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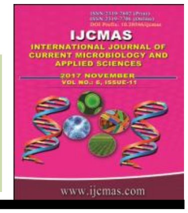

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Role of Ethrel in Manipulation of Sex Expression in Pistillate and Monoecious Lines of Castor (*Ricinus communis* L.) at Different Concentrations

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A B S T R A C T

An experiment was conducted during *rabi* season in the year 2013, to know the effect of Ethrel on sex expression of Pistillate or Staminate flowers in Pistillate/Female and Monoecious lines of castor. The study was carried out with one monoecious line *i.e.,* DCS-107 and two pistillate lines *i.e.,* M-574 and DPC-9. Ethrel was sprayed at 100 ppm, 150 ppm and 200 ppm concentrations successively at 15, 30, 45 and 60 DAS. The results indicated that ethrel sprayed at all concentrations significantly increased the expression of pistillate flowers by suppression of interspersed staminate flowers (ISFs) in pistillate line and male flowers in monoecious line. Total number of female flowers per spikes significantly increased in ethrel sprayed plots as compared to unsprayed ones. Ethrel sprayed at 200 ppm gave maximum number of pistillate whorls, increased spike length, more number of capsules, increased seed weight and seed yield. The study revealed that Ethrel at 200 ppm has a great potential as growth regulator in maintaining pistillateness in hybrid seed production plots, thereby increasing genetic purity of hybrid seed.

Introduction

Castor *(Ricinus communis L.)* is an important industrial and non-edible oil seed crop grown under varied climatic conditions including tropical, sub-tropical and temperate regions. The castor seed oil is unique in terms of its dominance of a single fatty acid- ricinoleic acid (85-95%), Castor oil and its derivatives are being used in textiles, soaps, wetting agents, synthetic resins, cosmetics, nylon fibers, bullet-proof glass and as antifreeze for fuels and lubricants utilized in aircrafts and space rockets (Ogunniyi, 2006).

Castor is a sexually polymorphic species with different sex forms *viz.,* monoecious, pistillate, sex revertants and pistillate with interspersed staminate flowers (ISFs). The most natural occurrence of annual and perennial castor is in the form of monoecious. The spike has basal 1/3rd to ½ 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). Sex expression in castor is highly influenced by environmental factors *viz.,* high day temperature, photoperiod, fertility, age of the plant, nutrition, etc. (Shifriss, 1960; Zimmerman and Smith, 1966). Castor performs well at moderate temperature of 20-26°C. Mean temperatures of 31-32°C promote ISF, while low temperature resulted in fully female racemes (Ankineedu and Rao, 1973). Low temperature (< 30^0C) and higher nutrition promote female flowers and shift the balance towards femaleness on spike. High temperature (>32^0C), late order spikes and low nutrition promote male flowers on a spike (Lavanya, 2002).

The expression of environmentally sensitive ISFs plays a key role in maintenance of pistillate lines. The instability of pistillate lines due to occurrence of ISFs is causing a serious problem in maintaining the genetic purity of the seed. As the conventional methods being time consuming, keeping the above issues in view an attempt has been made to know the effect of ethrel in reducing or suppressing the production of ISF or male flowers and cause an increase in female tendency and seed yield. Enhanced flowering by ethylene in angiosperms is well documented and ethylene-releasing compounds have been applied to enhance flowering in agriculture plants (Abeles *et al.*, 1992).

Materials and Methods

A field experiment was conducted during *rabi*, 2013 at College of Agriculture, Rajendranagar, Hyderabad. The experimental soil was sandy loam in texture. The experiment was laid out in randomized block design with 12 treatments and replicated thrice. The experiment consisted of one monoecious line DCS-107 and two pistillate lines i.e., M-574 and DPC-9. Ethrel at 100, 150 and 200 ppm concentrations and control (water spray) was sprayed at 15, 30, 45 and 60 DAS. When ethrel is applied in aqueous spray is actively taken up in transpiration stream and translocated to leaves and flowers. Based on the fact that ethrel disintegrates in plant tissues and is converted to ethylene with consequent biological effects indicates that exogenous ethrel-treated tissues produce plant responses similar to endogenous ethylene (Cooke and Randall, 1968; Morgan, 1969; Warner and Leopold, 1969). Data were collected on various parameters *viz.*, number of Interspersed Staminate Flowers (ISFs) or male flowers per primary and secondary spikes, phenological parameters, yield and yield components.

