International Journal of Horticultural Science 2007, 13 (4): 41–44
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Efficacy of ethrel (2-chloroethyl phosphonic acid) as a chemical hybridizing agent in red pepper (*Capsicum annuum* L. var. Pusa jwala)

Agnihotri D. K. & Chauhan S. V. S.

Department of Botany, School of Life Sciences, Dr. B. R. Ambedkar University, Agra-282002, India e-mail: svs250@rediffmail.com

Summary: A field experiment was conducted during 2003–2004 and 2004–2005 to study the effect of foliar sprays of ethrel or ethephon (2-chloroethyl phosphonic acid) on pollen sterility and yield parameters in *Capsicum annuum* var. Pusa jwala. Effect of treatments was also studied in F_1 hybrids raised from treated male sterile plants crossed with the control plants. Plants sprayed with 0.1, 0.2 and 0.3% (v/v) ethrel exhibited 93.1–100% pollen sterility. This was associated with significant reduction in yield parameters (number of flowers, fruits/plant, fruit size, number of seeds/fruit and total yield/plant). However, the plants sprayed only once with 0.1% ethrel at pre-meiotic stage showed 93.1% pollen sterility without any significant reduction in yield parameter. The F_1 hybrids obtained by crossing the 100% male sterile treated plants with the pollen of untreated (control) plants exhibited only insignificant reduction in the number of flowers/ plant, fruits/plant, fruit size, number of seeds/fruit and total yield/plant. However, these parameters in F_1 hybrids were significantly higher over the treated plants.

Key words: *Capsicum annuum*, ethrel, pollen sterility and yield parameters

Introduction

Growers always aim for an increase in the yield of their crops which can be enhanced up to 05–30% through better fruit setting; disadvantageous influence of the growing circumstances, such as agro-technical failure, bad weather conditions, absences of optimal varieties may be greatly eliminated. Through these effects, fluctuations in yield can be eliminated and yield can be promoted. The chemical method for inducing sterility can obviate the often lengthy time period required to obtain male sterile and restorer lines, which usually must precede evaluation of hybrid performance. Consequently, chemicals became of interest both for use as breeding tools and as well as means of producing hybrid seeds on a commercial scale. In recent years, however, companies in the private sector have tested and developed proprietary chemical hybridizing agents and have made them available on a very restricted basis to public and seed company breeders.

The chemicals capable of selectively inhibiting pollen development and thus blocking male fertility are known as chemical hybridizing agents (CHAs). The literature on the use of chemicals inducing male sterility has vastly accumulated (*Chauhan & Kinoshita*, 1982). According to *Chauhan & Kinoshita* (1982), male sterility in 65 species of 54 genera of 20 families has been successfully induced by the treatments with several chemical hybridizing agents (CHAs). *Cross & Schulz* (1997) and *Chauhan* et al. (2007) have reviewed the recent work done on chemical induction of male sterility in large number of plants.

Ethrel is an ethylene generating synthetic compound that acts as a plant growth regulator. It has unique property of releasing ethylene in plant tissue and it also acts as an inhibitor of microspore development (*Cross & Schulz*, 1997) Recently, ethrel has also been successfully used to induce pollen sterility in various crops e.g. *Abelmoschus esculentus* (*Agnihotri & Chauhan*, 2005); *Lycopersicon esculentum, Nicotiana tabacum*, *Cicer arietinum* and *Lens culinaris* (*Chauhan* et al., 2005) and *Gossypium arboreum* (*Gupta & Chauhan*, 2005). However, perusal of available literature shows that ethrel has not been tested as chemical hybridizing agent in chill (*Capsicum annuum*). Therefore, present investigation has been undertaken to evaluate the afficacy of this chemical as a chemical hybridizing agent in *Capsicum annuum* L.

