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DETERMINATION OF THE AGRICULTURAL CHARACTERISTICS OF THE POLE FRESH BEAN POPULATION IN GREENHOUSE

Seher Yıldız Madakbas[1,*], Meral Ergin[2] and Hüseyin Özcelik[2]

[1]University of Ahi Evran, Faculty of Agriculture, Horticulture Department, 40100, Kırşehir,Turkey; [2]Blacksea Agricultural Research Institute, Field Department, 55001, Samsun, Turkey
[*]Corresponding author's e.mail: seheryldz@yahoo.com

In this study, improvement of pole fresh bean populations gathered from the Middle Black Sea Region was attempted using pure-line selection method under greenhouse conditions. The aim was to regain the populations that have lost their distinctive typical properties through breeding and bring them into use of local farmers. Fresh pole bean populations collected from Çarşamba Plain of Middle-Black Sea region in 2003 were evaluated in terms of their agricultural characteristics under greenhouse conditions. In 2006 observation gardens were established in greenhouses; pre-yield and yield experiments were performed in the following 3 years (2007-2009). Eleven lines were selected according to UPOV criteria. In addition to best phenological and morphological traits being presented by Ç4-3, TK9-4 and TK43-4 lines in comparison to the control varieties; Ç4-3, TK43-4, L4 and TK50-3 lines outperformed the control varieties in terms of yield following stage I and stage II regional yield experiments on 11 lines between 2010-2011, and certain lines were selected to be candidates for certification.

Keywords: *Phaseolus vulgaris*, pure-line selection, phenological observations, morphological measurements, yield

INTRODUCTION

The genus *Phaseolus* consist of 230 varieties (Salk *et al*., 2008; Singh, 2005); the species of highest economical value in the genus is *Phaseolus vulgaris* L., which is cultivated commonly in the areas with mild and humid climates. Although beans originated from America and Asia, their seeds were easily adapted to the conditions in Turkey and widely cultivated (Ozdemir, 2002; Sozen, 2006). Turkey ranks 3rd worldwide after China and Indonesia in fresh bean production (603.653 tons/year) (FAO, 2009). Major fresh bean production occurs particularly in Middle Black Sea region. Bean serves as a valuable protein source and is consumed in Turkey as fresh (immature seeded pods), canned food, pickled and dried (mature seeds) (Salk *et al*., 2008; Sozen and Bozoglu, 2008).

Bean is an autogamous plant that can self-pollinate at a 99% rate (Madakbas *et al*., 2009). There are two types of growth in *Phaseolus vulgaris* L. species which are pole growth and dwarf growth. In dwarf beans, there are 3-10 joints in the main stalk which ends up with a bunch of flowers at maturity. However, in pole beans there are 11-35 joints in the main stalk which elongates by wrapping and show limitless growth (Guvenc and Gungor, 1996). Efforts for protection and determination of genetic varieties were initiated in the beginning of 19th century in many countries through preservation of the plant genetic resources. Although Turkey is rich with populations of local bean species adapted to various geographical and topological regions, preferential cultivation of high yielding imported foreign varieties by farmers caused subordination of our valuable and well adapted local varieties (Balkaya, 1999; Karagoz *et al*., 2010; Madakbas, 2006). Therefore, the aim of this study was to determine and develop pure lines from fresh bean populations to prevent genetic erosion by preserving local varieties.

MATERIALS AND METHODS

A population of 250 fresh pole beans was collected from Ladik, Terme, Carsamba and Tekkekoy towns located in Carsamba plain during 2002-03. An observation garden was established in 2004 and pure-line selection was applied to the population determined to be fresh bean according to UPOV (International Union for The Protection of New Varieties of Plants) criteria. Pre-yield experiments with 44 plants were conducted during 2006-07 by sowing plants each in separate lines. Yield experiment I (2008) and yield experiment II (2009) were performed three times on random blocks of plants using 11 lines (Ç4–3, TK43 -4, L4, TK50–3, T33, TK41-1, TK2, TK49–2, Ç9h–6, Ç36, TK9-4) and 2 varieties (Serra and SırıkAyşe). On April 15th 2008 and April 13th 2009, seeds were planted at 20 cm gaps (Plant gap (PG)) in 2m long parcels each containing 50cm interspaced rows. After seeding, 2 kg of CAN fertilizer was added. Harvesting was performed in 4 rounds between first week and the last week of July.

Characterization of lines was performed in accordance with UPOV criteria (Anonymous, 1982; Anonymous, 2001). All morphological measurements and pod characteristics

analysis were made using 10 plants per analysis. SAS (SAS Institute, Inc. Carry, NC, USA) statistics program was used in the estimation of data parameters and analysis of data in Table 3 and 4 was performed using randomized complete block design (SAS, 1998).