Results and Discussion

The present study revealed a trend of decreasing number of ISF or male flowers per spike with increasing concentration of upto 200 ppm concentration in both pistillate lines (M-574 & DPC-9) and monoecious line (DCS-107). Ethrel sprays were found effective in increasing female tendency and supress the number of ISF or male flowers in castor was reported by Ramesh *et al.*, (2000). Similar findings were also reported earlier by Gopala Krishna Murthy *et al.*, (2003); Dhedhi *et al.*, (2010) in castor. The reduced level of endogenous gibberellins and increased level of auxin after ethrel spray during initial stages may be probable reason for increased female flowers and decreased male flowers as reported by Rudinch *et al.*, (1972).

Number of Interspersed Staminate Flowers (ISFs) or male flowers in primary spike per plant

The data on number of ISF or male flowers in primary order spikes under different treatments, genotypes and their interaction were found to be statistically significant and presented in Table 1. Among the genotypes the pistillate line M-574 recorded in less number of ISFs (5.74) while in monoecious line DCS-107 more number of male flowers

(39.69) per primary spike was recorded. There was a significant impact on regulation of ISF or male flowers in primary spikes of three genotypes with different concentration of ethrel treatments. The minimum number of ISF or male flowers on primary spike per plant (13.23) was recorded with ethrel sprayed at 200 ppm, whereas highest number of ISF or male flowers on primary spike per plant (22.85) was recorded in control (water spray). Among the treatment combinations, in pistillate lines minimum number of ISF was recorded with ethrel sprayed at 200 ppm in M-574 (3.13) and the highest number of ISF was recorded in DPC-9 (12.39) with water spray (control). Whereas, in case of monoecious line DCS-107 the minimum number male flowers (31.47) were observed when ethrel was sprayed at a concentration of 200 ppm and the maximum number male flowers (48.13) on primary spike per plant were recorded in control (water spray).

A significant reduction of upto 34 percent in number of male flowers in monoecious variety DCS-107 was observed at 200 ppm ethrel concentration compared to control (48.13), indicated the scope of ethrel to maintain proper male: female ratio even in male lines and varieties of castor. Similar findings were also reported by (Mary Varkey *et al.*, 1982; Ramesh *et al.*, 2000 in castor and Gopala Krishna Murthy *et al.*, 2003a in castor); (Karchi and Grovers, 1972; Sitaram *et al.*, 1989 and Arora *et al.*, 1989 in cucurbits.) that ethrel sprayed plants resulted in increased femaleness as compared to untreated plants.

Number of Interspersed Staminate Flowers (ISFs) or male flowers in secondary order spike per plant

The data on ISF or Male flowers on secondary spike were presented in Table 2. Genotypes exhibited significant impact on number of ISF or Male flowers on secondary spikes of castor. Among the genotypes the minimum number of ISF or Male flowers on secondary spike was observed in M-574 (6.75) followed by DPC-9 (8.37) and DCS-107 (22.92). The trend of decreasing number of ISF in secondary spike with increasing concentration of ethrel upto 200 ppm is also observed in both pistillate lines DPC-9 & M-574. Similar trend was also observed in the monoecious variety DCS-107 with significant reduction of upto 14 to 27 percent (100 to 200 ppm) over control in number of male flowers on secondary spike. Among all the treatments ethrel at 200 ppm recorded minimum number of ISF or Male flowers (10.09) followed by ethrel at 150 ppm (11.77) and ethrel at 100 ppm (13.26). Control (water spray) recorded maximum number of ISF or Male flowers (15.58) as compared to ethrel treatments. Among the interactions effects, ethrel at 200 ppm on M-574 (4.20) recorded minimum number of ISF in DPC-9 (6.33) and DCS-107 (19.75 male flowers). While the maximum number of ISF or Male flowers on secondary spike were observed in control (water spray) on DCS-107 (27.20 Male flowers) followed by DPC-9 (10.60 ISFs) and M-574 (8.96 ISFs) (Fig. 1).

