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EFFECT OF ETHREL ON REPRODUCTIVE EFFICIENCY IN CHICKPEA

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SUMMARY

An experiment was conducted with chickpea (*Cicer arietinum* L.) cultivar BG 209 to study the effect of ethrel applied as foliar spray at low (250 ppm), medium (500 ppm) and high (1000 ppm) concentrations at pre flowering (65 DAS: S_1), mid-flowering (94 DAS: S_2) and post-flowering (125 DAS: S_3) stages. The low and medium concentrations resulted in increase in dry matter over the control plants, though medium concentration was less effective than lower concentration at all the stages. Maximum leaf area was observed at lowest ethrel concentration at all stages and there was decline in leaf area with increasing ethrel concentration. Low concentration increased the pod number at S_1 (17%) and S_2 stages (11%), while at S_3 stage, a 22% reduction in pod number was observed. The medium concentration was slightly better than lower concentration when applied at S_1 stage, while at S_2 and S_3 stages it was inferior to lower concentration. High concentration at all the stages reduced pod number by 4, 8 and 27%, respectively. At higher concentrations, number of seeds decreased by 10, 18 and 46% at S_1, S_2 and S_3 stages, respectively. High concentration again decreased pod set from 3 to 24% depending upon stage of application, maximum decrease being at S_3 stage. High concentration reduced biomass production from 1 to 31% depending upon stage. At stage S_1 and S_2, low concentration increased yield by 11 and 14% respectively while medium concentration increased it by 14 and 2% at S_1 and S_2 stages, respectively. The percentage of flowers and pods shed in treated plants in comparison to control was more when plants were sprayed at post-flowering stage than pre-flowering and mid-flowering stages. The total number of pods formed at pre-flowering and mid-flowering stages show substantial increase over control with low and medium concentration, while high concentration registered a decrease.

Key words: **Chickpea, ethrel, flowering, reproductive efficiency**

INTRODUCTION

Flower and fruit/pod drop is one of the serious problem of chickpea, resulting in its poor reproductive efficiency viz. the number of flowers formed/retained and the per cent fruits developed with normal seeds (Van Schaik and Probst 1958), and consequently poor yield. Ethrel (ethylene producing commercial preparation) has been reported to improve productivity of pulse crops like cowpea, pigeonpea, mungbean and soybean by increasing the number of pods, seed weight and seed yield (Chandra 1985, Singh 1984, Yadav *et al.* 1980, Bora and Bohra 1989). In cucurbits ethrel application at 250 ppm promoted pistillat flower formation (Robinson *et al.* 1970). Beneficial effects of ethylene/ethrel application on increasing flowering, fruit size and fruit yield have also been reported in tomato (Atta-Aly *et al.* 1999), Ficus (Johnson and Joiner 1978), apples (Anonymous II 2003, Anonymous III 2006-2007) and mango (Thanda 2007). Foliar application of a phosphonic acid plant growth regulator to rice crop plants, when the plants are at a growth stage of between the start of

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tillering and initiation of panicle primordia, at about 750 grams per hectare results in rice yield significantly greater than untreated rice crops by reducing decline in tiller number and increasing the number of seed producing tillers (Anonymous I 1985). In paddy, ethrel improved the tillering, crop growth rate, grains per ear and grain yield. In the present study, an attempt has been made to investigate the effect of ethrel on growth and reproductive efficiency in chickpea.

MATERIALS AND METHODS

A field experiment was conducted with chickpea (*Cicer arietinum* L.) cultivar BG 209 at IARI, New Delhi. Sowing was done in rows 30 cm apart and plant-to-plant spacing was maintained at 10 cm. Fertilizer was applied @ 15 kg N and 25 kg P_2O_5 ha^{-1} as urea and single superphosphate, respectively at the time of sowing. Before sowing seeds were inoculated with rhizobium culture (F75). Besides a pre-flowering irrigation, a supplementary irrigation was given before flowering. Low (250 ppm), medium (500 ppm) and high (1000 ppm) concentrations of ethrel designated as L, M and H, respectively were applied exogenously as fine foliar spray at vegetative (pre flowering) (65 DAS: S_1), mid-flowering (94 DAS: S_2) and post-flowering (125 DAS: S_3) stages. All the plots were given three sprays on alternate days. The control plants were sprayed with distilled water. Attributes of reproductive efficiency were recorded on representative plants from each treatment. The plants were selected for non-destructive observations and following parameters were recorded.

