



Effect of Ethephon Application on Seed Yield and Yield Components of Two Faba Bean (*Vicia faba* L.) Cultivars[#]

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ABSTRACT

The aim of present study was to determine the effects of different ethephon doses on grain yield and yield components of two faba bean cultivars. The experiment was established in 2019/2020 and 2020/2021 cropping season at Research Area of Field Crops Department, Agriculture of Faculty, Cukurova University Adana, Turkey. The field experiment was laid out in randomized complete blocks design (RCBD) with three replications on the basis split plot design with cultivars (Luz de Otono and Hista) in main plots and ethephon doses (0, 500, 1000, 1500 g ha⁻¹) in sub plots. Plant height (cm), branches per plant, pods per plant, seeds per plant, seed yield per plant (g), 100 grain weight (g), seed yield (kg ha⁻¹) were investigated. Differences among the cultivars and ethephon applications were significant for seed yield and it varied from 1782 to 3388 kg ha⁻¹ in the mean of the years. Seed yield also decreased with increasing ethephon doses. Seed yield was higher in 2019/2020 (3355 kg ha) than 2020/2021 (1841 kg ha⁻¹) where low rainfed and high temperature. The present results suggested that ethephon applications at initiation of flowering were not useful for seed production of faba bean.

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Introduction

Faba bean (*Vicia faba* L.) is used as animal feed in addition to human nutrition. Faba bean has an important role in agricultural production and it is a beneficial food crop in terms of high protein content and quality (Sheelamary and Shivani, 2015). At the same time, faba bean is need to low input in the cropping systems. It fixed the nitrogen from the air through the *Rhizobium* symbiotically. Faba bean can be grown as a winter crop in coastal regions under rainfed conditions for grain production (Ton et al., 2021). In this regions plant height may be increasing in the excessive rainy years, so seed maturity is late and harvest can be difficult due to lodging. So, low seed yield is one of the most problems for producers. Plant bio regulators are natural or synthetic compounds and they also have importance for increasing yield and quality of legume crops (Kumar, 2021). The studies relation to ethephon application on seed production of some crops are wide, but there are very limited studies for using growth retard in legumes. Plant growth regulators provided increasing seed yield in pulses and use of various growth regulators positively affected crop growth rate and

assimilation rate in chickpea (Verma et al., 2018). The applications of ethephon and other growth regulators on various crops were reported by some studies. Ethephon is a synthetic growth retarding chemical and it reduces plant height in sunflower and maize (Spitzer, 2011; Spitzer et al., 2015) and chickpea (Güler et al., 2009). Ethilen regulates flowering, so provides early and same time maturity in plants (Kumlay and Eryiğit, 2011). The effect of plant growth regulators is important in early application timing than late applications in faba bean (Walela et al., 2016). Bora and Sarma (2006) reported that gibberellic acid (GA3) and cycocel can increase seed yield and protein content in seed of pea. The highest yield was obtained from 500 and 750 ppm doses of cycocel applied in three-leaves stage of faba bean, but grain yield was not increasing yield due to cycocel application in pod setting of faba bean (Beşer and Adak, 1999). Ethephon can be used to benefit for early maturity of crops. Ngatia et al. (2003) recorded that ethephon application did not positively affect bean production. Flowering time is very important for legumes and early or late flowering depend on weather conditions.

Ethephon delayed flowering time and reduced plant height in several herbaceous perennials (Hayashi et al., 2001). Spitzer et al. (2011) reported that growth regulators delayed in flowering onset of sunflower. Paclobutrazol reduced stem height, so increased seed yield and yield components in field bean (*Vicia faba*), but paclobutrazol and triapenthenol did not affect seed yield in lens (Field and et al., 1989). Effendi et al. (1989) indicated that effect of paclobutrazol and triapenthenol on seed yield is not significant, but these plant growth regulators reduced plant height and mean internode length in lentil.

The present study was carried out to determine the effects of applications for different ethephon doses on seed yield and yield components of two faba bean cultivars.