Material and method

Present experiment was conducted during 2003–2005 at the Botanical garden, School of Life Sciences, Dr. B. R. Ambedkar University, Agra to test the afficacy of ethrel (2-chloroethyl phosphonic acid). The experiments were laid out in a randomized row design with five replicates with fifty plants each. The distance between row to row was 75cm and between plant to plant it was 45cm. The plants of chilli (*Capsicum annuum* var. Pusa jwala) were sprayed with aqueous solutions of 0.1, 0.2 and 0.3% (v/v) ethrel. A group of 90 plants were sprayed a week before the initiation of first

floral buds (T_1) i.e. 50 days after sowing, while leaving a group of 30 plants after first treatment, the remaining 60 plants were sprayed again at the time floral bud initiation (T_2) i.e. 55 days after sowing and again after leaving a group of 30 plants, the other 30 plants were sprayed again at the time of anthesis i.e. 60 days after sowing, thus receiving three sprays (T_3). A group of 30 plants were sprayed with distilled water to serve as control (T_0). 30 ml of each concentration was sprayed on one plant to run off. Pollen fertility of variously treated and control plants were checked at regular intervals with the help of Alexander's (1980) staining technique. The ovular sterility in treated plants checked by calculating the seed-set percentage in the treated plants pollinated with the control plants. The treated plants exhibiting 100% pollen sterility was crossed with the pollen of untreated (control) plants and the seeds thus obtained were sown next year to obtain F_1 hybrids.

Data on days taken to first flowering, number of flowers and fruits/plant, fruit size, ovular sterility, total seeds/fruit and total fruit weight in treated and untreated plants were collected and statistically analyzed by analysis of variance, standard deviation and student 't' test.

Results and discussion

Days taken to first flowering

All the treatments with various concentrations of ethrel enhanced the number of days taken to first flowering. Increase in the days taken to first flowering increased with the increase in number of treatments and concentrations. Plants treated thrice (T_3) with 0.3% ethrel exhibited maximum delay and flowering in these plants was observed 63.8 days after sowing as compared to control plants taking only 50.6 days respectively (*Table 1*). Delayed flowering by sprays with ethrel has also been recorded in *Abelmoschus esculentus* (*Agnihotri & Chauhan*, 2005); *Lycopersicon esculentum, Nicotiana tabacum, Cicer arietinum* and *Lens culinaris* (*Chauhan* et al., 2005) and *Gossypium arboreum* (*Gupta & Chauhan*, 2005).

Pollen sterility

Foliar application of different concentrations of ethrel effectively induced pollen sterility ranging between 93.1–100% and sprayed twice (T_2) and thrice (T_3) with 0.2 and 0.3% ethrel induced 100% pollen sterility lasting for 20–25 days. The bagged flowers of treated plants failed to show any seed-set, thus conforming induction of complete pollen sterility by these treatments (*Table 1*). Recently, ethrel has also been successfully used to induce pollen sterility in various crops e.g. *Abelmoschus esculentus* (*Agnihotri & Chauhan*, 2005); *Lycopersicon esculentum, Nicotiana tabacum, Cicer arietinum* and *Lens culinaris* (*Chauhan* et al., 2005) & *Gossypium arboreum* (*Gupta & Chauhan*, 2005).

Number of flowers/plant

There was a significant reduction in the number of flowers/treated plants (*Table 1*). The number of flowers/plant gradually decreased with the increase in concentration and number of treatments. There were only121.0 flowers/plant sprayed thrice (T_3) with 0.3% ethrel as compared to 139.6-flowers/untreated plant. However, it was interesting to note that in plants sprays only once with 0.1% ethrel, there was also a reduction in flowers/plant but this reduction was not significant different from that of control plants.

Number of fruits/plant

There was a significant reduction in the number of fruits/treated plants (*Table 1*). The number of fruits/plant

Table 1. Effect of ethrel (2-chloroethyl phosphonic acid) on reproductive parameters in chilli (Capsicum annuum L. var. Pusa jwala)