$$\text{Loss due to shedding (flowers and pods)} = \frac{\text{No. of flowers and pods shed}}{\text{Total number of flowers}} \times 100$$

$$\text{Pod set} = \frac{\text{No. of pods}}{\text{Total number of flowers}} \times 100$$

$$\text{Fruiting efficiency} = \frac{\text{No. of developed pods}}{\text{Total number of pods}} \times 100$$

$$\text{Seed efficiency} = \frac{\text{No. of seeds/pods}}{\text{Total number of ovules/pod}} \times 100$$

The crop was harvested at maturity from a 1.0 m^2 area from the middle of the plot. The results are expressed both on per m^2 and per plant basis.

RESULTS AND DISCUSSION

The effect of ethrel on reproductive efficiency and growth parameters was found to be related to stage of application and concentration dependent. Total dry weight of plant increased with time at all the growth stages (Table 1). The low and medium concentrations resulted in increase in dry matter over the control plant, though medium concentration was less effective than lower concentration at all the stages. However, high concentration of ethrel seems to be detrimental as compared to untreated control. The leaf area at pre-flowering and 50 % flowering stages increased with time both in the control and treated plants and thereafter it decreased during the post-flowering pod development stage (Table 2). Maximum leaf area was observed at lowest ethrel concentration at all stages and there was decline in leaf area with increasing ethrel concentration.

Table 1. Effect of different concentration of ethrel applied at pre-flowering (S_1), mid-flowering stage (S_2) and post flowering pod development stage (S_3) on total dry weight (g $plant^{-1}$)

Ethrel concentrations	Pre-flowering vegetative stage (S_1)			Mid-flowering stage (S_2)			Post-flowering pod development stage (S_3)		
	73 DAS	80 DAS	87 DAS	102 DAS	109 DAS	116 DAS	133 DAS	140 DAS	147 DAS
Control (0 ppm)	2.166	2.755	3.436	5.939	7.686	9.607	16.527	18.278	19.984
Low (250 ppm)	2.633	3.330	4.214	7.221	9.282	11.307	20.782	21.578	22.017
Medium (500 ppm)	2.380	3.147	3.783	6.409	8.288	10.262	18.104	18.268	18.597
High (1000 ppm)	1.878	2.504	3.137	5.395	6.984	8.983	14.306	13.986	13.478

CD at 5% P: stage (S)= 0.495, Concentration (C)= 0.330, SXC= 0.990

Table 2. Effect of different concentration of ethrel applied at pre-flowering vegetative stage (S_1), mid-flowering stage (S_2) and post flowering pod development stage (S_3) on leaf area (cm^2 $plant^{-1}$)

Ethrel concentrations	Pre-flowering vegetative stage (S_1)			Mid-flowering stage (S_2)			Post-flowering pod development stage (S_3)		
	73 DAS	80 DAS	87 DAS	102 DAS	109 DAS	116 DAS	133 DAS	140 DAS	147 DAS
Control (0 ppm)	160.67	221.63	282.59	411.27	446.75	480.29	652.15	563.18	484.02
Low (250 ppm)	195.13	266.19	335.16	497.31	534.75	566.40	743.28	656.24	583.20
Medium (500 ppm)	175.32	236.25	305.17	440.06	487.59	523.20	684.60	621.75	567.00
High (1000 ppm)	148.36	197.21	248.04	365.78	413.69	441.60	625.92	545.37	480.60

