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Araştırma Makalesi (Research Article)

Determination of Morphological and Phenological Properties of Faba Beans Grown in Eastern Mediterranean Region of Turkey

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Abstract

This study was conducted in the ecological conditions of Hatay/Turkey in 2009-2011 to determine some phenological and morphological characteristics of faba bean cultivation conducted in 52 fields in 10 districts within the boundaries of the district's faba bean genotypes. The study was to determine characteristics such as plant height, first pod height, number of pods per plant, pod length, pod seed number, hundred bean weight, grain yield, flowering time, first pod formation time, stomata number, stomata width, stoma length, stomata index and the number of epidermal cells. According to the location, results ranged between 178-212 cm plant height, first pod height of 23-30 cm, pod number of 23.6-32.1 units, 2.7-4.1 units of seed per pod, a hundred weights of 137-158 g, and 236.1-313.6 kg da^{-1}. To conclude, it was found that ecological factors had a significant effect on varieties and there were differences between plants' growth and development. It is understood that these obtained differences can be used for breeding studies and can be instructive specifically for persistence studies.

Keywords: Faba bean, genotype, location, property, yield

Türkiye'nin Doğu Akdeniz Bölgesi'nde Yetiştirilen Bakla Genotiplerinin Fenolojik ve Morfolojik Özelliklerinin İncelenmesi

Öz

Bu çalışma, Hatay iline bağlı yerel bakla yetiştiriciliğinin yapıldığı 10 adet ilçe ile bu ilçe sınırları içinde yer alan 52 adet tarladan alınan yerel bakla genotiplerinin bazı fenolojik ve morfolojik özelliklerini belirlemek amacıyla 2009-11 yılları arasında Hatay ekolojik koşullarında yürütülmüştür. Çalışmada bitki boyu, ilk bakla yüksekliği, bitkide bakla sayısı, bakla boyu, baklada tane sayısı, yüz tane ağırlığı (YTA), tane verimi, çiçeklenme süresi, ilk bakla bağlama süresi, stoma sayısı, stoma genişliği, stoma uzunluğu, stoma indeksi, epidermal hücre sayısı gibi özellikler belirlenmiştir. Lokasyonlara göre bakla genotiplerinde bitki boyunun 178-212 cm, ilk bakla yüksekliğinin 23-30 cm, bakla sayısının 23.6-32.1 adet, baklada tane sayısının 2.7-4.1 adet, yüz tane ağırlığının 137-158 g, 236.1-313.6 kgda^{-1} arasında değiştiği tespit edilmiştir. Sonuç olarak ekolojik faktörlerin çeşitlilik konusunda ciddi etkisinin olduğu ve bitkilerin büyüme ve gelişmelerinde farklılıkların olduğu tespit edilmiştir. Elde edilen bu farklılıkların ıslah çalışmalarında kullanılabileceği ve özellikle dayanıklılık çalışmalarında bizlere yol gösterici olabileceği anlaşılmaktadır.

Anahtar Kelimeler: Bakla, genotip, lokasyon, özellik, verim

Introduction

The faba bean has an important place in nourishment. It is quite a significant legume for closing protein deficit (25-35%) because it has higher protein content than other legumes (Nachi and Guen 1996). Faba beans contain proteins that are close to animal protein. For this reason, its significance increases more and more (Çiftçi 2004). Faba beans in our country reached 8.533 hectares in cultivation area, 18.406 tons in production and 216 kg da^{-1} yield according to 2012 data (TUIK 2013).

Instability experiences for agriculture generally and the absence of registered seed

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that could reach sufficient levels have great roles in yield looseness and the failure to reach the desired level for the cultivation area (Karadavut et al. 2000; Pekşen et al. 2006).

The faba bean can be affected by environmental conditions and most of its florets that occur in the flowering period can be shed climatically (Bozoglu et al. 2002). It is stated that this ratio can reach over 80% in some cases (Gates et al. 1993). A large amount of lacking yield has been experienced because of these high quantities of shedding. Also, looseness of genetic influences negatively affects the success of studies that will be conducted about it (Lawes et al. 1983).

The faba bean is so responsive to environmental conditions that resistant strains should be developed to increase the yield of the beans and let them come into their own. Producers generally utilise seeds that they separate from the plants they grow during harvest instead of importing seeds. Thus, using seeds responsive to environmental conditions continues constantly. Determining genotypes that are less affected by ecologic factors than others among genotypes cultivated locally and supporting their cultivation have importance with regard to faba bean agriculture.