Chemical	Concentrations (%)	Days taken to first flowering			Pollen sterility (%)			Number of flowers/plant			Number of fruits/plant		
		T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
Ethrel	0.1	55.1* ±2.1	58.7* ±1.7	**60.9* ±1.9**	93.1* ±1.2	95.7* ±0.8	**100.0* ±0.0**	136.0 ±2.5	130.6* ±2.8	**128.8* ±2.2**	124.4* ±2.1	117.0* ±1.7	**110.3* ±1.71**
	0.2	55.9* ±1.8	58.9* ±1.2	62.7* ±2.1	95.8* ±1.9	100.0* ±0.0	100.0* ±0.0	133.6* ±1.9	128.0* ±2.0	124.6* ±1.9	114.8* ±2.3	111.2* ±1.9	108.0* ±1.7
	0.3	57.1* ±1.9	59.9* ±2.3	63.8* ±2.2	98.9* ±1.7	100.0* ±0.0	100.0* ±0.0	130.0 ±1.5	128.2* ±1.4	121.0* ±1.7	112.6* ±1.9	108.6* ±2.2	103.0* ±2.1
Control			50.6 ±2.7			2.3 ±0.8			139.6 ±1.9			130.2 ±3.0	
CD at 5% level			4.7			3.0			8.2			5.6	

Where as:
T_1: Single spray before floral bud initiation.
T_2: Two sprays, first before floral bud initiation an d second 2–3 days after floral bud initiation.
T_3: Three sprays, first before floral bud initiation; second 2–3 days after floral bud initiation and th ird at the time of anthesis.
T_0: Sprayed with distilled water to serve as control.
*: Significant at 5% level

Table 2. Effect of ethrel (2-chloroethyl phosphonic acid) on reproductive parameters in chilli (*Capsicum annuum* L. var. Pusa jwala)

Chemical	Concentrations (%)	Ovular sterility (%)			Fruit size (cm)			Number of seeds/fruit			Total fruit weight		
		T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
	0.1	3.8 ±0.5	4.9* ±0.9	**9.3* ±1.0**	5.8 ±0.7	5.6 ±1.3	**5.4* ±1.5**	82.1 ±2.0	80.1* ±1.9	**80.0* ±1.9**	370.0 ±3.3	365.1* ±3.0	**360.0* ±4.7**
Ethrel	0.2	4.7* ±0.9	6.7 ±1.1	13.0* ±1.3	5.7 ±1.3	5.5* ±1.7	5.2* ±1.4	81.7* ±3.0	80.0* ±2.0	79.0* ±2.1	365.1* ±2.1	350.1* ±1.9	334.7* ±3.3
	0.3	11.6* ±1.4	14.8* ±1.4	18.3* ±1.9	5.3* ±1.2	5.1* ±2.0	4.4* ±2.3	79.7* ±2.2	77.1* ±1.7	75.2* ±1.9	352.3* ±2.9	340.4* ±2.3	335.1* ±2.9
Control			2.1 ±0.9			6.1 ±2.1			85.1 ±2.3			370.5 ±3.3	
CD at 5% level			1.1			2.9			4.8			12.1	

Where as:
T_1: Single spray before floral bud initiation.
T_2: Two sprays, first before floral bud initiation and second 2–3 days after floral bud initiation.
T_3: Three sprays, first before floral bud initiation; second 2–3 days after floral bud initiation and third at the time of anthesis.
T_0: Sprayed with distilled water to serve as control.
*: Significant at 5% level

Table 3. Yield parameters in chilli (*Capsicum annuum* L.) plants (F1) raised from the seeds of plants treated thrice (T_3) with 0.1% ethrel crossed with the pollen of control plants

	Days taken to first flowering	Pollen sterility (%)	Number of flowers/plant	Number of fruits/plant	Ovular sterility (%)	Fruit size (cm)	Number of seed/fruit	Total fruit weight (g)
Control	50.6 ±2.7	2.3 ±0.8	139.6 ±1.9	130.2 ±3.0	2.1 ±0.9	6.1 ±2.1	85.1 ±2.3	375.2 ±3.3
F_1 generation of 0.1% (T_3) ethrel treatment	52.0 † ±3.1	7.3*† ±0.9	136.6† ±2.0	122.9*† ±1.7	9.5* ±1.9	6.0 ±1.7	83.0 ±2.0	370.5† ±2.6

Where as:
*: Significant at 5% level (Control Vs ethrel treated plants and F_1 generation)
†: Significant at 5% level (Ethrel treated plants Vs F_1 generation)

gradually decreased with the increase in concentration and number of treatments. There were only 103.0 fruits/plant sprayed thrice (T_3) with 0.3% ethrel as compared to 130.2 fruits/untreated plant.

