*Ricinus communis* L.) is one of the important non edible oilseed crops of India cultivated in 8.26 lakh ha with 10.99 lakh tonnes production and 1331 kg/ha productivity earning nearly Rs.800 crores through export of castor oil and its products (OSDOC press gleanings, 2008-09). India accounts for nearly 55% of the world castor area (12.64 lakh ha) and 67% of world castor production (11.40 lakh tones) and ranks first in area and production.

Castor is grown under varied climatic conditions including tropical, subtropical and temperate regions. Major castor growing countries are India, China, Brazil and Thailand. As per available literature, castor is indigenous to eastern Africa and most probably originated in Ethiopia. It belongs to the family Euphorbiaceae with a diploid chromosome number 2n=20.

Castor is grown for its non-edible oil. Today castor oil finds its application in the manufacture of a wide range of ever expanding industrial products such as nylon fibres, jet engine lubricants, hydraulic fluids etc.,

India is the first country in the world to commercially exploit heterosis in castor on a large scale since 1970’s with the release of GCH-3 from Gujarat. Since then cultivation of several hybrids like GAUCH-1, GCH-2, GCH-4, GCH-5, GCH-6, DCH-32 etc. led to a phenomenal increase in productivity from 306 kg/ha to 1331kg/ha. Seed production technology has been standardized and improved
with a close interaction between plant breeders and seed technologists. However, an inherent problem with the basic mechanism of sex expression of castor led to poor quality hybrid seed and it became the major problem for large scale adoption of hybrids.

Castor is a sexually polymorphic species with different sex forms viz., monoecious (pistillate or female flowers at the top and staminate or male flowers at the bottom of the inflorescence), pistillate (all female flowers without any male flowers), sex revertants (pistillate plants become monoecious in later order spikes) and Interspersed Staminate Flowers (ISF) (pistillate spikes with male flowers in between).

The normal inflorescence in castor is a monoecious raceme which bears pistillate flowers in the upper portion and staminate flowers in the lower portion of spike. Sex expression in castor is highly influenced by environmental factors like high day temperature (\(>32^\circ\text{C}\)), photo period, fertility, age of the plant, nutrition etc. (Shifriss, 1960). To exploit the heterosis, hybrid seed production in castor is a major constraint, there is a need to search the feasible environment for the improvement of quality of hybrid seed.

Hybrid seed production in castor is revolutionized by the identification of pistillate lines. Occurrence of Interspersed Staminate Flowers (ISF) is causing a serious problem in maintaining genetic purity of the seed. Application of nitrogen plays a key role in improving the pistillate character. Available literature suggested that application of growth regulators can alter the sex expression in
castor (Shiffriss, 1961). The manipulation of sex towards induction of pistillate or reduction of staminate and ISF will be helpful in overcoming the problems associated with maintenance of pistillate lines and hybrid seed production irrespective of the season during the seed production programme.

Studies on manipulation of new pistillate line M-574 using application of nitrogen and growth regulators to increase the quantity and quality of hybrid seed produced is utmost essential for the spread of the new castor hybrid DCH-519. As there is a lack of information on the role of nitrogen and ethrel on the pistillate line M-574, the present investigation was undertaken with the following objectives.

1. To study the effect of nitrogen on expression of pistillate / staminate flowers in the pistillate line M-574

2. To study the effect of growth regulators on sex expression, genetic purity and quality seed production in the pistillate line M-574
CHAPTER 11

REVIEW OF LITERATURE

Availability of literature and research work on sex expression and manipulation of pistillate character of castor is scanty. Hence the available information on similar aspects was reviewed with other crops besides castor crop and is presented under the following headings.

2.1 EFFECT OF NITROGEN ON SEX EXPRESSION, SEED YIELD AND YIELD COMPONENTS

Shiffriss (1956) worked on sex instability in castor at Israel and reported that female tendency was relatively strong in young plants, especially in primary racemes and under conditions of moderate temperature, moderate vegetative activity and high level of nutrition. In contrast, male tendency was relatively strong in old declining plants and under conditions of very high temperature, high vegetative activity and low level of nutrition.

Sex expression in castor is highly influenced by environmental factors like high day temperature, photo period, fertility, age of the plant and nutrition etc. (Shiffriss, 1960; Zimmerman and Smith, 1966).
The increase in seed yield in castor with enhanced levels of nitrogen supply was due to greater length of spikes, number of seeds per spike and 100-seed weight (Narkhede et al. 1984).

Significantly higher plant height (139.6 cm) was observed with application of 60 kg N/ha as compared to control (0 kg N/ha) (108 cm) and 20 kg N/ha (121 cm) in castor. The plant height with 60 kg N/ha was on par with that of 40 kg N/ha (Muthuvel et al. 1987).

Ramachandram and Ranga Rao (1988) reported that pistillate character in castor (Ricinus communis L.) is polygenically controlled and is highly unstable varying with management levels, time of planting, nutrition and other environmental factors and it can revert to monoecious or ISF at any stage.

Patel et al. (1991) reported that the application of 75 kg N/ha in three splits was optimum for castor to get optimum yield and maximum net profit in North Gujarat under irrigated conditions.

Plant height was significantly higher in castor with 120 kg N/ha applied in four splits (DOR, 1994).
Rao et al. (1995) reported genetic variations in fertilizer responses and castor hybrid ‘GCH-4’ responded positively to fertilizer application (75 kg N + 22 kg P/ha) in terms of seed and oil yields whereas ‘Aruna’ was not responsive. ‘GCH-4’ was superior to ‘Aruna’ for 100-seed weight, oil content, seed and oil productivity.

The treatment with 80 kg N/ha recorded significant increase in the oil percentage. However, the percentage of oil recorded was similar to that with 40 kg N/ha and control (0 kg N/ha) (Vani, 1995).

Raghavaiah (1999) reported that castor hybrid DCH-177 fertilized with 75% RDF + FYM 5t/ha offered distinct improvement in seed yield over the rest of the treatments. The treatments differed in oil content, while fertilizer application had a desirable effect on oil content.

The number of ISF plants decreased while proportion of pistillate plants increased with higher levels of nitrogen at DOR, Hyderabad and Tindivanam in Tamil Nadu. Application of 40 kg N as basal followed by 20 kg N each at 35, 70 and 105 days recorded the highest mean seed yield of 1745 kg/ha in three isolations for two years at Tindivanam. Maintenance of VP-1 during February by refined method with application of 80 kg N/ha at 90 x 60 cm spacing at DOR,
Hyderabad and 100 kg N/ha along with irrigation at 1.0 I W/CPE at Palem gave highest seed yield of VP-1 (DOR, Hyderabad, 1999).

There was no effect of nitrogen up to 125 kg/ha and irrigation up to 1.25 IW/CPE on the percentage of ISF, pistillate plants and reversion below the fourth order of spike at S.K. Nagar. Both at S.K. Nagar and Junagadh, pistillate line Geeta gave higher seed yield compared to VP-1 with higher doses of nitrogen (100-125 kg N/ha) and irrigation level (IW/CPE) above one. However, the influence of nitrogen (0, 40, 80, 120 kg N/ha) on ISF was not significant in 11 interspersed (ISF) and 5 non interspersed (NISF) breeding lines isolated from late revertant pistillate progenies of VP-1 at DOR, Hyderabad (DOR, Hyderabad, 1999).

Raghavaiah and Sudhakar Babu (2000) reported that application of 50 kg N/ha resulted in highest seed yield of 10.41 q/ha, beyond which the seed yield declined with every additional dose of nitrogen in castor hybrid GCH-4.

Patel and Pathak (2001) reported that application of 120 kg N/ha (40 kg N/ha as basal and at 40 and 100 DAS), along with 50 kg P₂O₅/ha to castor hybrid GCH-5 is recommended under irrigated conditions of North Gujarat.

An attempt has been made to isolate isogenic lines of VP-1 pistillate line to overcome the problems of maintenance of pistillate line in summer season at
DOR, Hyderabad. The study identified two lines with Less Environmentally Sensitive (LES) i.e., ISF-2 and ISF-4 (Lavanya, 2002).

Sivalakshmi and Sambasiva Reddy (2002), reported that spike length, number of spikes per plant, capsules per spike, spike weight, 100-seed weight, seed and stalk yield increased significantly with the increase in nitrogen level up to 80kg/ha.

In a study on sex expression in castor, Gopala Krishnamurthy et al. (2003) reported that maximum expression of pistillateness was found in September 15th sowing while it was the lowest in March 15th sowing and the expression of Interspersed Staminate Flowers (ISF) was maximum in February 15th sowing in castor. They also stated that the primary spike produced the highest number of pistillate whorls compared to secondary, tertiary, quartenary and pentenary spikes. The highest number of ISF was produced on the secondary spikes.