This study was conducted to determine locally cultivated faba bean genotypes' phenological and morphological properties by picking them from their cultivation areas within the ecological conditions of Hatay province. This study aims to cultivate new variation candidates that are compatible with ecology and have high yields by taking advantage of the parts that are seen as favourable among variations within local faba bean genotypes.

Materials and Methods

This study was conducted under Hatay ecological conditions between 2009 and 2011. Firstly, which faba beans were grown locally and the areas for taking samples were determined. The number of samples and sampled districts are given in Table 1.

Seed samples were taken from 52 fields situated within the borders of 10 counties where faba beans are grown locally in Hatay. This study was carried out on agricultural and situated in Topbogazı approximately 30 km from Hatay centre over two vegetation years.

This study was conducted as a Randomised Complete Block Design with three replications. The experiment area was ploughed before the seeds were sown and shaped so as to provide complete seed and soil contact.

Sowing was applied along lines that were opened by hand and seeds were sown in lengths of 5 m with four rows in each plot. 50 cm was determined as the space within rows and 20 cm for in-rows. Local faba bean genotypes were sown on November 17 in the first year and on November 15 in the second year. After sowing there was no irrigation but weeds were cleared once. In the meetings with producers it was found that farmers fertilised fields either not at all or too much during sowing.

Accordingly, 15 kg da^{-1} Di Ammonium Phosphate fertiliser was applied as nitrogen at the sowing time of seeds. When the experiment area was investigated in terms of climatic characteristics within cultivation periods for both years, there were no significant differences for climatic data between the years that the study was conducted and long years.

While average temperatures were 16.7 °C and 16.8 °C in the two years that the study was conducted, it was seen that average temperature was 16.2 °C for long years.

While total rainfalls for both years were 1156.3 and 1128.4 mm, respectively, this value was close to 1117.2 mm for the long year average.

Table 1. The number of samples and sampled districts
Çizelge 1. Örnek alınan ilçeler ve örnek sayıları

Number	The Names of Locations	The Number of Samples	Number	The Names of Locations	The Number of Samples
1	Antakya	6	6	Yayladağı	3
2	Serinyol	7	7	Samandağı	3
3	Kırıkhan	7	8	Dörtyol	4
4	Kumlu	4	9	Erzin	5
5	Reyhanlı	8	10	İskenderun	5

While values were 70.2% and 64.8%, respectively in terms of moisture, this value averaged 69.6% for long years. When the experiment area was investigated in terms of soil structure, it was determined that the soil has medium texture (2.2%) in terms of organic substance, pH: 7.6 and is slightly alkaline with non-salinity and rich in terms of potassium. Agronomic and phenological characteristics given in Table 2 were determinedin this study over two years.

Besides agronomic and phenological characteristics being found for faba bean genotypes, the leaves of plants were analysed and stomata number (mm^{-2}), stomata width (µm) and length (µm), stomata index (%) and epidermal cell number were also determined. We also attempted to establish whether leaf characteristics had an effect on the environmental exposure of plants or not (Meidner and Mansfield 1968).

MINITAB statistical software was used for the variance analysis of obtained data over two year's average. DUNCAN test was used for significant characteristics in the conclusion of variance analysis. Co-variance analysis was applied for these kinds of variances to minimise mistakes that can occur because of fluctuations in yield depending particularly upon plant number because of being a local plant.

Results and Discussions

Data belonging to characteristics that were examined for local faba beans are given in Table 3. In the conclusion of variance analysis, it was found that all characteristics belonging to faba bean genotypes were statistically significant.

When locations were compared in terms of flowering day numbers, while the flowering day number was the longest in Yayladagı and Samandagı, flowering finished in ashorter time in Kumlu, Reyhanlı, Dörtyol, Erzin and Iskenderun. Similar results on flowering were obtained in terms of the first sowing time.

While the first sowing was later in Yayladagı and Samandagı, values that were close to each other were obtained for other counties. The difference between them was not found significant statistically.

Maturity day number had a reverse situation to that of flowering and sowing. It was found that while local faba bean genotypes matured at the latest in Yayladagı and Samandagı, they matured at the earliest in Kumlu and Reyhanlı.