Effective length of primary spike

Treatments had significant impact on effective length of primary spike and were found to be statistically significant and the data presented in Table 3. Among the genotypes maximum length of primary spike was recorded in M-574 (57.81 cm) followed by DPC-9 (52.70 cm). Minimum spike length was recorded in DCS-107 (40.50 cm). Ethrel at 200 ppm resulted in maximum effective spike length of primary spike (53.36 cm) followed by ethrel at 150 ppm (51.21 cm) and ethrel at 100 ppm (49.30 cm). Minimum length of effective spike (47.48 cm) was recorded in control. Spraying of ethrel might have coincided with active vegetative growth and rapid cell elongation and cell division in growing portion of the plant and later increase the uptake of nutrients and photosynthetic activity resulting in increased length of spike.

The results are in agreement with earlier reports of Mary Varkey *et al.*, (1982) in castor; Sidhu *et al.*, (1982) in musk melon; Arora *et al.*, (1989) in pumpkin (Fig. 2).

Table.1 Effect of ethrel on number of ISF or male flowers in primary spike of castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	6.33	9.33	42.93	19.53
T_2 - Ethrel @ 150 ppm	5.48	8.63	36.22	16.77
T_3 - Ethrel @ 200 ppm	3.13	5.08	31.47	13.23
T_0 - Control (Water Spray)	8.03	12.39	48.13	22.85
Mean	5.74	8.86	39.69	
	T	**G**	**T X G**	
S.E m±	0.28	0.24	0.48	
C.D (0.05)	0.82	0.71	1.43	

Table.2 Effect of treatments on number of ISF or male flowers in secondary spike of castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	7.64	8.90	23.26	13.26
T_2 - Ethrel @ 150 ppm	6.20	7.66	21.46	11.77
T_3 - Ethrel @ 200 ppm	4.20	6.33	19.75	10.09
T_0 - Control (Water Spray)	8.96	10.60	27.20	15.58
Mean	6.75	8.37	22.92	
	T	**G**	**T X G**	
S.E m±	0.21	0.18	0.37	
C.D (0.05)	0.63	0.54	1.09	

Table.3 Effect of ethrel on effective length of primary spike in castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	56.14	51.44	40.33	49.30
T_2 - Ethrel @ 150 ppm	58.10	53.74	41.80	51.21
T_3 - Ethrel @ 200 ppm	61.40	55.54	43.16	53.36
T_0 - Control (Water Spray)	55.60	50.10	36.73	47.48
Mean	57.81	52.70	40.50	
	T	**G**	**T X G**	
S.E m±	0.28	0.24	0.49	
C.D (0.05)	0.84	0.72	NS	

Table.4 Effect of ethrel on number of capsules in primary order spike of castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	53.05	56.00	49.30	52.78
T_2 - Ethrel @ 150 ppm	54.40	57.35	50.66	54.14
T_3 - Ethrel @ 200 ppm	57.20	60.63	53.86	57.23
T_0 - Control (Water Spray)	50.20	52.30	41.66	48.05
Mean	53.71	56.57	48.87	
	T	**G**	**T X G**	
S.E m±	0.20	0.17	0.35	
C.D (0.05)	0.60	0.52	1.04	

Table.5 Effect of ethrel on 100- seed weight (g) in castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	27.66	28.60	29.13	28.46
T_2 - Ethrel @ 150 ppm	28.33	29.13	29.95	29.14
T_3 - Ethrel @ 200 ppm	30.14	29.82	31.73	30.65
T_0 - Control (Water Spray)	26.72	27.26	28.37	27.45
Mean	28.28	28.70	29.80	
	T	**G**	**T X G**	
S.E m±	0.14	0.12	0.25	
C.D (0.05)	0.42	0.36	NS	

