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Evaluation of Vegetable Cowpea (*Vigna unguiculata* (L.) Walp.) Breeding Lines for Cultivar Development

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ABSTRACT: This study was conducted to evaluate 12 advanced cowpea breeding lines developed from 27 local cowpea populations of Turkey using single plant selection based on some plant characteristics and fresh pod yield in comparison with Akkız-86 and Karagöz-86 control cultivars. Field experiments were arranged in randomized complete block design with three replications and conducted at Kurupelit and Ambarköprü locations of Samsun, Turkey in 2005 and 2006. According to combined results, L3 was the superior line for fresh pod yield by 18.0 t ha^{-1}. It was followed by L12, L13 lines and Karagöz-86 cultivar. Genotype x environment interaction was significant ($P<0.01$) for fresh pod yield. Stability analysis revealed that L3 line showed the best adaptation in optimal environmental conditions among all lines/cultivars. All cowpea lines/cultivars were found to be moderately adaptable to all environmental conditions with the exception of L3, L12, L1 and L9. Based on the two years study results, L3, L12 and L13 lines were recommended for the vegetable cowpea cultivation because of their crisp, slender, stringless and tasty pods. L3 and L13 lines were registered as the first vegetable cowpea cultivars in Turkey under the name of Pekşen and Reyhan, respectively, in April 15, 2011 by VRSCC (Variety Registration and Seed Certification Center, Turkey).

Keywords: Cowpea, cultivar development, fresh pod yield, *Vigna unguiculata*

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Sebze Börülce (*Vigna unguiculata* (L.) Walp.) Islah Hatlarının Çeşit Geliştirme Amacıyla Değerlendirilmesi

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ÖZET: Bu çalışma, Türkiye'nin 27 yerel börülce populasyonundan bazı bitkisel özellikleri ve taze meyve verimine dayanarak tek bitki seleksiyonu ile geliştirilen ileri börülce ıslah hatlarını Akkız-86 ve Karagöz-86 kontrol çeşitleri ile karşılaştırmalı olarak değerlendirmek amacıyla yürütülmüştür. Tarla denemeleri Şansa Bağlı Bloklar Deneme desenine göre üç tekrarlamalı olarak düzenlenmiş ve Samsun ilinin Kurupelit ve Ambarköprü lokasyonlarında 2005 ve 2006 yıllarında yürütülmüştür. Birleştirilmiş sonuçlara göre en üstün hat 18.0 t ha^{-1} taze verim ile L3 olarak bulunmuştur. Bunu L12 ve L13 hatları ile Karagöz-86 çeşidi izlemiştir. Taze meyve verimi bakımından genotip çevre interaksiyonu çok önemli ($P<0.01$) bulunmuştur. Stabilite analizi, tüm hat/çeşitler arasında L3 hattının optimum çevre şartlarında en iyi uyum gösterdiğini ortaya koymuştur. L3, L12, L1 ve L9 dışında kalan tüm börülce hat/çeşitleri tüm çevrelere orta derecede uyumlu olarak bulunmuştur. İki yıllık çalışma sonuçlarına dayanarak, L3, L12 ve L13 hatları gevrek, ince, kılçıksız ve lezzetli meyveleri nedeniyle sebze yetiştiriciliği için önerilmiştir. L3 ve L13 börülce hatları 15 Nisan 2011'de TTSM (Tohumluk Tescil ve Sertifikasyon Merkezi) tarafından Türkiye'nin ilk sebze börülce çeşitleri olarak sırasıyla Pekşen ve Reyhan adları ile tescil edilmiştir.

Anahtar kelimeler: Börülce, çeşit geliştirme, taze meyve verimi, *Vigna unguiculata*

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INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most important food legumes which serve as vital source of protein in the diet of the people of developing countries. It is widely grown in the third world for its cheap source of dietary protein (Ibrahim et al., 2010). Cowpea has considerable adaptation to high temperatures and drought compared to other crop species, but is intolerant of frost. Cowpea is usually better adapted to drought, high temperatures and other biotic stresses than other crop plant species (Ehlers and Hall, 1997; Kuykendall et al., 2000; Hall et al., 2002; Martins et al., 2003; Hall, 2004). It is primarily grown in drier regions of the world where it is one of the most drought-resistant food legumes (Dadson et al., 2005).