It can be understood that genotypes, particularly in Kumlu and Reyhanlı, started to mature fast because of the temperature. As the harvest time came closer, the temperatures got higher.

It is estimated that there was a delay stemming from the height in Yayladagı and Samandagı because they have higher altitudes than the other counties.

Table 2. The investigated agronomic, phenological and morphological features
Çizelge 2. İncelenen agronomik, fenolojik ve morfolojik özellikler

Agronomic Features	Phenological and Morphological Features	
Plant height (cm)	Flowering time (day)	The degree of pod slope at green period
First pod height (cm)	First pod formation time (day)	The degree of green colour per pod
Branches per plant (number)	The number of days to maturity (day)	Number of leaflets (number)
Number of pods per plant	The number of flowers in careme (number)	The sectional shape of longitudinal seed
Pod length (cm)	The number of caremes (number)	The colour of testa
Pod width (cm)	Flower width (cm)	The number of stomata (mm^{-2})
The number of seeds per pod	Melanin spots on the wing	Stoma width (µm)
100 seed weight (g)	Melanin spots on the flag leaf	Stoma length (µm)
Seed yield	The situation of anthocyanin in the flag leaf	Stoma index (%)
Biological yield	Number of pods in pod bunch (number)	The number of epidermal cells
Harvest index (%)		

Table 3. Some phenological and morphological features of faba bean plants
Çizelge 3. Bakla bitkilerine ait bazı fenolojik ve morfolojik özellikler

Number	The Names of Locations	The Number of Samples	Flowering Time (day)	First Pod Formation Time (day)	The Number of Days to Maturity (day)	Plant Height (cm)	First Pod Height (cm)	Branches Per Plant (number)	Number of Pods Per Plant
1	Antakya	6	123 b	147 b	228 bc	210 ab	24 b	5.3 b	28.3 b
2	Serinyol	7	123 b	145 b	228 bc	212 a	25 b	5.4 ab	30.5 a
3	Kırıkhan	7	121 bc	147 b	224 c	206 b	24 b	4.7 c	29.7 ab
4	Kumlu	4	120 c	144 b	223 cd	203 bc	23 b	4.4 c	31.2 a
5	Reyhanlı	8	120 c	144 b	223cd	198 c	30 a	5.2 b	32.1 a
6	Yayladagı	3	126 a	158 a	237 a	178 e	24b	3.7 d	24.3 c
7	Samandagı	3	126 a	155 a	235 a	180 e	25 b	3.8 d	23.6 c
8	Dörtyol	4	120 c	146 b	230 b	195 c	24 b	5.3 b	27.1 b
9	Erzin	5	120 c	145 b	230 b	193 d	24 b	5.7 a	28.4 b
10	İskenderun	5	120 c	148 b	229 b	196 cd	23 b	5.2 b	27.5 b

Number	The Names of Locations	The Number of Samples	Pod Width (cm)	Pod Length (cm)	The Number of Seeds Per Pod	100 Seed Weight (g)	Seed Yield (kg-1)	Biological Yield kg-1	Harvest Index (%)
1	Antakya	6	2.7 a	11.7 b	3.8 a	152 b	312.4 a	684.3 ab	38.4 a
2	Serinyol	7	2.7 a	11.8 b	4.1 a	150 b	308.5 a	692.5 a	39.3 a
3	Kırıkhan	7	2.8 a	12.6 a	3.9 a	158 a	313.6 a	673.1 b	38.7 a
4	Kumlu	4	2.8 a	12.5 a	4.0 a	151 b	297.8 ab	680.1 b	37.4 a
5	Reyhanlı	8	2.6 a	12.7 a	4.0 a	149 b	296.5 ab	703.6 a	38.0 a
6	Yayladagı	3	2.1 b	10.3 c	2.8 c	137 c	247.9 c	612.4 c	33.1 b
7	Samandagı	3	2.0 b	10.6 c	2.7 c	140 c	236.1 d	596.2 c	34.7 b
8	Dörtyol	4	2.7 a	12.1 ab	3.6 ab	152 b	288.7 b	688.8 ab	40.6 a
9	Erzin	5	2.8 a	12.4 a	3.5 b	150 b	296.3 ab	679.3 b	40.7 a
10	İskenderun	5	2.8 a	11.9 b	3.8 a	154 ab	301.4 ab	690.2 ab	40.9 a