Table.6 Effect of ethrel on Seed yield (g) /plant in castor

Treatments (T)	Genotypes (G)			Mean
	M-574	DPC-9	DCS-I07	
T_1 - Ethrel @ 100 ppm	82.26	90.64	85.05	85.98
T_2 - Ethrel @ 150 ppm	83.82	90.88	86.19	86.96
T_3 - Ethrel @ 200 ppm	85.42	91.60	88.30	88.44
T_0 - Control (Water Spray)	79.95	88.97	80.97	83.29
Mean	82.86	90.52	85.12	
	T	**G**	**T X G**	
S.E m±	0.23	0.20	0.41	
C.D (0.05)	0.69	0.60	1.20	

Fig.1 Effect of ethrel on number of ISF or male flowers in primary and secondary spike of castor

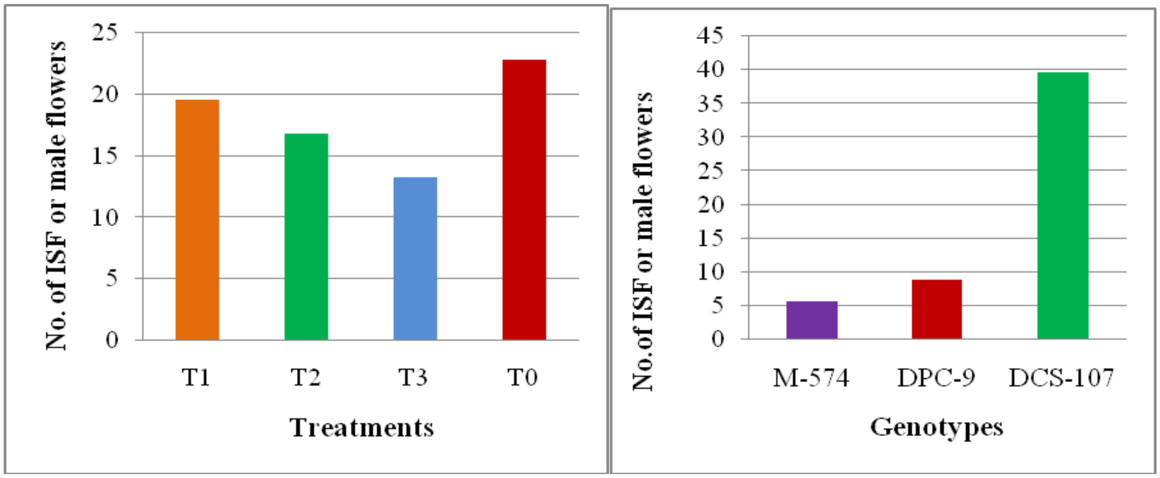
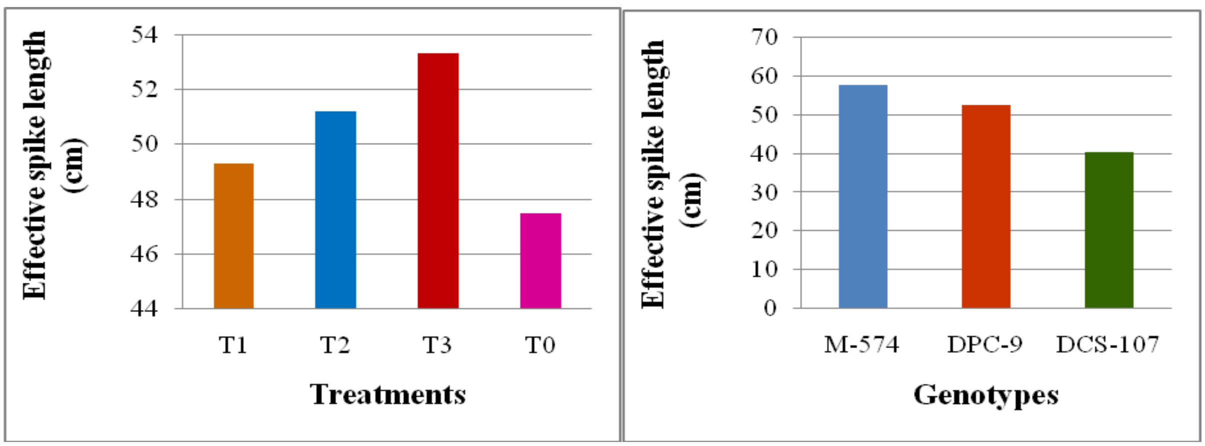