Some differences exist between vegetable cowpea and grain types for their vegetative characteristics, physiological characteristics and green pod yield (Gani et al., 2003). Generally, grain type cowpea varieties produce short pods with more number of seeds and mature early, while vegetable type varieties are grown for their immature long succulent pods with less number of seeds and maturing late and the pods remaining tender and soft for longer period. They are named as long bean, bodi, bora, sitao, snapea, snake pea and asparagus bean in different parts of the world (Umaharan et al., 1997; Pandey et al., 2006).

Cowpea planting area, production and seed yield of Turkey are 2032.3 ha, 2149 tons and 1060 kg ha^{-1} in 2011, respectively (TurkStat, 2012). It is mainly grown in Aegean and Mediterranean regions of the country. It is also grown by small-scale farmers just for their own requirements in Sinop and Kastamonu provinces, and some villages of Çarşamba district of Samsun at Black Sea region (Pekşen et al., 2000). Two types of cowpea are grown in Turkey including grain cowpea cultivated for dry seeds and vegetable cowpea cultivated for pods. In general, the fresh immature pods and seeds are consumed as vegetable. Samsun is one of leading cities of Turkey regarding sowing area and production of many vegetables (Turkstat, 2012).

There are some studies have been carried out on cowpea under Samsun conditions (Gülümser et al., 1989; Pekşen et al., 2000; Pekşen et al., 2002; Özturan and Gülümser, 2004; Pekşen, 2004; Pekşen and Artık, 2004; Pekşen et al., 2005; Pekşen, 2007; Bozoğlu and Pekşen, 2009). However, studies on vegetable cowpea are limited. It is necessary to develop specific cowpea genotypes for different environments and social conditions, with special focus on irrigated conditions (Santos et al., 2000). Vegetable cowpea genotypes currently grown in Turkey are in the form of population or landraces. Therefore, breeding studies on vegetable type cowpea has big importance.

This study was conducted to determine the most promising cowpea lines from cowpea breeding program regarding high fresh pod yield and to recommend them for registration as new cowpea cultivar/s, well adapted to Black Sea Region of Turkey as an alternative vegetable crop.

MATERIALS AND METHODS

Plant material

Vegetable cowpea breeding program was started in 1997 at The University of Ondokuz Mayıs, Faculty of Agriculture in Samsun, Turkey. This program has been continued up to 2008. Some promising cultivar candidates have been developed from local cowpea populations currently grown in Aegean and Mediterranean regions of Turkey by single plant selection method during this period. In this study, 12 cowpea lines that were come out of the 11 years vegetable cowpea breeding program and 2 released control cultivars, Akkız-86 and Karagöz-86, were evaluated for some plant characteristics and fresh pod yield. Flower, seed and pod characteristics of cowpea lines developed in the vegetable cowpea breeding program and registered control cultivars are given in Table 1.

Properties of experimental areas

Field experiments were conducted at the Research Station of Faculty of Agriculture, Ondokuz Mayıs University of Samsun (41° 17' N latitude, 36° 19' E longitude, 150 m asl) and Black Sea Agricultural Research Institute Ambarköprü Research Station (41°21' N latitude, 36° 15' E longitude, 4 m asl), Çarşamba, Turkey, in 2005 and 2006.