Material and Methods

Climate and Soil Characters of Experiment Site

The experiment was established in 2019/2020 and 2020/2021 cropping season at the Research Area of Field Crops Department (37° 02' 18.06 N, 35° 22' 39.93'E and 73 m above sea level), Faculty of Agriculture, University of Cukurova, Adana, Turkey. The soil type of experimental site was loam in textures. The other soil characters are salt content, value of pH, available phosphour content, organic matter were 0.275 milimhos cm⁻¹ and 8.2, 3.3 kg da⁻¹, 2.3% respectively.

Values of monthly average temperature and total precipitation of area are given in Table 1.

Plant Material

Two commercial cultivars (Luz de otono and Hстал) were used as the plant material in the study. Luz de otono is early cultivar, while Hстал is late cultivar.

Methods

Experiment Design and Cultural Practices

The field experiment was laid out in randomized complete blocks design (RCBD) with three replications on the basis split plot design with cultivars in main plots and ethephon doses in sub plots. Different ethephon (480 g/lt) doses (0, 500, 1000, 1500 g/ha) were applied at the flowering initiation.

The sowings were made in 13 November 2019 and 18 November 2020. Experimental plots consists of 4 rows with row to row distance of 45 cm and plant to plant distance of 10 cm. The plot area was 7.2 m² (4.0 m × 1.8

m). Harvest was made in the middle two rows after eliminating the border rows. Fertilizer was applied at rate 30 kg ha⁻¹ N and 80 kg ha⁻¹ P₂O₅ before sowing. Field emergences were recorded on 17 December 2019 and on 15 December 2020. Maturing date was recorded on the 8th of May for Luz de otono and on the 19th of May for Hстал in 2020 while it was recorded on the 29th of April for Luz de otono and on the 11th of May for Hстал in 2021.

Observations

Data were recorded from five randomly selected plant of each plot. Plant height (cm), first podding height (cm), primary branches per plant, pods per plant, seeds per plant, seed weight per plant (g), 100-seed weight (g), seed yield (kg ha⁻¹) were observed.

Statistical Analysis

The data for morphological traits were analysed according to the split plot experiment design for every year separately and combined year by using the MSTAT-C a computer software package. Comparisons among the means were using LSD multiple range test at 0.05 probability level.

Results and Discussion

The effects of cultivars and ethephon applications on plant height, first podding height and branches per plant of faba bean is presented in Table 2.

Differences among the cultivars were significant for plant height in both of the years and the combined years (Table 2). There were not significant differences among the years for this trait. Later maturing variety Hстал has higher plant height (63.7 cm) as compared to early maturing Luz de Otona (46.1) in the mean of the years. Previous studies showed that plant height varied between 85.5-115.2 cm (Musallam et al. 2004) and 80.07- 100.63 cm (Pekşen et al. 2006) according to cultivars and environmental conditions. There were significant differences among the ethephon doses for plant height in the first year and the mean of experimental years. Plant height in the second year where low rainfed and high temperature in vegetative stage of crop was not influenced by ethephon doses. As the mean of years, the highest plant height was achieved by control application (0 g ha⁻¹) with 61.5 cm followed by 500 g ha⁻¹ doses of ethephon with 56.2 cm whereas the lowest value was obtained from 1500 g ha⁻¹ with 49.5 cm.

Table 1. Values of monthly average temperature and total rainfall of experiment area

Months	Min Temperature (°C)		Max Temperature (°C)		Mean Temperature (°C)		Relatively Humidity (%)		Total Rainfall (mm)	
	Years									
	A	B	A	B	A	B	A	B	A	B
November	10.3	7.1	30.6	27.8	18.1	17.0	56.7	59.5	22.6	52.6
December	6.5	4.2	20.7	22.7	12.2	13.4	79.4	63.9	414.0	31.0
January	0.6	-0.1	18.0	22.9	9.9	11.7	67.9	63.7	140.2	131.4
February	-2.1	2.4	22.8	24.3	10.4	13.1	67.1	61.4	93.0	23.9
March	5.8	3.1	27.6	34.4	15.3	13.9	69.3	68.7	47.4	45.7
April	8.3	6.6	29.9	34.0	18.3	18.3	70.2	64.9	21.4	44.0
May	12.9	14.9	40.3	30.7	23.3	23.9	61.0	64.9	66.6	4.1

A: 2019- 2020, B: 2020 - 2021

Table 2. The effects of cultivars and ethephon applications on plant height, first podding height and branches per plant in faba bean