CD at 5% P: stage (S)= 20.575, Concentration (C)= 13.717, SXC = NS

The number of flowers in untreated control plants was 215-216. There was non- significant increase at low concentration (Fig. 1A). At medium concentration, there was an increase in flower number only when plants were sprayed at S_1 and slightly at S_2 stage, while at stage S_3 there was a marginal decrease in flower number. At high concentration, there was reduction in flower number at all the stages although the decrease was non- significant. Low concentration increased the pod number at S_1 (17%) and S_2 stages (11%), while at S_3 stage, a 22% reduction in pod number was observed (Fig. 1B). Similar trend was observed at medium concentration (Fig. 1B). High concentration at all the stages reduced pod number by 4, 8 and 27%, respectively. The medium concentration was slightly better than lower concentration when applied at S_1 stage while at S_2 and S_3 stages it was inferior to lower concentration. The results suggest that for full effect of optimum concentration of ethrel, the spray should be done at early stage so that to provide sufficient time for the resultant metabolic processes to result in morphological responses. Ethrel/ethephon induced increase in flowering has been reported in *Ficus benjamina* (Johnson and Joiner 1978), mango (Thanda 2007) and tomato (Atta-Aly *et al.* 1999).

Total number of seeds formed in control plant was about 88, which in plant treated at low concentration increased by 20 and 15 % at S_1 and S_2 stages (Fig. 2B). However, at S_3 stage 31 % decrease in number of seeds was observed. At medium concentration, the increase was 25 and 6 % at stage S_1 and S_2, respectively while 37 % reduction in seed number was observed at S_3 stage. At high concentration, number of seeds decreased by 10, 18 and 46 % at S_1, S_2 and S_3 stages, respectively.

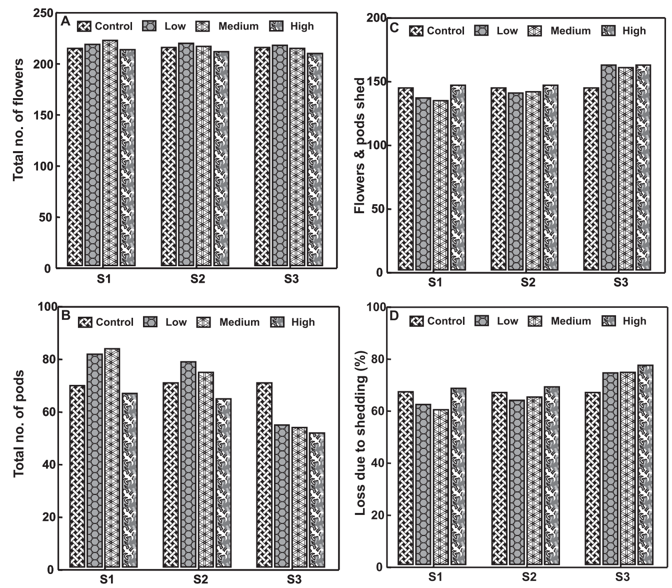

Fig. 1. Effect of ethrel applied at pre-flowering (S_1), mid-flowering (S_2) and post flowering stages (S_3) on (A) total number of flowers, (B) total number of pods, (C) flowers and pods shed, and (D) loss due to shedding in chickpea.

Seed number per pod did not exhibit much variation with the application of ethrel at stages S_1 and S_2 but there was drastic reduction in seed number per pod at S_3 stage with all the three treatments (Fig. 2C). Thus, application of different concentrations of ethrel at stage S_1, S_2 and S_3 indicate that low and medium concentration were beneficial at stage S_1 and S_2 only. The effect of high concentration at all stages was negative.