In a study on cropping sequence of rabi castor, Patel et al. (2005) stated that length of primary spike, number of capsules/primary spike and number of branches/plant were significantly superior with application of 80 and 120 kg/ha over 40 kg N/ha and control.
Tank *et al.* (2007) reported that among different spacings (120×60 cm, 120×75 cm, 150×60 cm, and 150×75 cm) and different doses of nitrogen levels (60, 80, 100, and 120 kg N/ha) in castor, the application of nitrogen at 60 kg N/ha and 150×75 cm spacing were found economical for commercial hybrid cultivation under irrigated conditions of middle part of Gujarat.

Sridharamurthy *et al.* (2008) reported that in castor the treatment with 120 kg N/ha exhibited higher plant height, nodes, higher length of primary spike, number of spikes per plant, total number of capsules per spike, test weight and seed yield compared to the treatments which received 90 and 60 kg N/ha.

### 2.2 REGULATION OF SEX EXPRESSION BY USING CHEMICALS

Availability of literature and research work on sex expression and manipulation of pistillate character using chemicals in castor is scanty. Hence the available information on similar aspects was reviewed with other crops besides castor crop and is presented under the following headings.

#### 2.2.1 CASTOR

Shiffriss (1961) reported that spraying monoecious inbreds with GA$_3$ markedly increased female tendency due to stimulative action of long days in castor. Further, it was also revealed that the effective range of concentration was between 250 and 1500 ppm of potassium gibberellate.
Mohan Ram and Rina Seth (1980) reported that aqueous solution of silver nitrate (10-100 µg/plant) and cobalt chloride (125-500 µg/plant) injected into the main stem of the pistillate castor induced the formation of staminate flowers with viable pollen in the normal strictly pistillate terminal inflorescence of castor. The number of staminate flowers increased with the dose of silver and cobalt ions.

Mary Varkey et al. (1982) reported that among different treatments viz., Chloroflurenol, Ethephone and NIA applied at different stages of castor, chloroflurenol @ 240 ppm at 5-7, 10-12 leaf stages resulted in complete maleness. However, Ethephon @ 960, 1920, and 2880 ppm resulted in high degree of femaleness, where as application of NIA 10637 @ 1000, 2000 ppm at cotyledon to 5-7 leaf stage resulted in high degree of maleness and showed high degree of femaleness when applied at 10-12 leaf stage.

Jaiswal and Madan Lal (1985) reported that pthalimides increased the percentage of female flowers in castor with simultaneous decrease in the percentage of male flowers when treated @ 125, 250 and 500 ppm. Some male flower buds failed to open, dried and abscised at 500 ppm of pthalimide.

Rudradhya and Habib (1985) showed that irradiation of castor (Ricinus communis L.) seeds with 10K r gamma radiation resulted in production of spikes
with 100 per cent pistillateness in M₁ plants, whereas in M₂, 40 per cent of population reverted to the normal monoecious condition, while, the remaining 60 per cent produced 100 per cent pistillate spikes.

Ramesh et al. (2000) reported that spraying ethrel @ 250ppm gave the maximum number of female flowers and it was the optimum dose for obtaining mean seed yield in Aruna variety of castor (Ricinus communis L.).

Lakshmamma et al. (2002) revealed that interspersed staminate flower production was more with the application of GA₃ and silver nitrate upto 100 ppm in secondary, tertiary and quaternary spike orders during October, November and December months in castor, pistillate line (VP-1).

In a study on sex expression in castor, Gopalakrishna Murthy et al. (2003) reported that, Ethrel sprayed @ 200 ppm gave maximum number of pistillate whorls, while AgNO₃ @50 ppm gave maximum number of interspersed staminate flowers when sprayed at 25 and 57 days after sowing.

Severino et al. (2006) reported that the chemical Mepiquat chloride had significant effects on the number of female flowers, ratio of female nodes to male nodes, and ratio of the number of female nodes to the length of female nodes.
Mepiquat chloride at 0.08% and 0.16% was most effective in feminization of castor bean plants.

2.2.2 OTHER CROPS

Karchi and Govers (1972) reported that spraying of Ethephone @150, 250 and 350 ppm in cucumber resulted in high frequency of pistillate flowers when sprayed at the onset of flowering in gynoecious plants, when compared to monoecious plants.

Besides environmental factors like temperature and photoperiod, endogenous growth regulators were reported as the important determinants of sex expression. Spraying ethylene releasing compounds causes formation of female flowers in place of male flowers in cucurbits (Augustine et al. 1973) and induces the formation of female flowers in staminate plants of *Cannabis sativa* L. (Mohan Ram and Jaiswal, 1974).

Augustine *et al.* (1973) reported that spraying of Ethephone @ 50 ppm at 3rd or 4th leaf stage resulted in induction of pistillate flowers without marked inhibition of growth in *Cucumis sativus* L.
Shannon and Robinson (1979) reported that application of 400 to 600 ppm Ethephone twice in summer squash resulted in development of the few staminate flowers without significantly reducing seed yield or quality.

Balasubramanian and Narayana Swamy (1980) reported that application of Ethrel @ 300 ppm resulted in gradual decrease of both male and female racemes whereas, Ethrel sprayed at 1000 ppm resulted in wholly pistillate racemes and also informed that plants sprayed with ethrel 200 ppm eliminated all maleness in *Acalypha indica*.

Hunsperger et al. (1983) reported that spraying of Silver nitrate @ 300-400 ppm on hermaphrodite cucumber lines resulted in maximum number of staminate flowers and also informed that 3-4 sprays are required to induce male flowers when sprayed at early stages.

Kumar et al. (1985) reported that application of silver nitrate @ 1000 ppm resulted in production of male inflorescence at high frequency (88.6%) in mulberry and further reported that exogenous application of gibberellins and silver nitrate resulted in production of male flowers in female plants by inhibiting the ethylene level in plants.
Sharma *et al.* (1988) reported that in bottle gourd when it is treated with several growth regulators at different stages, the highest average yields were obtained with NAA @ 50 ppm and with Atonik (Nitrophenolate-Sodium + Nitrogeraiecol-Sodium) at 0.1%.

Alvarez (1989) reported that hybrid seed percentage from Ethephone treated plants was significantly higher than that of control plants in musk melon.

Arora *et al.* (1989) revealed that ethrel @ 100 and 150 ppm significantly increased the number of fruits per vine and GA$_3$ @ 10 and 25 ppm improved vine growth and seed content in pumpkin (*Cucurbita moschata* L.).

Kabir *et al.* (1989) reported that in *Mimordica charantia* L. variety Pusa Domousami, treatment with cycocel @ 500ppm decreased vine length, leaf area, male: female ratio and the number of male flowers but increased the number of female flowers.

Sarkar *et al.* (1989) reported that sex ratio (female : male) increased from 1:1 to 1:0.33 after treatment with both 50 ppm and 100 ppm ethrel in pointed gourd.
Mandal et al. (1991) revealed that ethrel caused the production of female flowers at lower nodes, slightly earlier and gave the largest number of female flowers/plant in bottle gourd.

Kshirsagar et al. (1995) reported that Ethrel @ 300 ppm accelerated the appearance of first female flowers and the highest marketable fruit yield was obtained with 100 ppm of Ethrel in cucumber cv. Himangi.

Gedam et al. (1998) reported that in bitter gourd, application of Boron at 4 ppm showed a lower sex ratio of 1:3 as against 1:11 and 1:12 in water spray and absolute control, respectively and also reported that application of NAA @ 50 ppm showed the earliest maturity followed by Boron @ 4 ppm.

Wankhade et al. (2003) reported that in cucumber cv. Himangi, cycocel treatment significantly increased the number of female flowers per vine but significantly reduced the period of fruit maturity by 6-13 days as against control. They also reported that the per cent seed germination of cucumber seed was significantly increased due to cotyzyme crop treatment sprayed @ 0.2%.

Gaganpreeth (2005) reported that CoCl$_2$ at 15 µg/ml increased the flower number, pod: peg ratio, 100-seed weight and seed yield per plant, while Ethrel (ethephone) at 200 µg/ml reduced the flower number, pod: peg ratio, 100-seed
weight and seed yield per plant in two cultivars of groundnut (*Arachis hypogaea L.*) i.e. M-522 and SG-84. The CoCl$_2$ treatment increased the number of flowers to be fertilized and converted to pegs and mature pods.

Sudipta Basu *et al.* (2005) reported that in rice, application of GA$_3$ significantly increased the plant height and there was increase in seed yield with increase of GA$_3$ dose but had no effect on 100-seed weight and seed quality.