*, Significant at the 0.01, **; 0.05 significant at 0.05 probability level, ns no significant;
***, P<0.01 düzeyinde önemli, * P<0.05 düzeyinde önemli, ns önemli değil*

Table 3. continued
Çizelge 3'ün devamı

Number	The Names of Locations	Numbers of Flowers in Flower Bunches (number)	Flower Cluster Count (number)	Flower Height (cm)	Melanin Stainson the Wing	Melanin Stainson the Flag Leaf	Situation in the Flag Leaf Anthocyanin	Number of Beansin Bean Bundles (number)
1	Antakya	7,2 a	7,3 b	3,2 ab	Have	Have	Don't Have	2,2 a
2	Serinyol	7,1 a	7,1 bc	3,4 a	Have	Have	Have	2,4 a
3	Kırıkhan	6,0 b	6,8 bc	2,7 b	Have	Have	Have	2,5 a
4	Kumlu	5,9 b	6,8 bc	2,6 b	Have	Have	Have	2,5 a
5	Reyhanlı	6,1 b	7,0 bc	2,7 b	Have	Have	Have	2,4 a
6	Yayladagı	3,7 c	6,3 c	3,6 a	Have	Have	Don't Have	1,7 b
7	Samandagı	3,4 c	6,4 c	3,6 a	Have	Have	Don't Have	1,6 b
8	Dörtyol	6,2 b	7,6 b	3,0 b	Have	Have	Have	2,1 a
9	Erzin	6,0 b	8,1 a	2,9 b	Have	Have	Have	2,0 a
10	İskenderun	6,0 b	8,0 a	3,0 b	Have	Have	Have	2,2 a

Number	The Names of Locations	Green Pod Degree of Colour	Number of Leaflets (number)	Shape of Longitudinal Section of the Seed	Bean's Degree Tilt Green Period	Seed Crust Colour
1	Antakya	Green	7,1 a	Angular	Steep	Brown
2	Serinyol	Light Green	6,9 a	Angular	Steep	Brown
3	Kırıkhan	Light Green	5,5 c	Angular	Steep	Brown
4	Kumlu	Green	6,1 b	Angular	Light	Brown
5	Reyhanlı	Green	6,0 b	Angular	Light	Brown
6	Yayladagı	Dark Green	5,5 c	Angular	Light	Green
7	Samandagı	Dark Green	5,5 c	Angular	Light	Green
8	Dörtyol	Green	6,3 ab	Angular	Steep	Tile Red
9	Erzin	Green	6,3 ab	Angular	Light	Tile Red
10	İskenderun	Green	6,5 a	Angular	Light	Tile Red

*, Significant at the 0.01, **; 0.05 significant at 0.05 probability level, ns no significant;
***, P<0.01 düzeyinde önemli, * P<0.05 düzeyinde önemli, ns önemli değil*

While plant height as one of the observed morphological characteristics differentiated between 178 cm and 212 cm, it was observed that genotypes picked from Yayladagı and Samandagı had the shortest plant height. In addition, it was determined that faba bean genotypes picked from Antakya and Serinyol had the highest plant height. It was determined that first pod height values were at a level generally close to each other for observed faba beans and it was found that first pod height values changed between 23-30 cm (Table 3).

While faba bean genotypes picked only in Reyhanlı were seen to have higher first pod values than the other counties, it was not determined that there was any difference in first pod height values between genotypes picked from the other counties except Reyhanlı.

While faba bean genotypes picked from Erzin had the highest value with 5.7 in terms of branches per plant, the lowest value was obtained from genotypes picked from Yayladag with 3.7. While there was a small difference between Yayladag and Samandag genotypes, it was not found to be significant statistically.

Pod number per plant is one of the significant criteria to determine plant yield. Pod number per plant got higher values for faba bean genotypes picked from Reyhanlı (32.1) and Kumlu (31.2).

While pod number per plant for faba bean genotypes picked from Serinyol was ranked third with 30.5 average, it was not found to be different from Kumlu and Reyhanlı genotypes statistically. Yet the lowest pod number was obtained from Yayladag and Samandag genotypes with 23.6 and 24.3, respectively.

The difference was quite small between the counties where genotypes were picked in terms of pod width. While Samandag and Yayladag genotypes had shorter widths, the other counties' genotypes had long pod widths.