Loss due to shedding in control plant was around 67 %. Ethrel at low and medium concentration reduced shedding at S_1 and S_2 stages ranging from 2 to 10 % depending upon the stage but at stage S_3 shedding

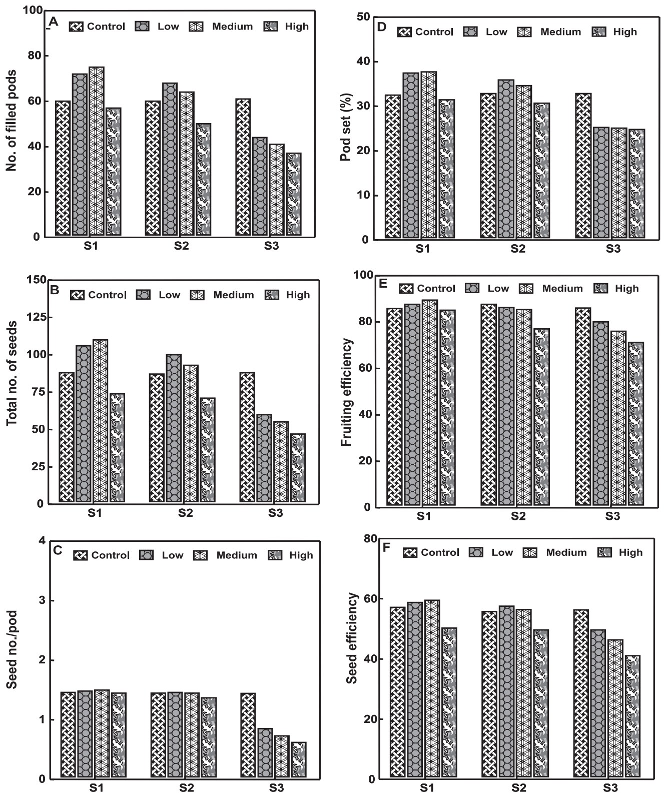

Fig. 2. Effect of ethrel applied at pre-flowering (S_1), mid-flowering (S_2) and post flowering stages (S_3) on (A) number of filled pots, (B) number of seeds, (C) seed number per pod , (D) pod set, (E) fruiting efficiency, and (F) seed efficiency.

increased by 8 %. At high concentration, the shedding enhanced at S1, S_2 and S_3 stages by 2, 3 and 16 %, respectively (Fig. 1C & D). Pod set was better at stages S_1 and S_2 by application of ethrel at low and medium concentrations, and increased from 5 to 16 %, while at S_3 stage it registered a decrease of 23 % (Fig. 2D). High concentration decreased pod set from 3 to 24 % depending upon stage of application, maximum decrease being at S_3 stage. Fruiting efficiency showed a similar response but of lower magnitude (Fig. 2E). The increase in fruiting efficiency was 1 to 4 % with low and medium concentration at stage S_1 and S_2 but at stage S_3 registered a decrease of 7 % over control. High concentration reduced fruiting efficiency by 1, 9 and 17 % at stage S_1, S_2 and S_3, respectively. Seed efficiency showed similar trend as observed for fruiting efficiency but there was only marginal increase at stage S_2 by application of low and medium concentration of ethrel (Fig. 2F).

Total biomass increased by 14 % and 10 % by low and medium concentration of ethrel at S_1 stage. However, the beneficial effect was less at S_2 than S_1 stage under similar treatments. At stage S_3, all the concentrations registered a decrease in dry weight ranging from 7 to 31 %. High concentration reduced biomass production from 1 to 31 % depending upon stage (Table 2). The seed yield also showed a similar trend (Table 3). At stage S_1 and S_2, low concentration increased yield by 11 and 14 %, respectively, while medium concentration increased it by 14 and 2 % at S_1 and S_2 stages, respectively. At stage S_3 all the concentrations showed marked reduction in yield ranging from 20 to 67 %. Further, it was observed that high concentration reduced the seed yield at all stages ranging from 20 to 67 %. Application of ethrel at low, medium and high concentration at stage S_2 and S_3 increased 100 seed weight by 6, 10 and 11 % and 7, 13 and 16 %, respectively. Spray at S_1 stage at all the concentrations showed 1 to 14 % increase in 100 seed weight. The increase in harvest index was observed with low concentration at S_2 stage. Medium and high doses at S_2 and S_3 stages were inhibitory (Table 3).