Marbhal and Musmade (2007) reported that the production of male flowers per vine was reduced by spraying of Ethrel (50 ppm), NAA (50 ppm) and Maleic Hydrazide (100 ppm) in bitter gourd (*Momordica charantia L.*). The growth regulators significantly increased the fruit yield per vine. The highest fruit yield per vine (1.43 kg), number of seeds per fruit (27.95), and seed yield (539.83 kg) were obtained with NAA treatment.
CHAPTER III
MATERIAL AND METHODS

The present investigation was carried out at the Seed Research and Technology Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during rabi, 2008-09. The details of the experimental material used and methods adopted in the present investigation are elucidated in this chapter under appropriate heads.

3.1 EXPERIMENTAL MATERIAL

The basic material for conducting the experiment consisted of parental lines M-574 (female) and DCS-78 (male) of DCH-519 castor hybrid obtained from the Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad. The main objective of the investigation was to study the effect of nitrogen and growth regulator (ethrel) on sex expression and genetic purity status. The details of the material are given table (a).

Composite soil sample was drawn from 0 to 30 cm depth before the commencement of the experiment. They were analysed for availability of nutrients by adopting standard procedures and methods employed. The results revealed that the soil was low in available nitrogen (215.6 kg/ha).
3.2 METHODS

3.2.1 Influence of Nitrogen on sex expression

The present investigation was carried out to study the effect of Nitrogen on sex expression in female parental line M-574 of newly released castor hybrid DCH-519. The parental lines M-574 (female line) and DCS-78 (male line) were sown in 4:1 ratio during the second fortnight of October, 2008-09. Nitrogen was applied in five doses viz., 40 (T₁), 60 (T₂), 80 (T₃), 100 (T₄) to 120 (T₅) kg N/ha in three splits at the time of sowing, at primary and secondary spike initiation stages. As per standard recommendations, treatment with 40 kg N/ha was treated as control.

3.2.2 Regulation of sex expression by chemicals

Exogenously applied plant growth regulators are known to affect sex expression in several monoecious and dioecious species. Studies have been made on the possible role of gibberillins, amino acids, silver and cobalt ions, ethrel, chloroflurenol and peroxidase and its isozymes in sex expression of *Ricinus communis* L.

The experiment was carried out to study the influence of exogenous application of chemical like ethrel in two different concentrations on sex expression in female parental line of DCH-519 hybrid i.e. M-574. The chemical was sprayed on the female parent at 28 and 45 days after sowing (DAS) to coincide with primary and secondary spike initiation stages. Nitrogen was applied
in five different doses in three splits at the time of sowing, primary spike and secondary spike initiation stages.

Table (a): Details of various treatments and their dosage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen - (T₁ – T₅)</td>
<td>40, 60, 80, 100 and 120Kg/ha</td>
</tr>
<tr>
<td>Ethrel - (T₆ &amp; T₇)</td>
<td>40 Kg N + 200 ppm/ha and</td>
</tr>
<tr>
<td></td>
<td>40 Kg N + 400 ppm/ha</td>
</tr>
</tbody>
</table>

*Recommended doses of phosphorous (60kg/ha) and potassium (60kg/ha) were applied in all the seven treatments.

3.3 Crop management

Recommended package of practices were adopted to raise a healthy crop. A plot size of 5×5 m to accommodate male and female plants in a 1:4 ratio where in 32 pistillate plants and 8 male plants were maintained with a spacing of 90×60 cm to accommodate in each row 8 plants uniformly.

Irrigation and weeding was done as and when required. Necessary prophylactic plant protection measures were carried out to protect the crop from pests and diseases.
3.4 OBSERVATIONS RECORDED

3.4.1 Number of ISF in different order spikes

The number of ISF were recorded in different order spikes i.e., primary, secondary spikes. The observations were recorded on five random plants selected in each plot.

3.4.2 Number of pistillate plants

The number of stable pistillate plants was recorded per plot by ensuring the sex of the plant in different spike orders

\[
\text{Number of pistillate plants} = \frac{\text{Percent of pistillate plants}}{100} \\
\text{Total number of plants observed}
\]

3.4.3 Number of pistillate plants with ISF

The number of pistillate plants producing ISF was recorded

\[
\text{Number of pistillate plants with ISF} = \frac{\text{Percent of pistillate plants}}{100} \\
\text{Total number of plants observed}
\]
3.4.4 Number of monoecious plants

Number of monoecious plants per plot was recorded by ensuring the sex of the plant in the primary spike and secondary spike.

Number of monoecious plants

Percent of monoecious plants = \frac{\text{Number of monoecious plants}}{\text{Total number of plants observed}} \times 100

3.4.5 Total plant stand

Data was recorded by counting the number of plants per plot.

3.4.6 Days to first raceme

Number of days taken for the appearance of first raceme was recorded in each plot.

3.4.7 Days to 50 per cent flowering

The number of days taken from sowing to the first flower appearance in 50 percent plants was recorded.

3.4.8 Days to maturity

The number of days taken from sowing date to the date when all the capsules in the primary spike of all plants turned brown and matured was recorded.
3.4.9 **Plant height (cm)**

Plant height from ground level up to the base of the primary spike was recorded.

3.4.10 **Number of nodes up to primary spike**

The number of nodes up to primary spike was recorded after the emergence of primary spike on the main stem.

3.4.11 **Length of primary spike (cm)**

The length from the base of the spike to the top most point of the spike was recorded in centimeters.

3.4.12 **100-seed weight (g)**

One hundred randomly selected dried seeds were weighed with the help of an electronic top pan balance and recorded in grams.

3.4.13 **Oil content (%)**

The oil content of the seed was estimated with the help of Nuclear Magnetic Resonance (NMR) in the laboratory of Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad and expressed in percent.
3.4.14 Seed yield (g)

Seed yield of single plant (total of two pickings) was recorded in grams after thorough drying and shelling.

3.4.15 Genetic purity

For testing the genetic purity status of the hybrid seed produced in different treatments, seeds were taken from primary spike and Grow-Out Test (GOT) was conducted.

For conducting GOT, a working sample size of 400 seeds were taken separately from each treatment by mixing and dividing technique. The seeds were sown in four replications of 100 seeds each separately with a spacing of 20 cm × 25cm. An authentic sample was sown adjacent to the GOT plot. All the recommended package of practices were adopted to raise a healthy crop. The following observations were made at the time of spike initiation stage by comparing with authentic plot.

\[
\text{Total plant population} \\
\text{True plants} (%) = \frac{\text{Selfed plants + Off-type plants}}{\text{Total plant population}} \times 100
\]

\[
\text{Number of selfed plants} \\
\text{Selfed plants} (%) = \frac{\text{Selfed plants}}{\text{Total plant population}} \times 100
\]
Number of Off-types

Off-type plants (%) = ----------------------------- × 100
Total plant population

True plants

Genetic purity (%) = ----------------------------- × 100
Total plant population

3.4.16 Germination percentage

One hundred seeds of each treatment in three replications were subjected to germination test following between paper method. On 10\textsuperscript{th} day, the number of seeds germinated was counted and the germination percent was calculated as per the formula given below.

\[
\text{Germination percent} = \frac{\text{No. of normal seedlings}}{\text{Total number of seeds}} \times 100
\]

3.4.17 Seedling vigour index

Ten seedlings in each replication of germination test were selected and root and shoot length was measured. These seedlings were dried in oven at 70 ± 1°C for 24 hours and dry weight of these seedlings was expressed in milligrams (mg), as per standard procedure (Abdul Baki and Anderson, 1973).

Seedling vigour index–I: Seed germination percent × seedling length (cm)
Seedling vigour index–II: Seed germination percent × seedling dry weight (mg)
3.4.18 Field Emergence index (EI)

The field Emergence index was recorded on alternate days from 7th to 14 days after sowing (DAS) in all the treatments. The rate of emergence (EI) was determined as decided by Baskin (1998).

3.4.19 Meteorological data

Meteorological data viz., temperature, relative humidity, rain fall, sunshine hours and wind speed were recorded and presented in appendix.

3.5 Statistical analysis

The data was subjected to statistical scrutiny by the method of analysis of variance outlined by Panse and Sukhatme, 1985. Statistical significance was tested by ‘F’ value at 5 per cent level of probability and wherever the ‘F’ value was found significant Critical Difference (C.D) was worked out at 5 per cent level of probability and the values are furnished.
CHAPTER IV

RESULTS

In the present investigation, the parental lines of newly released castor hybrid DCH-519 i.e., M-574 (female line) and DCS-78 (male line) were sown in 4:1 ratio in the second fortnight of October in a Randomized Block Design (RBD) with three replications at the Seed Research and Technology Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during rabi, 2008-09.