Treatments	Plant Height(cm)			First Podding Height(cm)			Main Branches/Plant		
	2019/20	2020/21	Mean	2019/20	2020/21	Mean	2019/20	2020/21	Mean
Cultivar									
Luz de otono	46.7 ^b	45.6 ^b	46.1 ^b	14.4	16.2 ^b	15.4 ^b	2.58	3.46	3.02
Histal	66.1 ^a	61.3 ^a	63.7 ^a	19.7	20.9 ^a	20.3 ^a	2.71	3.47	3.09
p.(cultivar)	0.0162 [*]	0.0224 [*]	0.0005 ^{**}	N.S	0.0024 ^{**}	0.0023 ^{**}	N.S.	N.S.	N.S.
Doses (g ha ⁻¹)									
0	65.8 ^a	57.3	61.5 ^a	20.5 ^a	25.5 ^a	23.0 ^a	2.60	2.25 ^c	2.43 ^c
500	58.6 ^{ab}	53.7	56.2 ^b	17.4 ^{ab}	21.2 ^b	19.3 ^b	2.70	3.27 ^b	2.98 ^b
1000	52.7 ^{bc}	52.6	52.7 ^{bc}	15.3 ^b	14.6 ^c	14.9 ^c	2.67	4.13 ^a	3.40 ^{ab}
1500	48.6 ^c	50.4	49.5 ^c	15.0 ^b	13.1 ^c	14.1 ^c	2.63	4.20 ^a	3.42 ^a
LSD %5	7.31	N.S.	4.30	3.60	3.51	2.38	N.S.	0.73	0.42
Mean	56.4	53.5	55.0	17.1	18.6	17.8	2.65 ^b	3.46 ^a	3.05
p.(year)			N.S.			N.S.			0.0014 ^{**}
CV %	10.3	7.99	9.27	16.8	15.0	15.8	15.5	16.7	16.5

P_{≤0.05}^{*}; P_{≤0.01}^{**}

Table 3. Interaction of cultivars and ethephon doses for faba bean in combined years

Doses (g ha ⁻¹)	Cultivar			
	First podding height (cm)		Branches/plant	
	Luz de otono	Histal	Luz de otono	Histal
0	20.58 ^{bc}	25.40 ^a	2.65 ^{cd}	2.20 ^d
500	14.30 ^d	24.27 ^{ab}	3.13 ^{bc}	2.83 ^c
1000	13.40 ^d	16.43 ^{cd}	3.07 ^{bc}	3.73 ^a
1500	13.13 ^d	14.97 ^d	3.23 ^{a-c}	3.60 ^{ab}
LSD 5%	4.53		0.60	

P_{≤0.05}^{*}; P_{≤0.01}^{**}

Walela et al. (2016) recorded that various plant growth retardants reduced plant height and it varied between 34-53 cm in faba bean. Previous studies have explained a more significant effect of PGRs in reducing vegetative growth or plant height in faba bean (El-Betagy et al, 1976; Field et al., 1989), lentil (Effendi, 1989) and bean (Ngatia, 2003). However, Turk et al. (2003) recorded that plant height was not affected by ethephon applications in lentil. Application timing can be shown different effects for plant height in faba bean and various legumes. Thus, Walela et al. (2016) noted that plant height reduced by PGRs applications in faba bean and effective of its in early growth stage is more than later applications pre flowering in faba bean.

Differences among the cultivars were not significant for first podding height in the first year (Table 2). First podding height of late maturing Histal (20.9 cm) in the second year was significantly higher than early maturing Luz de otono (16.2 cm). First podding height was significantly influenced by ethephon applications in both of the years and combined years. Increasing ethephon doses reduced the first podding height. Hence, in the first year differences between the 0 and 500 g ha⁻¹ ethephon applications were not significant for this trait. As the average of the years, the first podding height varied from 14.1 (1500 g ha⁻¹) to 23.0 cm (0 g ha⁻¹). Sözen and Karadavut (2016) recorded that first pod height was between 23.0-30.0 cm. This findings showed that first podding height varied according to ecological conditions, genotypes and growing techniques. The first podding height was not affected by years as in plant height. Statistical analysis exhibited a significant of cultivar ×

ethephon doses interaction for first podding height in the mean of years (Table 3).