Table 1. Flower, seed and pod characteristics of advanced cowpea lines and registered cowpea cultivars used in the study

Cowpea lines/ cultivars	Seed coat color	Hilum color	Flower color		Pod color	Stringiness	Presence of anthocyanin	Pod shape	Tip shape of pod
			outer	inner					
1	Mustard	Black	Yellow	Purple	Dark green	-	-	Straight	Narrow-tipped
2	White	Brown	Yellow	Cream	Dark green	-	-	Straight	Narrow-tipped
3	Black	Black	Purple	Purple	Light green	-	Pod tip	Straight	Narrow-tipped
4	White	Brown	Yellow	Purple	Dark green	-	-	Straight	Blunt-ended
5	Mustard	Black	Yellow	Purple	Dark green	-	-	Straight	Blunt-ended
6	Cream	Brown	Yellow	Purple	Dark green	-	-	Straight	Narrow-tipped
7[a]	White	Black	Yellow	White	Dark green	+	Pod tip and whole pod	Straight	Blunt-ended
8[b]	White	Brown	Yellow	White	Dark green	+	-	Straight	Narrow-tipped
9	Mustard	Black	Yellow	Purple	Light green	+	Pod tip	Slightly curved / S shaped	Narrow-tipped
10	Black and white	Black	Yellow	Cream	Dark green	-	Pod tip and whole pod	Straight	Narrow-tipped
11	White	Brown	Yellow	Cream	Dark green	-	-	Straight	Blunt-ended
12	Black	Black	Purple	Purple	Light yellowish green	-	Pod tip and whole pod	Straight	Narrow-tipped
13	Black and white	Black	Yellow	Cream	Dark green	-	Pod tip and whole pod	Straight	Narrow-tipped
14	White	Brown	Yellow	Cream	Dark green	-	-	Straight	Narrow-tipped

[a] and [b]: Karagöz-86 and Akkız-86 cowpea cultivars were registered by Aegean University, Agricultural Faculty, Department of Field Crops

The soil of the Kurupelit experimental area had heavy clay texture, low levels of total salt and neutral reaction was low in calcium and potassium, moderate in organic matter and rich in phosphorus, while the soil of Ambarköprü experimental area had loamy texture, neutral reaction and low levels of total salt and was low in phosphorus and organic matter, moderate in calcium and potassium in both experiment years.

Meteorological conditions

During the field experiments from May to September, the average air temperatures were 21.4, 21.4 and 20.3°C in Kurupelit and 20.7, 20.4 and 20.3°C in Ambarköprü, in 2005, 2006 and long term (1974-2003), respectively. Total rainfall was 275.3, 180.5 and 212.2 mm in Kurupelit and 232.5, 262.5 and 212.2 mm in Ambarköprü for the same periods (Table 2).

Field trials

The experimental design was a randomized complete block design with three replications. Seeds were sown in rows 0.6 m apart with 0.1 m distance within the rows on 29 and 24 May in Kurupelit and 30 and 22 May in Ambarköprü in 2005 and 2006, respectively.

In all experiments, nitrogen and phosphorus as basal nutrients were applied at rate of 40 and 60 kg ha^{-1}, respectively. Weeds were controlled by hand-hoeing.

Table 2. Climatic data of the research locations in 2005, 2006 and long term (1974-2003)

Years	Months					Total/Mean
	May	Jun	Jul	Aug	Sep	
Çarşamba Ambarköprü Research Station						
Monthly total rainfall (mm)						
1974-2003	50.6	47.9	31.3	31.5	50.9	212.2
2005	44.2	37.4	12.6	0.8	137.5	232.5
2006	58.0	37.7	16.4	0.2	150.2	262.5
Monthly mean temperatures (°C)						
1974-2003	15.3	20.0	23.1	23.2	19.8	20.3
2005	15.7	19.3	23.4	24.8	20.4	20.7
2006	14.4	20.8	22.0	24.9	19.7	20.4
Samsun Kurupelit Research Station						
Monthly total rainfall (mm)						
1974–2003	50.6	47.9	31.3	31.5	50.9	212.2
2005	34.7	51.1	5.9	114.2	69.4	275.3
2006	69.0	36.3	9.0	-	66.2	180.5
Monthly mean temperatures (°C)						
1974–2003	15.5	20.0	23.1	23.2	19.8	20.3
2005	15.8	20.2	24.2	25.4	21.3	21.4
2006	14.6	21.3	23.7	26.5	20.9	21.4

All plots were irrigated during different plant growth stages including seedling emergence, prior to flowering, pod setting, pod development and after each fresh pod harvest to provide a good plant growth and more pod formation.