Commercial cultivation of castor hybrids led our country to attain numero-kno position in the world. The threat to this position is mainly the decreasing genetic purity levels due to instability of pistillate lines and production of ISF in seed production plots. This leads to high number of selfed plants, high cost of rouging, low genetic purity and decreasing productivity levels in commercial hybrids. As per available literature, nitrogen and growth regulators like ethrel have a positive influence in maintaining femaleness and reducing ISF in female plants.

In this context, the present investigation was conducted to understand the effect of nitrogen on the expression of Interspersed Staminate Flowers (ISF) which was responsible for selfing of pistillate parent in hybrid seed production. The present study also aimed to know the effect of growth regulator i.e., ethrel in two different concentrations on sex expression of pistillate parent in order to suppress the expression of staminate or ISF and to promote the expression of pistillate
flowers. Seven treatments were imposed namely, 40 kg N/ha (T1), 60 kg N/ha (T2), 80 kg N/ha (T3), 100 kg N/ha (T4), 120 kg N/ha (T5), 40 kg N + ethrel 200 ppm/ha (T6) and 40 kg N + ethrel 400 ppm/ha (T7). The following 16 characters were studied both at the field level and laboratory level – number of pistillate plants per plot, number of ISF in different order spikes, total plant stand per plot, days to initiation of first raceme, days to 50 per cent flowering of first raceme, days to maturity of first raceme, plant height (cm) up to primary spike, number of nodes up to primary spike, effective length of primary spike (cm), 100-seed weight (g), seed yield/plant (g), and genetic purity(%) were studied in the field level and the observations on oil content (%), germination per cent, seedling vigour index on length and dry weight basis and field emergence index were made at laboratory level. Among all the seven treatments, 40 kg N/ha was treated as control. The data were analyzed to know the extent of influence of nitrogen and growth regulator on sex expression. The results of present investigation are presented below.

4.0 Analysis of variance

The analysis of variance for RBD with respect to yield and yield components and quality parameters is presented in the tables1, 2 &3. The mean sum of squares for all treatments were found to be significant for all the traits
Table 1: Analysis of variance for yield and yield components

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>No.of ISF in primary spike</th>
<th>No.of ISF in secondary spike</th>
<th>Days to first raceme</th>
<th>Days to 50% flowering</th>
<th>Days to maturity</th>
<th>Plant height (cm)</th>
<th>No. of nodes up to main spike</th>
<th>Length of primary spike (cm)</th>
<th>100-seed weight (g)</th>
<th>Seed yield (g/plant)</th>
<th>Oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>2</td>
<td>13.19</td>
<td>7.00</td>
<td>0.62</td>
<td>1.00</td>
<td>2.70</td>
<td>2.99</td>
<td>0.57</td>
<td>1.39</td>
<td>3.39</td>
<td>4.27</td>
<td>4.18*</td>
</tr>
<tr>
<td>Treatments</td>
<td>6</td>
<td>131.38*</td>
<td>130.60*</td>
<td>8.27*</td>
<td>10.44*</td>
<td>13.53*</td>
<td>66.92*</td>
<td>0.63</td>
<td>35.71*</td>
<td>7.11*</td>
<td>29.17*</td>
<td>0.19</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>9.36</td>
<td>3.22</td>
<td>0.67</td>
<td>1.77</td>
<td>1.99</td>
<td>1.00</td>
<td>0.51</td>
<td>3.82</td>
<td>1.94</td>
<td>7.66</td>
<td>0.38</td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>0.23</td>
<td>0.16</td>
<td>1.92</td>
<td>2.90</td>
<td>1.10</td>
<td>1.87</td>
<td>4.97</td>
<td>3.52</td>
<td>5.31</td>
<td>0.04</td>
<td>1.19</td>
</tr>
</tbody>
</table>

* Significant at 5% level
Table 2: Analysis of variance for seed quality parameters

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Germination percentage</th>
<th>Seedling vigour index I</th>
<th>Seedling vigour index II</th>
<th>Field emergence index (EI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>2</td>
<td>12.33</td>
<td>3.14</td>
<td>3.89</td>
<td>0.01</td>
</tr>
<tr>
<td>Treatments</td>
<td>6</td>
<td>48.71*</td>
<td>51877.55*</td>
<td>14262.09*</td>
<td>1.49*</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>8.49</td>
<td>54.73</td>
<td>7.57</td>
<td>0.01</td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>0.03</td>
<td>1.20</td>
<td>1.20</td>
<td>1.51</td>
</tr>
</tbody>
</table>

* Significant at 5% level
except number of nodes up to primary spike and oil content, while the mean sum of squares for replications were found to be non-significant for all the traits except oil content (Table 1). The ANOVA for seed quality parameters indicated that mean sum of squares for germination percentage, seedling vigour index I and II and field emergence index were significant (Table 2). Genetic purity parameters like selfed plants (%) and genetic purity (%) were also significantly different (Table 3).

4.1 Interspersed Staminate Flowers (ISF)

4.1.1 Interspersed Staminate Flowers (ISF) on primary spike of seed parent

The data on number of ISF on primary spike under different treatments were found to be statistically significant and presented in the table- 4.

The average number of ISF in primary spike ranged from 4.00 (T7) to 23.00 (control) with a general mean of 12.95.

There was a significant impact on regulation of ISF on primary spike of the seed parent with treatments. Among nitrogen treatments, nitrogen @ 100 kg/ha recorded minimum number of ISF (7.66) followed by120 kg/ha (10.33), 80 kg/ha (18.33), 60 kg/ha (20.00) and maximum was with control i.e., 40 kg/ha (23.00). Minimum number of ISF were observed when etrel was sprayed at a
concentration of ethrel 400 ppm (4.00) followed by ethrel 200 ppm (5.33), at 40 kg N/ha or control.

Table 3: Analysis of variance for Genetic purity

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Selfed plants (%)</th>
<th>Genetic purity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>3</td>
<td>1.42</td>
<td>0.28</td>
</tr>
<tr>
<td>Treatments</td>
<td>6</td>
<td>210.14*</td>
<td>197.55*</td>
</tr>
<tr>
<td>Error</td>
<td>18</td>
<td>1.87</td>
<td>0.92</td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>0.10</td>
<td>1.09</td>
</tr>
</tbody>
</table>

* Significant at 5% level
4.1.2 Number of Interspersed Staminate Flowers (ISF) on secondary spike of seed parent

The data on number of ISF on secondary spike of seed parent under different treatments were found statistically significant and presented in table- 4.

The average number of ISF in secondary spike ranged from 5.33 (T₆) to 20.66 (control) with general mean of 11.30.

Among the nitrogen treatments imposed, 100 kg N /ha recorded minimum number of ISF on secondary spike (6.66) followed by 120 kg N/ha (9.00), 80 kg N/ha (16.33), and 60kg N/ha (17.00) followed by control i.e., 40 kg/ha (20.66). Ethrel at a concentration of 200 ppm/ha along with 40 kg N recorded minimum number of ISF (5.33) followed by 40 kg N+ ethrel  400 ppm/ha (6.00) which were significantly low compared to control i.e., 40 kg N/ha (20.70).

4.2 Number of monoecious plants/plot

In the female line i.e., M-574 used in the hybrid combination of DCH-519 maximum plants were pistillate in nature and no sex reversals to monoecious were observed in all the treatments.
### Table 4: Effect of different treatments on seed yield and yield components in seed parent M-574