The most striking observation is the decrease in seed yield when spray was made at post-flowering stage (S_3) with each of the concentration used in the present study. Another interesting observation is that application of lower concentration of ethrel at pre-flowering and mid-flowering stages improved seed yield over control, the maximum effect being with medium concentration at vegetative (S_1) stage and low concentration at mid-flowering stage (S_2). In case of mango Atta-Aly et al. (1999) reported that while late application of ethrel inhibited yield, early application extends tomato fruit cell division, and increased fruit size and yield.

It was observed that the percentage of flowers and pods shed in treated plants in comparison to control was more when plants were sprayed at post-flowering stage than pre-flowering and mid-flowering stages. It is understandable, as the spray made at flowering stage is already past the stage for affecting any effect on plant. On the other hand, ethrel/ethylene application at this stage might have hastened the senescence process.

Table 3. Effect of different concentration of ethrel applied at pre-flowering vegetative stage (S_1), mid-flowering stage (S_2) and post- flowering pod development stage (S_3) on total biomass, seed yield, 100-seed weight and harvest index (per m^2 basis)

Ethrel	Total biomass (g m^{-2})			Seed yield (g m^{-2})			100-seed weight (g)			Harvest index (%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Control (0 ppm)	695.00	707.00	703.00	212.36	214.30	215.23	12.22	12.51	12.65	30.64	30.27	30.63
Low (250 ppm)	795.00	745.00	656.60	235.43	245.30	170.53	10.49	13.27	13.52	30.61	32.87	25.86
Medium (500 ppm)	765.00	743.00	500.00	243.35	218.50	100.70	11.64	13.74	14.26	30.76	29.19	19.53
High (1000 ppm)	650.00	700.00	486.00	204.19	186.13	70.90	12.13	13.93	14.63	31.40	26.66	14.67
	CD at 5%			CD at 5%			CD at 5%			CD at 5%		
Stage (S)	35.250			11.674			0.641			1.499		
Concentrations (C)	40.703			13.480			0.740			1.731		
S x C	70.499			23.248			NS			2.998		

Hence the decrease in seed yield by ethrel application at post-flowering stage is associated with high abscission of flowers and pods. The total number of pods formed at pre-flowering and mid-flowering stages show substantial increase over control with low and medium concentration, while high concentration registered a decrease.

The effects of ethrel unlike other PGRs viz., benzyladenine, triadimefon (Saxena *et al.* 2000, 2003) primarily is not related to increase in number of reproductive unit. Thus, the difference in this behaviour can be attributed to the concentration and stage dependent effect on flower and pod retention.

The reduction of flowers and pods abscission by low and medium concentration at pre-flowering and mid-flowering stages increased the sink potential as the reproductive components and parameters determining reproductive efficiency were greater than control plants. It may be possible that at these stages the tissue sensitivity may be a factor or that the other factors associated with cell division and growth of the embryo are present adequately. Ethrel induced increase in cell division, resulting in increase in fruit size and yield have been reported in tomato fruits (Atta-Aly 1999).

Ethylene released from ethrel could possibly be utilized for promoting pod growth as Abbas (1991) has shown that early pod development is related to higher ethylene levels, thus decreasing flower and pod shedding and thereby reducing abscission and improving better pod set. The effect of high concentration of ethylene are clear cut as there is decline in dry matter production and leaf area, which clearly points out to the fact that poor biomass production is the result of high level of ethylene released by ethrel, which retards growth of the plant. The developmental effects of ethrel at post-flowering stage suggest that the benefit of application of any plant growth regulator can be achieved if that is capable of increasing assimilate supply, which could in turn contribute to seed growth, since high ethylene levels do not contribute in this direction, this results in poor seed yield. This explains the observation that although the seed yield realization is less by ethylene, yet seed weight is higher than the control. This suggests that seed weight can be increased under a reduced reproduction load. It seems that decrease in seed yield by higher concentration of ethrel could be due to enhanced leaf senescence leading to decrease in photosynthetic capacity of leaves and a decline in chlorophyll pigment as well as decreased supply of assimilates to developing fruit and seed.

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