First podding height of early flowering Luz de otono was significantly higher in unapplied (0 kg ha⁻¹) than other ethephon doses, but differences among the other ethephon applications were not significant (Table 3). However, value of first podding height of Histal cultivar obtained from 0 and 500 g ha⁻¹ ethephon applications was more than other applications.

Genotypic differences for branches per plant were not significant in both of the years and combined years (Table 2). However, branches per plant was significantly affected by ethephon doses in the second year and the combined years, but not in the first experimental year. The highest branches per plant was recorded in the application of 1000 and 1500 g ha⁻¹ while the lowest one was found in the control application (0 g ha⁻¹) in the second year and the combined years. Branches per plant was significantly affected by years. It increased due to low rainfall in the second year (3.46) compared to the first year (2.65). Thus, previous studies recorded that branches per plant may be affected by rainfall and ecological conditions (Pekşen et al., 2006; Etemadi et al., 2018). On the other hand, interaction between cultivar and ethephon application was significant for branches per plant in the combined years (Table 3). Branches per plant in Histal were more than Luz de otono in the high ethephon doses. Hayashi et al. (2001) reported that ethephon can be used to increase branching some crops. Field et al. (1989) reported that paclobutrazol slightly increased branches per plant in field bean. Thus, it can be said that the effect of PGRs may vary according to the species.

Table 4. The effects of cultivars and ethephon applications on pods per plant, seeds per plant, seed weight per plant in the faba bean

Treatments	Pods/plant			Seeds/plant			Seed weight/plant(g)		
	2019/20	2020/21	Mean	2019/20	2020/21	Mean	2019/20	2020/21	Mean
Cultivar									
Luz de otono	6.54 ^a	4.72	5.63 ^a	22.9 ^a	17.3	20.1 ^a	23.9 ^b	17.3	20.4
Histal	4.32 ^b	3.28	3.80 ^b	18.1 ^b	13.9	15.9 ^b	28.7 ^a	15.1	21.9
p.(cultivar)	0.0038 ^{**}	N.S.	0.0011 ^{**}	0.0272	N.S.	0.0137 [*]	0.0072 ^{**}	N.S.	N.S.
Doses g ha ⁻¹									
0	5.67	3.40 ^b	4.53	21.2	13.6 ^b	17.4	29.3	17.2	23.2
500	5.60	3.50 ^b	4.55	21.0	13.4 ^b	17.2	28.4	14.8	21.6
1000	5.03	4.35 ^{ab}	4.69	19.8	17.3 ^{ab}	18.5	22.8	16.2	19.5
1500	5.42	4.75 ^a	5.08	19.9	18.1 ^a	19.0	23.8	16.8	20.3
LSD %5	N.S.	1.04	N.S.	N.S.	3.85	N.S.	N.S.	N.S.	N.S.
Mean	5.43 ^a	4.00 ^b	4.72	20.5 ^a	15.6 ^b	18.0	26.1 ^a	16.2 ^b	21.1
p.(year)			0.0027 ^{**}			0.0077 ^{**}			0.0001 ^{**}
CV %	15.6	20.0	17.8	16.2	19.5	17.7	21.8	20.0	22.0

P<0.05^{*}; P<0.01^{**}Table 5. The effects of cultivars and ethephon applications on 100-seed weight (g) and seed yield (kg ha⁻¹) in the faba bean

Treatments	100-Seed Weight (g)			Seed Yield (kg ha ⁻¹)		
	2019/20	2020/21	Mean	2019/20	2020/21	Mean
Cultivar						
Luz de otono	125.0 ^b	115.6	120.3	2573 ^b	1773	2173 ^b
Histal	165.5 ^a	120.0	142.6	4137 ^a	1910	3023 ^a
p.(cultivar)	0.0001 ^{**}	N.S.	0.0001 ^{**}	0.0385 [*]	N.S.	0.0068
Doses g ha ⁻¹						
0	153.4 ^a	130.3 ^a	141.9 ^a	4491 ^a	2286 ^a	3388 ^a
500	149.8 ^a	121.8 ^b	135.8 ^b	3796 ^b	1851 ^b	2823 ^b
1000	144.7 ^b	111.2 ^c	127.9 ^c	3165 ^c	1635 ^b	2399 ^c
1500	133.1 ^c	107.1 ^c	120.1 ^d	1970 ^d	1594 ^b	1782 ^d
LSD %5	4.61	4.80	3.15	570	304	306
Mean	145.2 ^a	117.6 ^b	131.4	3355 ^a	1841 ^b	2598
p.(year)			0.0000 ^{**}			0.0008 ^{**}
CV %	2.52	3.24	2.85	13.5	13.1	13.9