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of ISF on primary spike</th>
<th>No. of ISF on secondary spike</th>
<th>Days to first raceme</th>
<th>Days to 50% flowering</th>
<th>Days to maturity</th>
<th>Plant height (cm)</th>
<th>No. of nodes up to primary spike</th>
<th>Length of primary spike (cm)</th>
<th>100-seed weight (g)</th>
<th>Seed yield (g/plant)</th>
<th>Oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (control)</td>
<td>23.00</td>
<td>20.66</td>
<td>45.00</td>
<td>49.00</td>
<td>131.00</td>
<td>49.53</td>
<td>13.00</td>
<td>51.67</td>
<td>25.00</td>
<td>58.80</td>
<td>51.45</td>
</tr>
<tr>
<td>T2</td>
<td>20.00</td>
<td>17.00</td>
<td>45.00</td>
<td>48.00</td>
<td>131.00</td>
<td>49.53</td>
<td>13.00</td>
<td>51.67</td>
<td>25.00</td>
<td>58.80</td>
<td>51.45</td>
</tr>
<tr>
<td>T3</td>
<td>18.33</td>
<td>16.33</td>
<td>43.00</td>
<td>47.00</td>
<td>129.00</td>
<td>50.93</td>
<td>14.00</td>
<td>53.80</td>
<td>25.00</td>
<td>59.43</td>
<td>51.61</td>
</tr>
<tr>
<td>T4</td>
<td>7.66</td>
<td>6.66</td>
<td>41.00</td>
<td>44.00</td>
<td>125.00</td>
<td>57.53</td>
<td>15.00</td>
<td>60.33</td>
<td>28.00</td>
<td>64.53</td>
<td>51.64</td>
</tr>
<tr>
<td>T5</td>
<td>10.33</td>
<td>9.000</td>
<td>43.00</td>
<td>47.00</td>
<td>127.00</td>
<td>58.00</td>
<td>14.60</td>
<td>55.40</td>
<td>25.53</td>
<td>63.30</td>
<td>51.80</td>
</tr>
<tr>
<td>T6</td>
<td>5.33</td>
<td>5.33</td>
<td>42.00</td>
<td>44.30</td>
<td>126.00</td>
<td>47.70</td>
<td>14.60</td>
<td>55.90</td>
<td>28.70</td>
<td>64.82</td>
<td>51.57</td>
</tr>
<tr>
<td>T7</td>
<td>4.00</td>
<td>6.00</td>
<td>41.00</td>
<td>44.00</td>
<td>126.30</td>
<td>46.00</td>
<td>14.60</td>
<td>60.33</td>
<td>26.70</td>
<td>65.33</td>
<td>52.18</td>
</tr>
<tr>
<td>T1 (control)</td>
<td>23.00</td>
<td>20.66</td>
<td>45.00</td>
<td>49.00</td>
<td>131.00</td>
<td>49.90</td>
<td>14.00</td>
<td>51.13</td>
<td>25.00</td>
<td>58.20</td>
<td>51.45</td>
</tr>
<tr>
<td>Mean</td>
<td><strong>12.95</strong></td>
<td><strong>11.30</strong></td>
<td><strong>43.00</strong></td>
<td><strong>46.00</strong></td>
<td><strong>128.00</strong></td>
<td><strong>51.22</strong></td>
<td><strong>14.00</strong></td>
<td><strong>55.51</strong></td>
<td><strong>26.20</strong></td>
<td><strong>62.00</strong></td>
<td><strong>51.67</strong></td>
</tr>
<tr>
<td>SEM ±</td>
<td><strong>1.80</strong></td>
<td><strong>1.03</strong></td>
<td><strong>0.50</strong></td>
<td><strong>0.80</strong></td>
<td><strong>0.80</strong></td>
<td><strong>0.80</strong></td>
<td><strong>0.55</strong></td>
<td><strong>0.40</strong></td>
<td><strong>1.12</strong></td>
<td><strong>0.80</strong></td>
<td><strong>1.60</strong></td>
</tr>
<tr>
<td>C.D (0.05)</td>
<td><strong>5.40</strong></td>
<td><strong>3.20</strong></td>
<td><strong>1.50</strong></td>
<td><strong>2.40</strong></td>
<td><strong>2.50</strong></td>
<td><strong>1.70</strong></td>
<td><strong>1.28</strong></td>
<td><strong>3.50</strong></td>
<td><strong>2.50</strong></td>
<td><strong>4.90</strong></td>
<td><strong>1.09</strong></td>
</tr>
<tr>
<td>C.V (%)</td>
<td><strong>0.23</strong></td>
<td><strong>0.16</strong></td>
<td><strong>1.92</strong></td>
<td><strong>2.90</strong></td>
<td><strong>1.10</strong></td>
<td><strong>1.87</strong></td>
<td><strong>4.97</strong></td>
<td><strong>3.52</strong></td>
<td><strong>5.31</strong></td>
<td><strong>0.04</strong></td>
<td><strong>1.19</strong></td>
</tr>
</tbody>
</table>

T1 = 40 kg N/ha (Control)  
T5 = 120 kg N/ha  
T2 = 60 kg N/ha  
T6 = 40 kg N + Ethrel 200 ppm/ha  
T3 = 80 kg N/ha  
T7 = 40 kg N + Ethrel 400 ppm/ha  
T4 = 100 kg N/ha
4.3 Yield and Yield components

4.3.1 Plant stand

There was no influence of treatments on total plant stand since uniform population was maintained in all the treatments i.e., 32 pistillate plants and 8 male plants per plot.

4.3.2 Days to first raceme

The number of days required for appearance of first raceme was found statistically significant and the data was presented in the table- 4.

Among the seven treatments the average number of days for the appearance of first raceme ranged from 41 days (T₇ and T₄) to 45 days (control and T₂) with a general mean of 43 days.

The treatments that received 40 kg N + ethrel 400 ppm /ha, and 100 kg N/ha took 41 days followed by 40 kg N + ethrel 200 ppm /ha (42 days), 120 kg N/ha & 80 kg N/ha (43 days) and delayed flowering was noticed in 60 kg N/ha (45 days) and it is on par with control i.e., 40 kg N/ha (45 days).

4.3.3 Days to 50 per cent flowering

The number of days required for 50 per cent flowering was found to be statistically significant and the values are represented in the table-4.
The mean values for days to 50 per cent flowering ranged from 44 days (40 kg N + ethrel 400 ppm/ha) to 49 days (40 kg N/ha) with a general mean of 46 days.

Among the seven treatments, the three treatments namely 40 kg N + ethrel 400 ppm/ha, 40 kg N + ethrel 200 ppm/ha and 100 kg N/ha exhibited 50 per cent flowering on 44\textsuperscript{th} day, while 50 per cent flowering was observed on 47\textsuperscript{th} day in the treatments namely 80 kg and 120 kg N/ha and on 48\textsuperscript{th} day in 60 kg N/ha. Late flowering was recorded in control i.e., 40 kg N/ha (49 days).

4. 3.4 Plant height up to primary spike

Treatments had a significant impact on plant height and it was found to be statistically significant and the data was presented in the table -4.

The average values for plant height ranged from 46.00 cm (40 kg N + ethrel 400 ppm/ha) to 58.00 cm (120 kg N/ha) with a general mean value of 51.22 cm.

Tallest plants of castor were noticed in the treatments with 120 kg N/ha (58.00 cm) followed by 100 kg N/ha (57.53 cm), while the plants of shortest stature were associated with 40 kg N + ethrel 400 ppm/ha (46.00 cm) followed by the treatment 40 kg N + ethrel 200 ppm/ha (47.70 cm).
4. 3.5 Days to maturity of primary spike

Treatments had significant influence on days to maturity of primary spike and the data was presented in the table- 4

The average number of days to maturity in different treatments ranged from 125 days (100 kg N/ha) to 131 days (40 & 60kg N/ha) with a general mean of 128 days.

Among the seven treatments, early maturity was noticed in the treatment of 100 kg N/ha (125 days), and the two treatments namely, 40 kg N +ethrel 200 ppm/ha and 40 kg N +ethrel 400 ppm/ha came to maturity on 126th day. The treatment 120 kg N/ha has taken 127 days to maturity followed by 80 kg N/ha (129 days), 60 kg N/ha (131days), which is on par with control i.e., 40 kg N/ha (131 days).

4. 3.6 Number of nodes upto primary spike

There was no significant difference among the treatments with respect to number of nodes upto primary spike. The number of nodes varied from 13.00(60 kg N/ha) to 14.60 (120 kg N/ha, 40kg N+ ethrel 200 ppm /ha & 40kg N+ ethrel 200 ppm /ha) with a general mean of 14.00.
4. 3.7 Effective length of primary spike (cm)

Treatments had significant impact on the length of primary spike of the seed parent and it was found to be statistically significant and data was presented in the table- 4.

The mean values for the length of primary spike ranged from 51.13 cm (40 kg N/ha) to 60.33 cm (100 kg N/ha & 40 kg N+ ethrel 400 ppm /ha) with a general mean of 55.51 cm.

Among the different treatments, the two treatments namely 100 kg N/ha and 40 kg N+ ethrel 400 ppm /ha recorded maximum spike length (60.33 cm) followed by 40 kg N+ ethrel 200 ppm /ha (55.90 cm), 120 kg N/ha (55.40 cm), 80 kg N/ha and (53.80), 60 kg N/ha (51.67 cm) and it is on par with control i.e., 40 kg N/ha (51.13 cm).

4. 3.8 100-seed weight (g)

Treatments had a significant impact on 100-seed weight and it was found to be statistically significant and the data was presented in the table- 4.

The mean values of 100-seed weight ranged from 25.00 g (40, 60 & 80 kg N/ha) to 28.70 g (40 kg N+ ethrel 200 ppm /ha) with a general mean of 26.20 g.

Among seven treatments, the highest value for 100-seed weight was recorded in the plants that received 40 kg N+ ethrel 200 ppm /ha (28.70) followed by 100 kg N/ha (28.00 g), 40 kg N+ ethrel 400 ppm /ha (26.70 g) and 120 kg N/ha (25.53 g). Lowest value for 100-seed weight was noticed in two treatments namely
80 kg N/ha & 60 kg N/ha (25.00 g) and these two treatments are on par with control i.e., 40 kg N/ha (25.00 g).