While the longest pod width was obtained from Kırıkhan, Kumlu, Erzin and Iskenderun genotypes at 2.8 cm, they were in the same group with the other genotypes statistically, because they had similar pod widths.

When genotypes were evaluated in terms of pod height, it was observed that there was little different variance from pod width. Pod height changed between 12.7-10.3 cm. Seed number per pod - one of the significant criteria that affects yield - had the highest value for Serinyol genotypes at 4.1. However, there were no significant differences between Antakya, Kırıkhan, Kumlu, Reyhanlı and Iskenderun genotypes statistically.

The lowest seed number per pod was obtained from Samandag and Yayladag faba bean genotypes at 2.7 and 2.8, respectively. Hundred seed weight is a significant criterion to determine yield. Thus, genotypes that have high hundred seed weight are regarded as having high yields. While genotypes picked from Serinyol gave the highest value (158 g) in terms of hundred seed weight, genotypes picked from Iskenderun (154 g) followed.

The lowest values were obtained from Yayladag (137 g.) and Samandag (140 g.) genotypes, respectively.

The variance between genotypes increased much in terms of seed yield. Seed yield changed between 236.1-313.6 kg da^{-1} and while genotypes picked from Kırıkhan gave the highest seed yield, Samandagı genotypes gave the lowest seed yield. This variance for seed yield is significant because it shows that plants can reveal their genotypic characteristics. Biological yield gives the number of shoots that the plant can develop.

It is stated that when biological yield is high, the plant is not much affected by ecological factors and benefits from nutrition elements sufficiently. Altitude restricted biological yield for Yayladag and Samandag genotypes.

Accordingly, few differences were seen in terms of evaluated harvest index except Yayladag and Samandag genotypes. Stoma characteristics per leaf were analysed by taking the leaves of picked local genotypes. Results are given in Table 4.

When Table 4 is analysed, it is seen that the leaves of local faba bean have close values to each other in terms of stoma number.

Stoma number changed between 89.73-99.62 mm^{-2}. Generally, Yayladag, Samandag, Erzin and Iskenderun genotypes had lower values than the other genotypes in terms of stoma number, and this difference was found significant statistically.

Table 4. Stomatal characteristics of the leaves of local genotypes
Çizelge 4. Yerel genotiplere ait yapraklardaki stomaların özellikleri

Number	The Names of Locations	The Number of Samples	Number of Stomata (mm^{-2})	Stoma Width (µm)	Stoma Length (µm)	Stoma Index (%)	The Number of Epidermal Cells
1	Antakya	6	98.15 a	15.67 b	21.33 a	12.99 a	657 a
2	Serinyol	7	96.27 a	17.48 a	22.17 a	12.71 a	661 a
3	Kırıkhan	7	98.54 a	16.19 b	21.58 a	13.02 a	658 a
4	Kumlu	4	95.84 ab	17.73 a	20.88 a	12.71 a	658 a
5	Reyhanlı	8	97.11 a	18.01 a	21.16 a	12.83 a	660 a
6	Yayladagı	3	90.50 b	13.65 c	17.56 b	12.88 a	612 b
7	Samandagı	3	89.73 b	13.97 c	17.91 b	12.84 a	609 b
8	Dörtyol	4	99.62 a	16.51 ab	22.38 a	11.95 a	651 a
9	Erzin	5	91.58 b	17.48 a	22.73 a	12.22 a	658 a
10	İskenderun	5	92.58 b	16.98 a	21.97 a	12.83 a	629 ab

*, Significant at the 0.01, **; 0.05 significant at 0.05 probability level, ns no significant;
***, P<0.01 düzeyinde önemli, * P<0.05 düzeyinde önemli, ns önemli değil*

Stoma amplitudes changed notwithstanding the number. While the lowest amplitude was obtained from Yayladag and Samandag genotypes, the highest stoma amplitudes were seen in Reyhanlı genotypes at 18.01 µm.

Stoma heights were found to be similar for all genotypes. The highest stoma height was obtained from Iskenderun genotypes at 22.73 µm. Yayladag genotypes gave the lowest stoma height at 17.56 µm, but stoma heights of Yayladag and Samandag were different from the other genotypes statistically.

Their stoma indices were found to be similar for all genotypes as distinct from the other stoma characteristics and this was found to be significant statistically.