Days to first flowering (DFF) and first pod setting (DFP), plant height (PH), number of pods per plant (PN), pod length (PL) and fresh pod yield per plant (FPY) were determined. Randomly selected 10 plants from the two central rows of four rows existed in each plot were tagged at flowering stage to indicate plants will be harvested for fresh pods. Immature pods at the green mature stage were harvested three times in a week through a period of 8-11 weeks. Fresh weight of pods from the individual plants was determined immediately after each pod harvest.

Data analysis

Data combined over years were subjected to the ANOVA by using MSTATC statistical package. Means separation was carried out using the Duncan's multiple range test whenever F values determined for variables showed significance. Regression coefficients (bi) and deviations from regression (S^2d) were calculated as stability parameters (Eberhart and Russell, 1966) and scatter diagram was plotted taking green pod yield per plant along X axis and regression coefficient (b) on Y axis.

RESULTS

Cowpea lines/cultivars showed significant differences ($P<0.01$) for DFF varying between 52.42 days in Karagöz-86 and 64.25 days in L9 (Table 3). Early flowering genotypes were Karagöz-86, L12, L13, Akkız-86, L3 and L14. A significant interaction ($P<0.05$) was found between cowpea genotypes and locations for DFF. In both locations, L9, L5 and L1 were the latest flowering genotypes, while L12, L13 and L14 were the earliest flowering genotypes as much as Karagöz-86 and Akkız-86 cultivars (Table 3).

DFP of cowpea genotypes showed similar trend to DFF. Karagöz-86, L12, Akkız-86, L13, L3 and L14 had the shortest first pod setting. DFP determined in the rest of genotypes were 60 days or over. Both DFF and DFP were significantly longer ($P<0.01$) in Kurupelit than in Ambarköprü location. Interaction between genotypes and locations was significant regarding DFP ($P<0.01$) (Table 3).

There were significant differences among cowpea genotypes for PH. L2 and L3 lines were found to be the tallest genotypes, while L4 line and Akkız-86 cultivar were the shortest. PH determined as the mean of Ambarköprü was significantly longer ($P<0.01$) than that of Kurupelit location. There was a significant interaction ($P<0.01$) between genotypes and locations in terms of PH (Table 3).

Cowpea lines/cultivars also showed significant difference for PN. Karagöz-86, L12, Akkız-86, L13 and L2 produced significantly more pods than that of the others. PN was found between 10.82 and 19.92 pods $plant^{-1}$. There was significant interaction for PN between genotypes and location. Karagöz-86, L12 and L13 gave the high PN in both Ambarköprü and Kurupelit locations, while L2, L3, L6, Akkız-86 and L14 had high PN just in Ambarköprü. PN determined in Ambarköprü was significantly higher than in Kurupelit location (Table 3).

A significant difference ($P<0.01$) was found for PL among cowpea genotypes. L3 line had the longest pods among all genotypes. This was followed by L12, L13, L10, L5 and L9 lines in descending order. PL of the rest of the genotypes was ranged between 11.40 and 14.11 cm (Table 3). Interaction between genotypes and location regarding PL was significant ($P<0.05$). Mean of Ambarköprü location for PL was significantly longer ($P<0.05$) that of Kurupelit.

Significant differences ($P<0.01$) were found among cowpea genotypes and locations for FPY per hectare. FPY were ranged between 18.0 t ha^{-1} in L3 and 4.48 t ha^{-1} in L1 line. The superior line for FPY was L3 line. This was followed by L12, L13 line and Karagöz-86 cultivar. The highly significant interaction ($P<0.01$) was found between genotypes and location for FPY (Table 3).

Means of cowpea lines/cultivars for FPY (g $plant^{-1}$) over two years (2005 and 2006) and two locations, regression coefficients and deviations from regression are presented in Table 4.