4. 3.9 Oil content (%)

The treatments were found to be statistically non significant for oil content and the data was presented in the table- 4.

The mean values for oil content ranged from 51.45% (40 kg N/ha & 60 kg N/ha) to 52.18% (40kg N+ ethrel 400 ppm /ha) with a general mean of 51.67%.

Among the seven treatments, maximum oil content was recorded in treatment of 40kg N+ ethrel 400 ppm /ha (52.18%) and minimum was observed in 60 kg N/ha and control i.e., 40 kg N/ha (51.45%).

4. 3.10 Seed yield per plant (g) (total of two pickings)

The data on seed yield per plant was found to be statistically significant and presented in the table- 4.

The average values for seed yield per plant ranged from 58.20g (40 kg N/ha) to 65.33 g (40kg N+ ethrel 400 ppm /ha) with a general mean of 62.00 g.

Among seven treatments, the highest seed yield of 65.33g was obtained in the treatment 40kg N+ ethrel 400 ppm /ha followed by 40kg N+ ethrel 200 ppm /ha (64.82 g), 100 kg N/ha (64.53 g), 120 kg N/ha (63.30 g), 80 kg N/ha (59.43 g), and 60 kg N/ha (58.80 g). Lowest seed yield was recorded in control i.e., 40 kg N/ha (58.20g).
4.4 Seed quality parameters

4.4.1 Germination (%)

The prescribed minimum seed certification standard of germination is 70 per cent for castor as per IMSCS (1998). Germination per cent of hybrid seed was significantly influenced by different treatments and data was presented in the table-5.

The average values for germination per cent of hybrid seed ranged from 81.70 % (40 kg N/ha) to 93.30 % (40kg N+ ethrel 400 ppm /ha) with a general mean of 87.40 per cent.

The treatment 40kg N+ ethrel 400 ppm /ha showed maximum germination per cent of 93.30 % followed by 40kg N+ ethrel 200 ppm /ha (90.30 %), 100 kg N/ha (89.00%), 120 kg N/ha (88.30%), 80 kg N/ha (85.00%) and 60 kg N/ha (84.00%). Where as minimum germination per cent was recorded in control i.e., 40 kg N/ha (81.70%) and all the treatments showed germination per cent above the certification standards.

4.4.2 Field emergence index

Treatments had significant impact on field emergence index of the hybrid seed and data was presented in the table-5.

The average values of field emergence index of the hybrid seed for seven treatments ranged from 7.40 (40 kg N/ha) to 9.40 (40kg N+ ethrel 200 ppm /ha) with a general mean of 8.71.
Maximum field emergence index was noticed in F1 seed produced with the treatment 40kg N+ ethrel 200 ppm /ha (9.40) and it is on par with 40kg N+ ethrel 400 ppm /ha (9.30). The seed produced from the plants that received 100 kg N/ha recorded a field emergence index value of 9.20 followed by 120 kg N/ha (8.85), 80 kg N/ha (8.45) and 60 kg N/ha (8.40). Lowest field emergence index was exhibited by the F1 seed obtained from control i.e., 40 kg N/ha (7.40).

4.4.3 Seedling vigour index I (Seedling length basis)

There was a significant difference in seedling vigour index I with different treatments and it was found to be statistically significant and data was presented in the table -5.

The mean values of seedling vigour index I ranged from 430.50 (40 kg N/ha) to 751.20 (40kg N+ ethrel 200 ppm /ha) with a general mean of 612.90.

Among seven treatments, maximum seed vigour index I was noticed in the treatment 40kg N+ ethrel 200 ppm /ha (751.20) followed by 40kg N+ ethrel 400 ppm /ha (711.70) whereas lowest seed vigour index I was recorded in control i.e., 40 kg N/ha (430.50).

4.4.4 Seedling vigour index II (Dry weight basis)

All the seven treatments were found to be statistically significant with respect to seedling vigour index II and presented in the table 5.
The average values of seedling vigour index II ranged from 161.30 (40 kg N/ha) to 318.30 (40kg N+ ethrel 200 ppm /ha) with a general mean of 229.00.

Among the seven treatments, the two treatments namely 40kg N+ ethrel 200 ppm /ha and 40kg N+ ethrel 400 ppm /ha recorded maximum seedling vigour index II of 318.30 & 315.20 respectively, while the minimum was noticed in control i.e., 40 kg N/ha (161.30).

4.5 Meteorological data

The weekly mean maximum temperature during the crop growth period ranged from 26.9 °C to 41.36 °C with an average of 33.9 °C while the weekly mean minimum temperature ranged from 12.0 °C to 26.8 °C with an average of 18.82 °C. The mean relative humidity ranged from 30.9 per cent to 93 per cent with an average of 74.5 per cent. The weekly mean sunshine during the crop growth period ranged from 3.8 to 9.8 hours with an average of 8.3 hour per day (Appendix I).

4.4.5 Genetic purity

4.4.5.1 Selfed plants

All the seven treatments tested were found to be statistically significant with respect to per cent of selfed plants and presented in the table -5.

The mean values for selfed plants ranged from 5.50 (40kg N+ ethrel 200 ppm /ha) to 24.75 (40 kg N/ha) with a general mean of 12.50.
In Grow Out Test (GOT) among all seven treatments, minimum per cent of selfed plants were noticed in treatment 40kg N+ ethrel 200 ppm /ha (5.50%) followed by 100 kg N/ha (7.50%), 40kg N+ ethrel 400 ppm /ha (8.25%), 120 kg N/ha (8.75%), 80 kg N/ha (13.50%) and 60 kg N/ha (19.25%). High per cent of selfed plants were recorded in control i.e., 40 kg N/ha (24.75%).

4.4.5.2 Genetic purity (%)

The prescribed minimum seed certification standard for genetic purity is 85 per cent for castor as per IMSCS (1998) and all the treatments were found to be statistically significant with respect to genetic purity per cent and data presented in the table-5.

Among the seven treatments, the mean values for genetic purity ranged from 75.25% (40 kg N/ha) to 94.00% (40kg N+ ethrel 200 ppm /ha) with a general mean of 87.42%.

Hybrid seed obtained from treatment 40kg N+ ethrel 200 ppm /ha recorded high genetic purity (94.00%) followed by 100 kg N/ha (92.00%), 40kg N+ ethrel 400 ppm /ha (92.50%), 120 kg N/ha (91.00%) and 80 kg N/ha (86.50) which were above prescribed standard of genetic purity (85 %). While, the two treatments namely, 40 kg N/ha and 60 kg N/ha exhibited very low genetic purity i.e., 75.25 % and 80.75 % respectively which were found to be sub-standard.
### Table 5: Effect of different treatments on seed quality parameters

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Germination percentage</th>
<th>Seedling vigour index I</th>
<th>Seedling vigour index II</th>
<th>Field emergence index (EI)</th>
<th>Selfed plants (%)</th>
<th>Genetic purity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>84.00</td>
<td>485.20</td>
<td>165.90</td>
<td>8.40</td>
<td>19.25</td>
<td>80.75</td>
</tr>
<tr>
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<td>175.60</td>
<td>8.45</td>
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<td>86.50</td>
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<td>667.50</td>
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<td>8.85</td>
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<td>92.00</td>
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<td>262.30</td>
<td>9.20</td>
<td>8.75</td>
<td>91.00</td>
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<td>751.20</td>
<td>318.30</td>
<td>9.40</td>
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<td>94.00</td>
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<td>93.30</td>
<td>711.70</td>
<td>315.20</td>
<td>9.30</td>
<td>8.25</td>
<td>92.50</td>
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<tr>
<td>T1(control)</td>
<td>81.70</td>
<td>430.50</td>
<td>161.30</td>
<td>7.40</td>
<td>24.75</td>
<td>75.25</td>
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<tr>
<td>Mean</td>
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<td><strong>612.90</strong></td>
<td><strong>229.00</strong></td>
<td><strong>8.71</strong></td>
<td><strong>12.50</strong></td>
<td><strong>87.42</strong></td>
</tr>
<tr>
<td>SEM ±</td>
<td><strong>1.70</strong></td>
<td><strong>4.30</strong></td>
<td><strong>1.60</strong></td>
<td><strong>0.08</strong></td>
<td><strong>0.70</strong></td>
<td><strong>0.50</strong></td>
</tr>
<tr>
<td>C.D (0.05)</td>
<td><strong>5.20</strong></td>
<td><strong>13.20</strong></td>
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<td><strong>0.23</strong></td>
<td><strong>2.00</strong></td>
<td><strong>1.40</strong></td>
</tr>
<tr>
<td>C.V (%)</td>
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<td>1.20</td>
<td>1.51</td>
<td>0.10</td>
<td>1.09</td>
</tr>
</tbody>
</table>