P<0.05^{*}; P<0.01^{**}

The effects of cultivars and ethephon applications on pods per plant, seeds per plant and seed weight per plant of faba bean are given in Table 4.

Number of pods per plant in early maturing Luz de otona was significantly higher than late maturing Histal in the first year and the combined year, but not in the second year (Table 4). Pods per plant varied between 3.80-5.63 in mean of the year. Similarly to our findings, Etamadi et al. (2018) reported that early maturing varieties have high pods per plant. Musallam et al. (2004) revealed that pods per plant was 5.5 pod plant⁻¹ under rainfed conditions. Alan and Geren (2006) reported that pods per plant varied from 9.8 to 13.8 pod plant⁻¹. Significant differences for pods per plant were not observed among the ethephon applications in the first year and mean of the years (Table 4). However, there are significant differences among the ethephon applications only in the second year and pods per plant increased by increasing ethephon doses due to increasing branches per plant. Hence, differences between 0 and 500 g ha⁻¹ doses were not significant. The highest pods per plant was found in 1500 g ha⁻¹ (4.75) ethephon application while the lowest one was obtained from control application (3.40). Previous studies reported that the number of pods per plant reduced by ethephon application in faba bean (Ngatia et al., 2003), but it increased in kidney beans

(Sulistyono, 2000). Field et al. (1989) reported that applications of PGRs didn't affect on pods per plant in lentil, but paclobutrozol applicants increased pods per plant in faba bean. Pods per plant in 2021 (4.00) significantly decreased as compared with 2020 (5.43). These reason may be lower rainfall and higher temperature in flowering period of 2021. Similar opinions were reported in faba bean by Abdelmula and Abuanja, (2007), Etamadi et al. (2018) and Alharbi and Adhikari (2020).

The effects of cultivars and ethephon applications on seeds per plant of faba bean are given in Table 4. The effect of cultivar on seeds per plant was significant in 2019/2020 and mean of years, but not in 2020/2021 (Table 4). Seeds per plant was significantly greater in Luz de otono with 20.1 than Histal with 15.9 in the mean of the years. Ethephon applications affected grains per plant in 2020/2021, but not in 2019/2020 and combined years. Seeds per plant increased with increasing ethephon doses as in pods per plant in the only 2020/2021. The highest seeds per plant was obtained from ethephon application of 1500 g ha⁻¹ with 18.1 followed by 1000 g ha⁻¹ doses with 17.3 in 2020/2021. Seeds per plant was significantly higher in 2020 (20.5) than 2021 (15.6) depend on low rainfall and high temperature at generative stage of plant as in pods per plant.

Seed weight per plant was significantly affected by cultivars in 2019/2020 but not in 2020/2021 and the combined year (Table 4). Seeds weight per plant was greater in Histal (28.7 g) than Luz de otona (23.9 g) in the first year. Differences among the ethephon doses was no significant for seed weight per plant in both of the year and combined year. Seed weight varied from 19.5-23.2 g for the different ethophon doses in mean of the years. The seed weight per plant was statistically higher in 2020 due to pods per plant, seeds per plant than 2021 where low rainfed and high temperature in seed formation stage of plant. The seed weight per plant was 26.1 g in 2019/2020 and 16.2 g in 2020/2021. Musallam (2004) noted that faba bean is very susceptible to drought at pod development stage of plant growth.

The effects of cultivars and ethephon applications on 100- seed weight and seed yield of faba bean are given in Table 5.