RESULTS AND DISCUSSION

***Phenological observations*:** Results of phenological observations are given in Table 1. Flower colors of greenhouse grown fresh pole bean lines and control varieties varied between white, light pink, pink, light lavender and light purple (Table 1). When 50% flowering time was evaluated, 45-50 days were regarded as early, 51-70 days as moderate and 71 days and over as late (Akdag and Duzdemir, 2001; Balkaya and Yanmaz, 2003; Duzdemir and Ece, 2010). Since in 2008-2009 the 50% flowering time of greenhouse grown fresh pole beans was 69-82 days, and were regarded as of the late group.

***Morphological measurements*:** One of the most in-tolerated properties of fresh bean, known as stringiness, has not been detected in any of the lines; nevertheless, beans of Serra variety were observed to be stringy. The following observations were made in 2008-2009; out of 11 lines and 2 varieties, only Ç4-3 and T33 lines and Serra variety have shown light green and green colored pods and spotting over pods. The lines and control varieties were only narrow elliptic in terms of pod flesh shape, light (Ç4-3, L4 and TK50-3) or moderate in terms of pod seed clarity and narrow long in terms of bract shape (Table 2). It was

Table 1. Phenological observations and flowers colours of greenhouse stick fresh bean lines (2008-2009)

Varieties	Duration of initial germination (day)		Duration of first flowering (day)		Duration of 50 % flowering (day)		Colour of flower	
	2008	2009	2008	2009	2008	2009	2008	2009
Ç4 – 3	13	11	78	70	82	74	Pink	Pink
TK43 -4	11	10	73	65	78	69	L.Purple	L.Purple
L4	10	11	71	70	76	75	L.Purple	L.Purple
TK50 – 3	10	10	72	69	76	73	L.Lavender	L.Lavender
Serra (CV)	10	11	74	70	78	74	L.Pink	L.Pink
T33	12	11	76	72	82	77	L.Purple	L.Purple
TK41 – 1	10	10	73	69	77	74	L.Purple	L.Purple
TK2	12	10	76	71	82	76	L.Purple	L.Purple
TK49 – 2	10	10	71	68	77	72	L.Purple	L.Purple
Ç9h – 6	12	10	76	70	82	75	White	white
Ç36	12	10	76	70	82	75	White	white
TK9 – 4	11	10	75	71	80	79	L.Purple	L.Purple
SırıkAyşe (CV)	11	11	75	72	80	79	L.Purple	L.Purple

T:Terme, Ç:Çarşamba, TK: Tekkeköy (Towns located in Çarşamba Lowland), CV: Control Variety, L:Light

Table 2. Pod characteristics of greenhouse stick fresh bean lines (2008-2009)

Varieties	Color of pod		Stringiness in pod		Spotting of pod		Flesh shape of pod		Clarity of seed in pod		Shape of bract	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Ç4 – 3	G	G	N	N	A-R	A-R	NE	NE	L	L	NL	NL
TK43 -4	LG	LG	N	N	N	N	NE	NE	M	M	NL	NL
L4	G	G	N	N	N	N	NE	NE	L	L	NL	NL
TK50 – 3	LG	LG	N	N	N	N	NE	NE	L	L	NL	NL
Serra (CV)	G	G	A	A	A-P	A-P	NE	NE	M	M	NL	NL
T33	G	G	N	N	A-R	A-R	NE	NE	M	M	NL	NL
TK41 - 1	G	G	N	N	N	N	NE	NE	M	M	NL	NL
TK2	G	G	N	N	N	N	NE	NE	M	M	NL	NL
TK49 - 2	G	G	N	N	N	N	NE	NE	M	M	NL	NL
Ç9h - 6	LG	LG	N	N	N	N	NE	NE	M	M	NL	NL
Ç36	LG	LG	N	N	N	N	NE	NE	M	M	NL	NL
TK9 - 4	LG	LG	N	N	N	N	NE	NE	M	M	NL	NL
SırıkAyşe (CV)	G	G	N	N	N	N	NE	NE	M	M	NL	NL

Ç:Çarşamba, T:Terme, TK:Tekkeköy (Towns located in Çarşamba Lowland), C: Control Variety, G:Green, LG:Light Green, A:Available, N:None, P:Purple, R:Red, L:Low, M:Moderate, NE:Narrow Eliptic, NL:Narrow Long

previously reported that 18-20°C is the optimum temperature for pod development and 15-20°C for pod growth in fresh bean. The growth slows down in temperatures below 10°C and above 27°C accompanied by increasing pod stringiness (Gil and De Ron, 1992; Singh, 1999; Bozoglu and Gulumser 2000, Kumar *et al*., 2006). Stringy quality of Serra variety as a control group was observed to be highly responsive to heat changes.