Fig.2 Effect of ethrel on effective spike length (cm) in castor



T_1-100 ppm Ethrel T_2- 150 ppm Ethrel
T_3-200 ppm Ethrel T_0- Control (Water spray)

Fig.3 Effect of ethrel on number of capsules in primary spike of castor

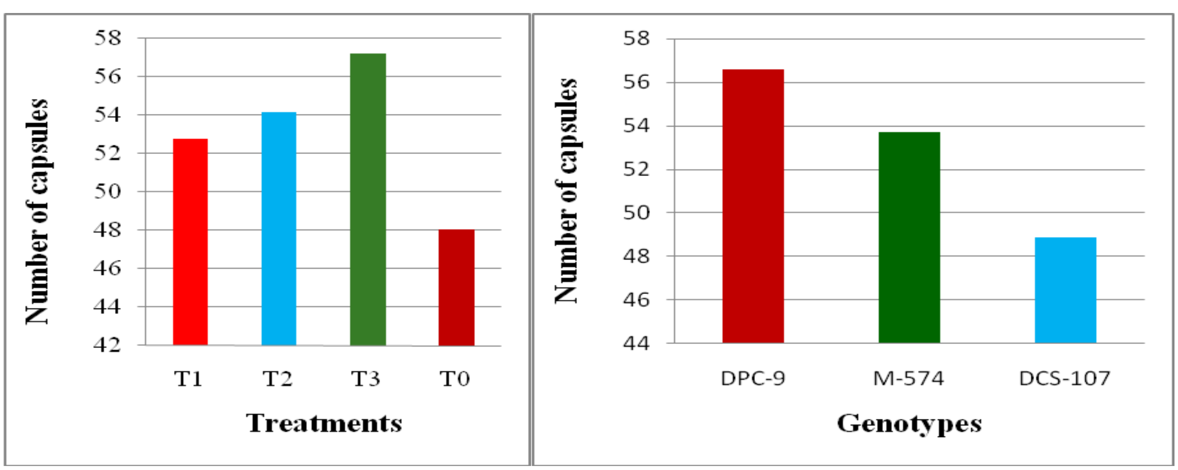
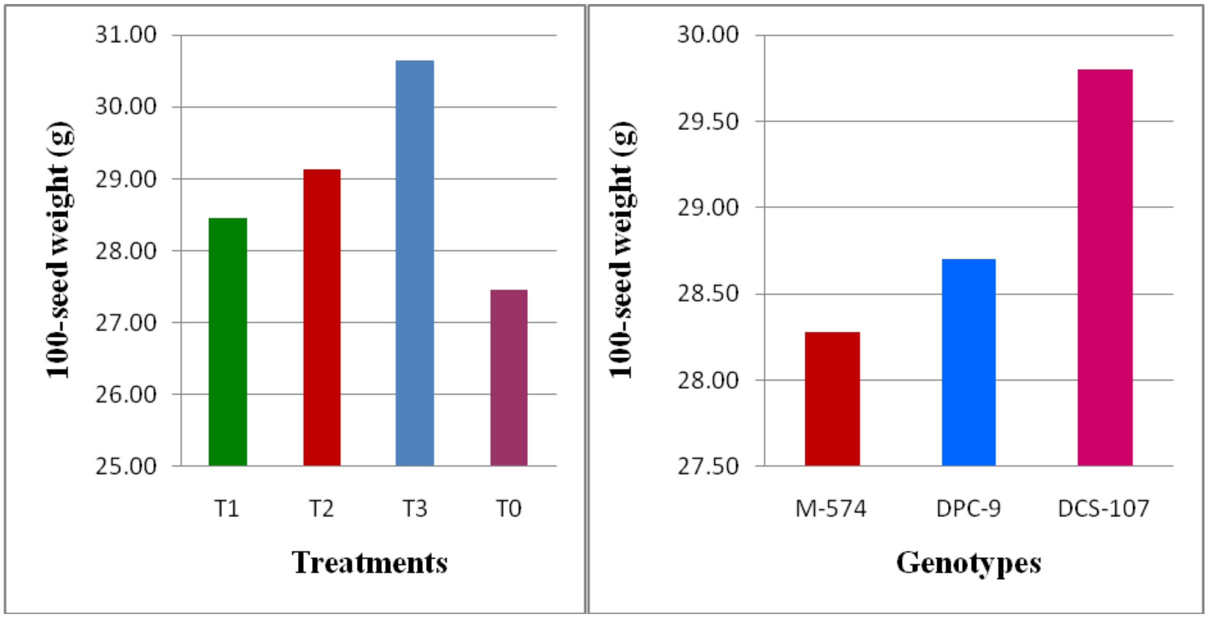
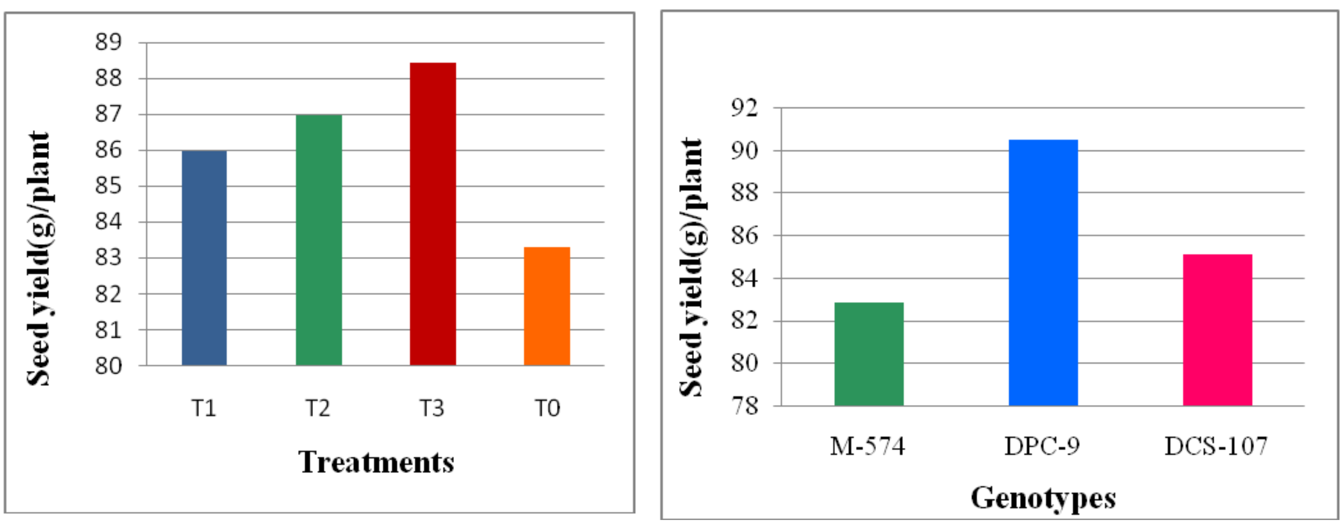