Differences among the cultivars were significant for 100-grain in the 2020, but not in 2021 and the mean of year (Table 5). 100-grain weight of Histal (142.6 g) was significantly higher as compared with Luz de otono (120.3 g) in the mean of the year. Late maturing Histal had higher 100-grain weight despite its lower pods per plant and seeds per plant. Seed size increased when number of pod decreased in faba bean was reported by Sözen and Karadavut (2016) and Alan and Geren (2006). Kambal et al. (1969) who that there are negative correlation between seed weight and pod number, seeds per pod in faba bean. 100-seed weight was significantly affected by ethephon doses in both of the years and mean of the years and it decreased with the increasing ethephon doses. The highest 100-seed weight was obtained from 0 g ha⁻¹ doses with 141.9 g, while the lowest one was in 1500 g ha⁻¹ with 120.1 g in the mean of the years. Similar result was found by Güler (2009) who indicated that increasing ethephon doses generally caused to decreasing 100 weight in chickpea. 100-seed weight was significantly higher in the first year (145.2 g) compared to the second year (117.6 g) where low rainfed and high temperature as in other generative traits.

The seed yield was significantly affected by cultivars in 2020 and the mean of the years, but not in 2021 (Table 5). The seed yield was significantly greater in later maturing Histal (3023 kg ha⁻¹) than early maturing Luz de otono (2173 kg ha⁻¹) in the second year. 100- seeds weight of Histal was also higher than Luz de otono. Similar findings were recorded by Sözen and Karadavut (2016) who found that genotypes with high 100-seed weight have higher seed yield infaba bean. Musallam et al. (2004) also reported that positive correlation was found between seed yield and 100 seed weight.

Differences among the ethephon doses was significant for seed yield and the maximum seed yield was produced at control application (0 g ha⁻¹), while the lowest one was determined in level of 1500 g ha⁻¹ in both of the years and mean of the years. Increasing ethephon applications also reduced seed yield. Seed yield varied from 1782 to 3388 kg ha⁻¹ in the mean of the years. Hence, differences among the ethephon application except for control doses was not significant only in the second year. Güler (2009) reported that highest grain yield was obtained from ethephon application of 450 g/ha, but higher doses decreased grain yield in chickpea. Previous studies reported that seed yield

was not positively affected by ethephon or some plant growth applications in faba bean (Walela et al., 2016), lentil (Turk et al., 2003), bean (Ngatia et al., 2003). On the other hand paclobutrazol increased seed yield and yield components in field bean (*Vicia faba*), but paclobutrazol and triapenthenol did not affect seed yield in lens (Field et al., 1989). Some studies exhibited that effect of PGR on grain yield may varied according to plant species, application time and doses of PGR, environment and physiological conditions (Walela et al. 2016; Field et al. 1989). Seed yield was higher in 2019/2020 (3355 kg ha⁻¹) than 2020/2021 (1841 kg ha⁻¹) where low rainfed and high temperature at the generative growth as in yield compenents. Similarly to our results, Abdelmula and Abuanja (2007) reported that heath stress during floral development decreased the seed yield in faba bean. Walela et al. (2016) indicated that seed yield was positively affected by cool and wet spring conditions during pod-filling in faba bean. Similarly to our study, Ton et al (2021) reported that seed yield in local genotypes varied from 2320 kg ha⁻¹ to 3130 kg ha⁻¹ in the Mediterranean climate conditions.

Conclusions

Early maturing Luz de otono had higher pods per plant, grains per plant, but lower plant height, first podding height, 100- seed weight and seed yield than late maturing Histal in the mean of the years. There were no significant differences among the cultivars for branches per plant. As mean of the years, plant height, first podding height, 100-seed weight and seed yield significantly decreased with increasing ethephon doses, but branches per plant increased. However, pods per plant, seeds per plant and seed weight per plant were not affected by ethephon applications . The maximum seed yield was produced by control application (0 g ha⁻¹), while the lowest one was determined in ethephon level of 1500 g ha⁻¹ in both of the year, but differences among the ethephon applications except for control does were not significant only in the second year. Interaction of cultivar and ethephon application was significant for branches per plant and first podding height in the mean of the years, but not other traits. Seed yield was higher in the first year than the second year where low rainfed and high temperature.

As a results, ethephon applications at initiation of flower were not useful for seed production of faba bean. However, it will be suitable that other experiments can be conducted with lower application doses and time to reveal effect of ethephon on the faba bean.

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