The measurements of pod length, pod width, pod flesh thickness, bract length and beak length in 2008 and 2009 along with their mean values are given in Table 3. According to the combined analysis of both years pod length of 11 lines and 2 control varieties was calculated to be between 12.17-16.61cm, pod width between 10.38 -15.89 mm, pod flesh thickness between 4.04-7.06 mm, bract length between 3.68-6.42 mm and beak length between 7.92-13.17mm. While the best performance in terms of pod length and beak length were displayed by Ç4-3 line in comparison with the Serra control variety, TK9-4 line had the highest pod width among both control varieties. Line Ç4-3 has shown the best pod flesh thickness in comparison with SırıkAyse control variety. Line TK43-4 has the longest bract among both control varieties. Furthermore, performance of both control varieties varied notably with regard to all analysed characteristics. Great differences are seen among varieties in terms of pod length, pod width and pod flesh thickness (Madakbas *et al*., 2004). Baggett and Kean (1992), Escribano *et al*. (1998) and Svetleva *et al*. (1992) established that pod length varied between 7.5- 28 cm among varieties. In the characterization studies of bean population collected from Turkey (Gulumser *et al*., 1998) obtained measurements of pod width ranging between 6-25 mm and of pod flesh thickness ranging between 4-9 mm. Singh and Urrea (1996) stressed the point that bract length and shape are important features in the identification of genotypes. Morphological measurements we have done on greenhouse grown fresh pole bean lines are consistent with the literature.

In a research aiming to determine the morphological properties of bean varieties grown in Çarsamba plain plant lengths were evaluated at the beginning of the flowering stage and during harvest. In previous studies, it was reported that pod length is the most outstanding quality among morphological characteristics of 33 bean varieties and it has a notable correlation with the number of seeds (*r:0,494*) (Duzdemir and Akdag, 2001; Madakbas *et al*., 2010). In a study on 121 local bean varieties collected from Spain and Portugal some pod based qualities such as pod length (cm), pod width (mm) and thickness of pod flesh (mm) were evaluated; while 4 varieties showed great adaptation to the various environmental conditions 51 of the varieties required specific conditions to produce adequate results (De Ron *et al*., 2004). It was observed that in addition to bract and beak lengths, the pod characteristics of the greenhouse grown fresh stick bean lines haven't shown any changes in 2008-09 and provided similar results unaffected by environmental factors.

***Yield data (kg/ha)*:** Yield evaluations have shown that TK50-3, L4, Ç4-3 performed best in 2008 with yields of 4306 kg/ha, 4153 kg/ha and 3690 kg/ha respectively. The lowest yield, 2323 kg/ha, was observed with SırıkAyse line. However, in 2009 TK 43-4 ranked first and Ç4-3 ranked second with yields of 6466 kg/ha and 6300 kg/ha respectively; Serra variety followed them with a yield of 5433 kg/ha. Similar to the 2008 results SırıkAyse variety has displayed the lowest performance in 2009 with 1666 kg/ha yield. In terms of yield from both years combined the top four yielders were Ç4-3(4995 kg/ha), TK43-4 (4705 kg/ha), L4 (4676 kg/ha) and T50-3 (4653 kg/ha) lines. The lowest yield (1995 kg/ha) was obtained from SırıkAyse variety (Table 4).

Although the seed output was regular in some lines in greenhouse, it was irregular in TK43-4, Ç4-3 and Serra variety in 2008 and Ç9h-6, Ç36, TK49-4 and SırıkAyşe variety in 2009 (Table 4). In this case, their flowering was negatively influenced and the yield was reduced. Our two year long observations on 11 lines and 2 varieties have shown that environmental factors did not have a significant influence on the morphological parameters. Climatic and edaphic factors aided us in our goal of selecting the lines that showed no variability in phenological observations, morphological measurements and yields of some lines during breeding and pure-line selection in greenhouse. Even though highly variable climatic factors significantly influence yields from field grown fresh bean, these varying climatic factors can be rendered effectless through greenhouse cultivation (Izguierdo and Hosfield, 1983; Lin and Binns, 1988; Anlarsal *et al*., 2000; Mekbib, 2003; Ceyhan, 2006; Papadopoulos *et al*., 2007; Asfaw *et al*., 2008). Yield from greenhouse cultivated genotypes was determined to be more susceptible to edaphic factors than climatic factors (Hussein *et al*., 2000). According to the yield values of every two years, Ç4-3, TK43-4, Ç9h-6, Ç36, TK9-4 lines and Serra, SırıkAyşe varieties were crucially influenced from edaphic factors in greenhouse.