Ovular sterility

All the treatment with various concentrations and number of treatments of ethrel enhanced the ovular sterility (*Table 2*). Plants treated once (1) with 0.1%, it was only 3.8% and plants treated thrice (T_3) with 0.3% ethrel, it was only 18.3% ovular sterility as compared to untreated plants (2.1%).

Fruit size

Treated plants showed reduction in fruit size that was inversely proportional to the increase in the concentrations as well as number of treatments (*Table 2*). Maximum reduction in fruit size was recorded in plants treated thrice (T_3) with 0.3% ethrel. The average fruit size in 0.3% ethrel treated chilli plants was 4.4cm long as compared to 6.1cm long fruits in control plants of chilli.

Number of seeds/fruit

Treated plants showed reduction in seeds/fruit that was inversely proportional to the increase in the concentrations as well as number of treatments (*Table 2*). Maximum reduction in seeds/fruit was recorded in plants treated thrice (T_3) with 0.3% ethrel. The average seeds/fruit in 0.3% ethrel treated chilli plants was 75.2 seeds to 85.1 seeds/fruits in control plants.

Total fruit weight/plant

There was a significant reduction in the total fruit weight in chilli treated with ethrel and this reduction was directly proportional to the number of treatments as well as

concentrations in chilli plants (*Table 2*). The maximum reduction in total fruit weight was recorded in plants treated thrice (T_3) with 0.3% ethrel and in chilli it was 335.1g/plant as compared to 370.5 g/control plant. The reduction in seed-set percentage in treated plants also indicated the extent of ovular sterility. Recently, ethrel has also been used as a chemical hybridizing agent in various crops e.g. *Abelmoschus esculentus* (*Agnihotri & Chauhan*, 2005); *Lycopersicon esculentum*, *Nicotiana tabacum*, *Cicer arietinum* and *Lens culinaris* (*Chauhan* et al., 2005) & *Gossypium arboreum* (*Gupta & Chauhan*, 2005).

F_1 hybrids

Data on various yield parameters in F_1 hybrids raised from the seeds obtained by crossing the plants treated thrice with 0.1% ethrel with the pollen of untreated (control) plants is shown in *Table 3*. The F_1 hybrids exhibited insignificant reduction in various yield parameters as compared to untreated (control) plants. However, these parameters were significantly higher than those of their treated parents. Thus, the application of ethrel can effectively induce male sterility, which can be exploited for hybrid seed production.

References

Agnihotri, D.K. & Chauhan, S.V.S. (2005): Ethrel induced male sterility in okra (*Abelmoschus esculenthus* L.). Jour. Cytol. Genet. 6: 75–78.

Alexender, M.P. (1980): A versatile stain for pollen, fungi, yeast and bacteria. Stain tech. 55: 13–18.

Chauhan, S.V.S. & Kinoshita, T. (1982). Chemically induced male sterility in Angiosperms. Seiken Ziho 30: 54–75.

Chauhan, S.V.S.; Agnihotri, D.K.; Gupta, H.K. & Bansal, S. (2005): Ethephon induced male sterility in *Cicer arietinum*, *Lens culinaris*, *Lycopersicon esculentum* and *Nicotiana tabacum*. J. Indian Bot. Soc. 84: 76–79.

Chauhan, S.V.S.; Agnihotri, D.K. & Singh, V. (2007): Some New Male Gametocides-A review. In: *Plant Reproductive Biology and Biotechnology*. (eds.). Chauhan, S.V.S.; Rana, Anita & Chauhan, Seema. Aavishkar Publishers, Distributors, Jaipur. pp. 210–221.

Cross, J.W. & Schulz, P.L. (1997): Chemical induction of male sterility. In: *Pollen Biotechnology for Crop Production and Improvement*. (eds.) Shivanna, K. R. and Sawhney, V. K. Cambridge University Press, London. Pp. 218–236.

Gupta, H.K. & Chauhan, S.V.S. (2005): Efficacy of ethrel and benzotriazole as chemical hybridizing agent in *Gossypium arboreum* L. Jour. Cotton Res. Develop. 19: 153–156.