Fig.4 Effect of ethrel on 100- seed weight in castor



T_1-100 ppm Ethrel T_2- 150 ppm Ethrel
T_3-200 ppm Ethrel T_0- Control (Water spray)

Fig.5 Effect of ethrel on seed yield (g) per plant



T_1-100 ppm Ethrel T_2- 150 ppm Ethrel
T_3-200 ppm Ethrel T_0- Control (Water spray)

Number of capsules in primary spike

In the present study, development of more number of capsules per primary spike is due to increased number of female flowers in primary spike. Ethrel sprays might have increased the endogenous auxin levels resulting in enhanced fruit set. The number of capsules in primary spike was found to be statistically significant and the data presented in Table 4. Among the genotypes the highest number of capsules per primary spike were recorded in DPC-9 (56.57) and minimum number of capsules were observed in DCS-

107 (48.87). Among the treatments minimum number capsules per primary spike (48.05) were recorded in control (water spray). Maximum number of capsules (57.23) was recorded in ethrel sprayed at 200 ppm concentration. The increasing concentrations of ethrel treatments were effective in increasing the capsules ranging from 9.8 to 19.0 percent as compared to control. The interaction between treatments and genotypes was found to be significant for number of capsules in primary spike. The maximum number of capsules was recorded in DPC-9 (60.63) when ethrel was sprayed at 200 ppm. Minimum number of capsules in primary spike was observed in DCS-107 (41.66) with water spray (control). Ramesh *et al.,* (2002) reported that increase in ethrel concentration increased the number of capsules in castor and was higher at 500 ppm. Similar findings were also reported by (Dhedhi *et al.,* 2010 in castor; Mangal *et al.,* 1981 in bittergourd; Saimbhi and Gill, 1988 in summer squash; Vadigeri *et al.,* 2001 in cucumber). The total number of capsules assumes importance as there exists a significant positive association with seed yield (Dorairaj *et al.,* 1973) (Fig. 3).

100 Seed weight (g)

100 seed weight (g) was significantly influenced by treatments and genotypes and was found to be statistically significant and the data was presented in Table 5. Among the genotypes the DCS-107 (29.80 g) recorded the highest value for 100-seed weight (g) followed by DPC-9 (28.70 g) and M-574 (28.28 g) recorded lowest value for 100-seed weight. Ethrel treatments improved the 100-seed weight in castor (Mary Varkey *et al.,* 1982 in castor; Sitaram *et al.,* 1989 in cucumber). Among the treatments the highest value for 100-seed weight (g) was recorded in plants sprayed with ethrel at 200 ppm (30.65 g) and Lowest value for 100-seed weight (g) was recorded in control (water sprayed) plants (27.45 g). A significant increase in 100-seed weight from 4 to 10 percent was observed with increasing concentration of ethrel treatments when compared to control. Ethrel treatments improved the 100-seed weight in castor (Mary Varkey *et al.,* 1982 in castor; Sitaram *et al.,* 1989 in cucumber). Increase in seed weight might be due to increased metabolic activity leading to higher translocation of metabolites from source to sinks. Similar results are reported by Arora *et al.,* (1989) in pumpkin. Ethrel caused a high degree of femaleness, increased fruit set in castor and thus, increased the number of seed output and produced heavy seeds (Mary Varkey *et al.,* 1982) (Fig. 4).

Seed yield per plant (g)

The data on seed yield per plant (g) was found to be statistically significant and presented in Table 6. Among the genotypes the DPC-9 (90.52 g) recorded the maximum seed yield per plant followed by DCS-107 (85.12 g) and minimum seed yield was recorded in M-574 (82.86 g). Among the treatments the highest seed yield was recorded in plants sprayed with ethrel at 200 ppm (88.44 g) followed by ethrel at 150 ppm (86.96 g) and ethrel at 100 ppm (85.98 g). Lowest seed yield (83.29 g) was recorded in water spray (control) (Fig. 5).

Arora and Pratap (1988) in pumpkin reported that spraying ethrel tends the plants remain physiologically more active to build up sufficient food to developing flowers and fruits and ultimately leading to higher yield. The interaction between treatments and genotypes was found to be significant for seed yield (g) per plant. Maximum seed yield per plant was recorded by ethrel at 200 ppm in DPC-9 (91.60 g) and minimum seed yield was recorded in M-574 (79.95) with water spray (control). Ethrel treatments caused a high degree of femaleness in castor and thus increased the number of seed and ultimately the final yield reported by Mary Varkey *et al.*, (1982) in castor.

Ethrel treatments were found to be effective in reducing or suppressing the ISF or male flowers, promoted early flowering and maturity, increased spike length, number of capsules per spike, 100-seed weight and seed yield/plant, resulted in genetic purity. The overall results of the present study revealed that, ethrel treatments are adjudged as the best to suppress the ISF or male flowers in castor, ensure low percentage of selfed seed and ultimately increasing the seed yield and quality of the seed. The present study also established that, ethrel at 200 ppm has a great potential as growth regulator in maintaining pistillateness in hybrid seed production plots, thereby increasing genetic purity of hybrid seed.

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