T1 = 40 kg N/ha (Control)  
T2 = 60 kg N/ha  
T3 = 80 kg N/ha  
T4 = 100 kg N/ha  
T5 = 120 kg N/ha  
T6 = 40 kg N + Ethrel 200 ppm/ha  
T7 = 40 kg N + Ethrel 400 ppm/ha
CHAPTER V
DISCUSSION

Castor (*Ricinus communis* L.) is one of the most important non-edible oilseed crops. It is sexually polymorphic species with different sex forms *viz.*, monoecious, pistillate, pistillate with Interspersed Staminate Flowers (ISF) and sex revertants. Sex expression in castor is highly influenced by environmental factors like high day temperature, photo period, fertility, age of the plant, nutrition (Shifriss, 1960) difference between maximum and minimum temperature etc. (Lavanya, 2002). The expression of environmentally sensitive ISF is causing a serious problem in hybrid seed production resulting in high cost of rouging due to high number of selfed plants and ultimately in low genetic purity. Hence, in this context the present study is planned to study the effect of fertilizers (nitrogen) and growth regulators (ethrel) on the expression of pistillateness and ISF. The ultimate aim of the present study was to arrive at a suitable combination of fertilizer and growth regulator so as to increase the pistillate expression and reduce the number of ISF in hybrid seed production plots of new castor hybrid DCH-519.

The present investigation was carried out with parental lines of castor hybrid DCH-519 i.e., M-574 (female line) and DCS-78 (male line) to study the effect of nitrogen and ethrel mainly on sex expression and seed quality. The
female and male lines were sown in 4:1 ratio in the month of October in a Randomized Block Design (RBD) with three replications at the Seed Research and Technology Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during *rabi, 2008-09*. Nitrogen was applied in five different doses viz., 40, 60, 80, 100 and 120 kg N/ha respectively in three splits, 1st at the time of sowing, 2nd at primary spike initiation and 3rd at secondary spike initiation stages. The chemical ethrel in two different concentrations like 40 kg N+ ethrel 200ppm and 40 kg N+ ethrel 400ppm was sprayed at 28 and 45 days after sowing.

The results obtained from the present investigation were discussed here under:

### 5.1 NUMBER OF INTERSPERSED STAMINATE FLOWERS

Castor is sexually polymorphic species. The most natural occurrence of annual and perennial castor is in the form of monoecious. The spike has basal 1/3rd to 1/2 male flowers while the top portion has female flowers. The pistillate spike occurs as a rare recessive mutant with the spike having female flowers throughout the spike. A variant of pistillate form with male flowers interspersed throughout the female flowers on the spike is termed as Interspersed Staminate Flowers (ISF) (Shiffiriss, 1960).

In the present study, occurrence of ISF on primary and secondary spike was greatly influenced by the different treatments of nitrogen and ethrel. Among the different treatments imposed 40 kg N+ ethrel 200ppm/ha and 40 kg N+ ethrel
400 ppm/ha exhibited a great influence in reducing the number of ISF on the primary and secondary spike of the seed parent to a maximum extent of 4 ISF per spike. The results are in accordance with earlier works of Gopala Krishna Murthy et al. 2003 in castor.

The present study also revealed a trend of decreasing number of ISF per spike with increase in nitrogen dose up to 100 kg/ha (7.7). However, the treatment 120 kg N/ha showed a differential reaction i.e., the number of ISF were increased up to 10.3. It is apparent from the results that the 40 kg N+ ethrel 200 ppm/ha as well as 40 kg N+ ethrel 400 ppm/ha resulted in drastic reduction of ISF and enhanced the number of pistillate flowers in the female parent in the primary spike. Similar findings were also reported by several researchers in castor (Mary Varkey et al. 1982; Ramesh et al. 2000; Gopalakrishna Murthy et al. 2003) and in cucurbits (Karchi and Grovers, 1972).

5.2 Yield and Yield components

5.2.1 Days to first raceme

There was significant difference in the number of days required for appearance of first raceme with different nitrogen and ethrel treatments. The number of days to first raceme was the earliest (41 days) in T7 (40 kg N + ethrel 400 ppm/ha) and T4 (100 kg N/ha) followed by 42 days in T6 (40 kg N + ethrel 200 ppm/ha). Late flowering (45 days) was recorded in control i.e., 40 kg N/ha. From the present study it was evident that ethrel treatment (40 kg N + ethrel 400
ppm/ha) and higher dose of nitrogen (100 kg N/ha) reduced the number of days to first raceme and attained flowering early. The present results of castor was in accordance with earlier results of Kshirsagar et al., 1995 and Wankhade et al., 2003 in cucurbit.

**5.2.2 Days to 50 per cent flowering**

The number of days required for 50 per cent flowering was significantly influenced by nitrogen and ethrel treatments. Castor plants that received 40 kg N +ethrel 400 ppm/ha, 40 kg N +ethrel 200 ppm/ha and 100 kg N/ha took less number of days i.e., 44 days to attain 50 per cent flowering, while the crop supplied with 40 kg N/ha flowered late (49 days). Days to 50 per cent flowering was delayed with decreased nitrogen levels, and ethrel sprays at a concentration of 40 kg N +ethrel 400 ppm/ha and 40 kg N +ethrel 200 ppm/ha resulted in less number of days to 50 per cent flowering.

**5.2.3 Plant height up to primary spike**

In castor short to medium plant height is desirable, since it allows proper intercultural operations, spraying and harvesting without any difficulty. In the present study, the tallest plants of castor were observed in the treatment T₅ (120 kg N/ha), while the plants of shortest stature were recorded in T₇ (40 kg N+ Ethrel 400ppm/ha). Adequate nitrogen supply probably increased the amount of protoplasm and chlorophyll which in turn, helps in better growth. Taller plants
were produced with nitrogen application, as the nitrogen is associated with cell enlargement resulting in vigorous growth. Nitrogen at 120 kg N/ha resulted in taller plants over other treatments in castor (Sridharamurthy et al. 2008). This was due to increased availability of nutrients. The results are in accordance with those of Muthuvel et al. (1987) and Anonymous (1994) in castor.

5.2.4 Days to maturity of primary spike

All the treatments had significant impact on days to maturity of primary spike of the seed parent. Early maturity (125 days) was recorded in treatments T6 and T7 (40 kg N + ethrel 200 ppm/ha and 40 kg N + ethrel 400 ppm/ha) and late maturity (131 days) was observed in T1 treatment (40 kg N/ha). Early maturity in ethrel treatment was due to early appearance of flowers. Ethrel caused the production of female flowers at lower nodes, slightly earlier. The results are in accordance with the earlier works of Mandal et al., 1991 in bottle gourd.

5.2.5 Length of primary spike

Spike length was significantly influenced by different treatments. Spike length determines the yield performance in castor. The longest spikes were produced with T3 and T6 (100 kg N/ha and 40 kg N+ ethrel 400ppm/ha), while the shortest spikes were associated with control (40 kg N/ha). Application of nitrogen resulted in increased nutrition and ultimately resulted in the longest spikes in castor (Narkhede et al. 1984).
5.2.6 100-seed weight

100-seed weight of seed parent was significantly influenced by different treatments. The highest 100-seed weight of castor was associated with the application of 40kg N+ ethrel 200 ppm /ha which is on par with 100 kg N/ha, whereas the lowest 100-seed weight was recorded with 40 kg N/ha. In general, seed weight increased due to increment in the dose of application of nitrogen as per the findings of Sivalakshmi and Sambasiva Reddy, 2002 in castor. Similar trend was also observed with the ethrel application. Ethrel treatment improved the 100-seed weight in castor (Mary Varkey et al. 1982). Ethephon caused a high degree of femaleness in castor and thus, increased the number of seed output and heavy seeds as per the findings of Mary Varkey et al. 1982.

5.2.7 Oil content

Among all the seven treatments, the treatment 40kg N+ ethrel 400 ppm /ha recorded the highest oil content (52.2) and the lowest was observed with 40 kg N/ha (51.5). The oil content tended to increase slightly with successive incremental dose of nitrogen from 40 to 120 kg/ha and among the nitrogen treatments the highest oil content was obtained with 120 kg N/ha (51.8). Higher dose of nitrogen has increased the oil content, which could be due to increased uptake of nutrients in castor (Vani, 1995). In the present study, the highest oil
content was noticed in ethrel treatments when compared to different nitrogen treatments.