It is estimated that this situation stems from the usage of other stoma characteristics while the stoma is being evaluated. Yet Yayladag and Samandag genotypes had lower numbers of epidermal cells than the other genotypes in terms of epidermal cell number. Even if the other counties' genotypes took different values, they were regarded as similar because they were in the same group statistically.

Pod number per plant is a characteristic related to yield. Thus, it is taken in consideration particularly by breeders. However, when pod number per plant increases, sometimes seed size can decrease (Lawess et al. 1983). In these situations seed yield can decrease (Peksen et al. 2006). Consequently, the balance should be kept at the good point. Karadavut et al. (1998) determined a significant variance for all characteristics analysed by them in their study carried out to determine the herbal characteristics of local genotypes that were picked from Antakya, Kırıkhan, Reyhanlı, Kumlu and Serinyol. Similar results were obtained by Stotdart (1986), Cabrera (1988), Lyad et al. (2004) and Peksen and Artık (2006).

Stoma number can differentiate considering plant species and variety even when they are taken from the same clone (Sophie et al. 2008). Thus, the differences of stoma numbers per plant should be seen as an expected characteristic, but when stoma numbers increase, plant tolerance or consistency with environmental factors decrease (Sophie et al. 2008). This is because stomas control everything related to plant water intake.

Almost all water loss occurs likewise via stomas. In addition, stomas are effective for all of the plant's photosynthesis, transpiration and photosynthetic activities (Sarwar et al. 2013). In this study, significant differences were found in all characteristics except the stoma index particularly for Yayladag and Samandag genotypes. Accordingly, it can be said that plants belonging to genotypes that were picked specifically from these regions are more resistant to environmental changes. This is because they took lower values both numerically and as height and width than the other genotypes. These values were found to be significant statistically.

Yield per plant is under the influence of many factors in terms of genetics. Each factor can increase plant yield just as it can decrease plant yield. In this study, the differences between genotypes should be seen as an indicator as to what extent genotypes have been affected by environmental factors. Kumari (1996) stated that faba beans have largely both phenotypic and genotypic variations in terms of analysed morphological characteristics. Toker

(2004) stated what factors affect faba beans and in conclusion said yield experience had the biggest positive or negative effect. Karadavut et al. (2011) stated phenotypic or genotypic effects for faba bean changed according to species. Peksen et al. (2006) emphasised that to investigate local genotypes' characteristics and fresh yields completely is quite important for developing a new variety. Because Hatay has different characteristics in terms of ecological factors, the differences between local genotypes are high (Karadavut et al. 1998).

Conclusions

Faba beans are edible legumes that are not very selective in terms of ecological conditions. Physical (rainfall, temperature, day length, topography and soil variety etc.), biological (pests and diseases), and socio-economic factors affect yield, quality and faba bean cultivation in Hatay (Woolley et al. 1991).

Significant characteristics that affect yields for faba beans show differences depending upon genetic and cultivation conditions (Sehirali 1980; Akcin 1988). The Hatay region has quite a long vegetation period when compared to other regions in terms of ecology and climatic factors. Thus local faba bean varieties increased. Many researchers stated that ecological factors increase varieties in their studies carried out in different regions (Ustun and Gulumser 1996; Karadavut et al. 1998; Madakbas et al. 2004; Sozen et al. 2012; Ekincialp and Sensoy 2013; Sozen et al. 2014).

Today, because of effective seed policies, lots of varieties particularly of foreign-origin have entered our country. At the same time, local varieties are developed with breeding studies. In the circumstances, yield has generally increased, but specifically local genotypes have disappeared fast. This is the negative side of this work, particularly because the breeding potential of local genotypes was not completely determined (Sozen 2006). In this study, wetried to determine the characteristics of local genotypes grown by producers under Hatay ecological conditions for years.

To conclude; it was found that ecological factors had a significant effect on varieties and there were differences between plants' growth and development. It is understood that these obtained differences can be used for breeding studies and can be instructive specifically for persistence studies. Producers who grow faba beans strictly do not apply disinfectants against diseases and pests because disinfectants are not economical. In addition, the defloration ratio was found to be about 35-40% from our observations. This shows us generally more successful selection can be applied about filled seed. Hatay has yields slight better than country-wide and shows that higher yields can be obtained with controlled cultivation because there is yield potential. This can be understood by the fact that it gives such yieldsfar better than in uncultivated conditions.

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