Indoor cultivation is greatly preferred in Turkey since outdoor cultivation of pole beans in large areas are both laborious and costly. Therefore, indoor cultivation ensures longer market supply of pole bean products during times when no indoor cultivation of dwarf bean is carried out. Such continuous supply to market throughout the whole season is more profitable for the farmers. Therefore, development of new pole bean varieties especially from a rich source of local populations with good agricultural qualities and superior yield performances was considered as the only suitable approach in competing with high yielding foreign varieties available in the market. The results of this work were not only informative of the local pole bean

Table 3. Length of beak, bract and pod of greenhouse stick fresh beans lines (2008-2009)

Varieties	Length of pod (cm)			Width of pod (mm)			Thickness of pod flesh (mm)			Length of bract (mm)			Length of beak (mm)		
	2008	2009	Combined analysis	2008	2009	Combined analysis	2008	2009	Combined analysis	2008	2009	Combined analysis	2008	2009	Combined analysis
Ç4 – 3	15.21 b	15.38 b	15.30 b	13.08cd	12.09def	12.59d	6.08b	6.03b	6.06b	5.03 ı					
TK43 -4	12.32ef	13.21f	12.70f	12.47e	12.52cde	12.49d	5.70de	5.62d	5.66c	6.45a	6.39a	6.42a	9.73g	10.07g	9.90g
L4	12.78ef	12.62h	12.70f	13.32c	13.05cd	13.19c	5.43fg	5.27h	5.35e	5.55e	5.61c	5.58c	11.02e	10.84e	10.93e
TK50 - 3	12.78ef	13.42e	13.10e	13.89b	14.42b	14.06b	4.74h	4.60k	4.67h	6.27b	5.93b	6.10b	7.34k	9.35ı	
Serra (C)	16.69 a	16.53 a	16.61 a	13.05d	13.46bc	13.25c	5.26g	5.76c	5.51d	6.18c	5.91b	6.04b	13.18a	13.17a	13.17a
T33	14.10 d	14.24 c	14.17d	11.92 f	12.80 cd	12.36 d	3.93 j	4.16 l	4.04ı						
TK41 - 1	12.87e	13.05g	12.96ef	13.11 d	12.12 def	12.61 d	5.84 cd	5.46 f	5.65 c	5.09 h	5.16 e	5.13 ef	10.05 f	10.37f	10.21 f
TK2	12.30 ef	12.38 ı													
TK49 - 2	14.96 bc	13.48 e	14.08d	16.05 a	12.15 def	14.10 b	5.90 c	4.70 j	5.30 e	3.85 l	3.52 g	3.68 h	7.53 j	11.61 c	9.57 ı
Ç9h - 6	12.59 ef	12.23j	12.41g	11.93 f	11.15fg	11.54 ef	4.07 j	5.15 ı							
Ç36	12.28 f	12.05 k	12.17 g	10.75 g	11.27 fg	11.01 f	4.35 ı								
TK9 - 4	14.74 bc	14.24 c	14.49 c	16.15 a	15.64 a	15.89 a	5.60 ef	5.72 c	5.66 c	5.46 e	5.65 c	5.55 c	8.92 ı		
SırıkAyşe (C)	14.42 cd	14.15 d	14.28 cd	10.29 h	10.47 g	10.38 g	7.32 a	6.88 a	7.06 a	5.30 g	5.07 e	5.19 e	7.39 jk	9.67 h	8.53 k
% CV	2.96	2.90	2.93	5.20	5.23	5.21	6.40	6.42	6.41	2.57	2.42	2.49	9.50	9.90	9.70

* Means followed by the same letter are not significantly different at P<0.01, Ç:Çarşamba, T:Terme, TK: Tekkeköy (Towns located in Çarşamba Lowland), C: Control.

Table 4. Yield rates of greenhouse stick fresh beans lines (kg ha^{-1}) (2008-2009)

Greenhouse stick fresh bean lines and controlling varieties	Yield of 2008 (kg/ha)	Yield of 2009 (kg/ha)	Combined analysis of Yield of 2008-2009 (kg/ha)
Ç4 - 3	3690 a	6300 a	4995 a
TK43 -4	2943 abc	6466 a	4705 a
L4	4153 a	5200 abc	4676 a
TK50 - 3	4306 a	5000 abc	4653 a
Serra (CV)	3080 abc	5433 ab	4256 ab
T33	3876 ab	4566 abc	4221 ab
TK41 - 1	3803 abc	3766 bcd	3785 abc
TK2	2960 abc	3300 cde	3130 bcd
TK49 - 2	2560 bc	3533 bcde	3046 bcd
Ç9h - 6	3383 abc	2166 de	2771 cd
Ç36	3153 abc	2333 de	2743 cd
TK9 - 4	3160 abc	2233 de	2696 cd
SırıkAyşe (CV)	2323 c	1666 e	1995 d
Means	3337	3997	3667
%CV			8.5

* Means followed by the same letter are not significantly different at P<0.01

T:Terme, Ç:Çarşamba, TK: Tekkeköy, L:Ladik (Towns located in Çarşamba Lowland), CV: Control Variety

population but also beneficial in the development of new candidate lines to be selectively dispatched for certification in 2011 as standard varieties available for use by our farmers.

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