5.2.8 Seed yield

The higher seed yield of castor was produced with 40kg N+ ethrel 400 ppm /ha and 40kg N+ ethrel 200 ppm /ha which is on par with 100 kg N/ha and significantly superior over other treatments. Similar results were reported in castor (Sivalakshmi and Sambasiva Reddy, 2002), summer squash (Shanon and Robinson, 1979) and in bitter gourd (Marbhal and Musmade, 2007). Increase in seed yield was due to more number of pistillate plants with less number of ISF, effective seed setting, more number of capsules per spike while heavy seed weight was observed with the different doses of ethrel treatments in the present study.

5.3 Seed quality

Germination per cent was significantly influenced by different treatments. Among different nitrogen treatments, the seeds produced from the treatments T₃ and control (80 and 40 kg N/ha) showed minimum germination per cent 85.0 and 81.0 per cent respectively. While, ethrel treatments T₅ and T₆ recorded high germination percent (88.3 and 90.3) respectively. Ethrel at two different concentrations improved germination per cent which might be due to activation of enzymes controlling germination in the developing seed. In addition it also improved quality of seed in terms of high germination and vigour.
The vigour parameters *viz.*, field emergence index, root length, shoot length and dry matter of seedlings were almost in the order of preference that were evaluated for seed germination, which could be attributed to the reserve food materials utilized at the time of germination as indicated by 100-seed weight. The maximum seed vigour was recorded in two ethrel treatments in the present study. Both the ethrel treatments used in the present study have improved the field emergence index over the other nitrogen treatments.

### 5.3.1 Genetic purity

Among different nitrogen treatments, hybrid seed obtained from the plants that received 80, 100 and 120 kg N/ha recorded high genetic purity which was above certification standard of genetic purity because of less number of ISF on pistillate parent during hybrid seed production. The ethrel sprayed plots showed maximum genetic purity. The hybrid seed obtained from the plants that supplied with 40 and 60 kg N/ha resulted in very low genetic purity (75.3 and 80.8) which was found to be sub-standard. This might be due to the production of more number of ISF in the raceme during hybrid seed production.

The present study highlighted that female plants with ISF were observed in seed parent M-574 irrespective of nitrogen treatments. Inherent factors like endogenous growth regulators or modifying genes as reported by Lavanya, 2002 may be involved in the production of ISF leading to high number of selfed seeds in hybrid seed lots, in turn resulted into low genetic purity. In order to maintain
high genetic purity, suppression of ISF is utmost essential for obtaining better quality seed with high genetic purity, which has to be manipulated either by growth regulators or nitrogen application.

Hybrid seed obtained from ethrel sprayed plots recorded very high genetic purity due to suppression of ISF and maintenance of high proportion of pistillate flowers in castor plants.
CHAPTER VI

SUMMARY

Development of castor hybrids ushered the way for a massive level hybrid seed production programmes in India. Seed production programmes were standardized keeping in view with the complexity of sex expression, cross pollination nature and isolation distance. However, sex instability of pistillate lines either as sex revertants/ monoecious or ISF is still a major problem. The expression of ISF is highly sensitive to environment particularly temperature, relative humidity, rainfall and other factors like endogenous hormones (Shiffriss, 1962). When temperature exceeds $30^\circ$C ISFs were noticed on pistillate spikes and ultimately resulting in selfing of pistillate plants in seed production plots, thus, leading to genetic impurity beyond threshold level which is of 85% (IMSCS).

Keeping in view with the above problems, present investigation entitled “Quality hybrid seed production in castor by manipulation of pistillate character” was conducted with an objective to study the effect of nitrogen and ethrel on sex expression and quality hybrid seed production in castor. In this experiment, seven treatments were imposed which includes five different doses of nitrogen and two different concentrations of ethrel along with recommended dose of nitrogen (40 kg
N/ha). Nitrogen was applied in three splits at the time of sowing, primary spike and secondary spike initiation stages and ethrel was sprayed on the female parent at 28 and 45 days after sowing (DAS).

For this purpose, the parental lines of newly released castor hybrid DCH-519 i.e., M- 574 (female line) and DCS-78 (male line) were sown in 4:1 ratio during the second fortnight of October in a Randomized Block Design (RBD) with three replications at the Seed Research and Technology Centre, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during rabi, 2008-09.

The data on various parameters viz., number of pistillate plants per plot, number of ISF in different order spikes, total plant stand per plot, days to initiation of first raceme, days to 50 per cent flowering of first raceme, days to maturity of first raceme, plant height (cm) up to primary spike, number of nodes up to primary spike, effective length of primary spike (cm), 100-seed weight (g), seed yield/plant (g) and genetic purity(%) were collected at the field level and the observations on oil content (%), germination per cent, seedling vigour index on length and dry weight basis and field emergence index were made at laboratory level. The data was analysed for variance as per Panse and Sukhatme, 1985.

The analysis of variance for RBD revealed that mean sum of squares for treatments were found to be significant for all the traits except number of nodes up to primary spike.

The perusal of ANOVA for different treatments revealed that the treatments differed significantly with respect to expression of pistillateness and ISF in
primary and secondary order spikes. Among different nitrogen treatments imposed, the seed parent that received 100 kg N/ha recorded less number of ISF and maximum number of pistillate plants and was found to be an ideal dose to take up hybrid seed production. The two ethrel treatments imposed, 40 kg N+ ethrel 200 ppm/ha as well as 40 kg N+ ethrel 400 ppm/ha noticed drastic reduction of ISF and enhanced the number of pistillate flowers in the female parent in the primary and secondary spike orders. The secondary order spike produced more number of ISF over primary order spike in all the treatments.

The effect of nitrogen and ethrel treatments was found to be significant for all the yield and yield components. Among different doses of nitrogen applied the plants that received 100 kg N/ha were early in flowering and maturity. Increase in nitrogen dose also increased 100-seed weight and seed yield except for 120 kg N/ha. Plant height of castor increased with successive incremental dose of nitrogen from 40 to 120 kg N/ha and the tallest plants produced with 120 kg N/ha while the shortest were observed with the 40 kg N along with different doses of ethrel treatments. Ethrel treatments exhibited suppressive effect on vegetative growth. When compared to nitrogen treatments, ethrel at two concentrations improved the spike length, seed yield, oil content and 100-seed weight.

Seed quality parameters like germination, vigour and field emergence index were high with ethrel treatments which is desirable for hybrid seed.

Ethrel sprays in seed production plots reduced the number of ISF and resulted in high genetic purity and better seed quality. Similarly, as the nitrogen
dose increased up to 100 kg N/ha recorded maximum genetic purity and better seed quality. Genetic purity was the lowest in the treatments with 40 and 60 kg N/ha. From the present investigation, the following conclusions can be drawn:

1. Two concentrations of ethrel treatments at 40 kg N+200 ppm and 40 kg N+400 ppm/ha suppressed the ISF and maintained more number of stable pistillate plants in female parent M-574 and resulted in high seed quality viz., genetic purity, germination per cent, vigour index, and field emergence index.

2. Among different doses of nitrogen, 100 kg N/ha alone is adjudged as the optimum dose for better quality hybrid seed production for the suppression of ISF, and increase of genetic purity.

The overall perusal of results indicated that, the ethrel treatment was adjudged as the best to suppress the ISF ultimately increasing the seed quality. Pistillate line of castor hybrid DCH-519 i.e., M-574 performed well with the application of 100 kg N/ha and ethrel at two different concentrations i.e., 40 kg N + ethrel 200 ppm/ha and 40 kg N + ethrel 400 ppm/ha as this combination resulted in higher seed yield.

**Future line of work**
The castor hybrids are gaining popularity throughout the country. The studies on sex expression and its manipulation with nitrogen and growth regulators in the parental lines of castor for hybrid seed production should be further investigated for confirmatory results. Such studies should also be extended to evaluation of more number of hybrids in different locations in different seasons in large areas.

- Study on the role of exogenous application of growth regulators like ethrel, GA$_3$ etc. on the concentration, time of application, number of applications etc. should have to be taken up.

- Basic studies on different stages of crop growth viz., primordial initiation, secondary spike initiation etc. may enhance understanding the mechanism of sex expression in this crop which ultimately helps in hybrid seed production programme to realise the quality seed.
LITERATURE CITED


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Effect of plant growth regulators on seed yield of cucumber cv.

Zimmerman L H and Smith J D 1966 Production of F1 seed in castor beans by

* Original not seen.

The pattern of “Literature cited” presented above is in accordance with the
“Guidelines” for thesis presentation for Acharya N.G. Ranga Agricultural
University, Hyderabad.
### Appendix-I

Weekly meteorological data recorded during the crop growth period

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Mean 33.9 18.82 74.5 33.2 0.91 0.1 8.3 4.03
Plate-1: Overall view of the hybrid seed production plot
Plate 7. Selfed plant in the GOT plot
Plate-3: Pistillate spike with ISF in female line M-574
Plate 4: Ethrel sprayed hybrid seed production plot
Plate-5: Overall view of the GOT plot