Table 3. Means of cowpea lines/cultivars and locations (Ambarköprü and Kurupelit) combined over two years (2005 and 2006) for days to first flowering, days to first podding, plant height, number of pods per plant, pod length and fresh pod yield per hectare

Cowpea lines / cultivars	Locations								
	Ambarköprü	Kurupelit	Mean	Ambarköprü	Kurupelit	Mean	Ambarköprü	Kurupelit	Mean
	Days to first flowering (days)			Days to first podding (days)			Plant height (cm)		
1	61.67a-d*	63.50ab	62.58ab**	64.50a-f**	66.50a-d	65.50ab**	137.72a-d**	83.40fg	110.56cd**
2	58.67d-g	62.50abc	60.58bc	61.50f-j	65.50a-e	63.50bc	156.20a	122.57cd	139.38a
3	52.50jkl	57.00f-i	54.75efg	55.17mn	60.83h-k	58.00ef	161.68a	98.13ef	129.91ab
4	52.67jkl	61.33a-d	57.00de	58.67jkl	64.33b-g	61.50cd	116.93de	62.40g	89.67e
5	62.50abc	64.00a	63.25ab	65.33a-e	67.00abc	66.17a	140.00a-d	77.33fg	108.67cd
6	57.83e-h	61.00a-e	59.42cd	60.83h-k	63.83c-h	62.33c	116.80de	96.03ef	106.42cde
7[a]	51.17l	53.67i-l	52.42g	54.17n	57.67klm	55.92f	127.60bcd	77.08fg	102.34cde
8[b]	51.00l	56.33f-i	53.67fg	53.83n	60.17i-l	57.00f	125.45cd	66.13g	95.79de
9	64.17a	64.33a	64.25a	67.33ab	67.33ab	67.33a	152.63ab	79.70fg	116.17bc
10	54.00i-l	59.50c-f	56.75de	57.00lmn	63.00e-i	60.00de	137.90a-d	88.13fg	113.02cd
11	60.50b-e	64.50a	62.50ab	63.33d-i	67.67a	65.50ab	136.80a-d	78.52fg	107.66cde
12	51.67kl	55.00h-k	53.33fg	54.50n	58.67jkl	56.58f	128.43bcd	79.30fg	103.87cde
13	51.17l	55.83g-j	53.50fg	54.83mn	59.17jkl	57.00f	144.43abc	73.62fg	109.03cd
14	55.67g-j	57.00f-i	56.33ef	58.67jkl	61.17g-j	59.92de	126.98bcd	82.52fg	104.75cde
Mean	56.08b**	59.68a		59.26b**	63.06a		136.40a**	83.21b	
	Pod number (pods plant^{-1})			Pod length (cm)			Fresh pod yield (t ha^{-1})		
1	10.75e-h**	7.84gh	9.30e**	12.33h-k*	12.86g-j	12.59fgh**	5.28efg**	3.67g	4.48e**
2	20.97abc	12.13d-h	16.550a-d	13.03g-l	12.38h-k	12.70fg	10.73cde	5.36efg	8.05cde
3	15.58a-g	6.23h	10.90e	34.62a	31.66b	33.14a	27.28a	8.71c-g	18.00a
4	13.76c-h	12.03d-h	12.90de	12.75g-k	12.08h-k	12.41fgh	6.22d-g	4.85efg	5.54e
5	11.60d-h	11.50d-h	11.55de	14.56def	14.51def	14.53cd	6.15d-g	5.66d-g	5.90e
6	17.13a-f	10.67e-h	13.90cde	12.30h-k	11.99ıjk	12.15fgh	8.18c-g	4.42fg	6.30e
7[a]	21.70ab	18.13a-e	19.92a	13.84efg	13.46fgh	13.65def	11.45bcd	9.01c-g	10.23bcd
8[b]	22.78a	14.37b-g	18.575abc	11.45jk	11.35k	11.40h	9.64c-f	5.30efg	7.47cde
9	9.46fgh	12.18d-h	10.82e	14.00d-g	14.67def	14.34cde	4.80fg	6.16d-g	5.48e
10	11.29e-h	12.32d-h	11.80de	14.58def	14.48def	14.53cd	6.47c-g	6.20d-g	6.33e
11	12.87d-h	14.53b-g	13.70cde	14.05d-g	14.16d-g	14.11cde	6.71c-g	6.93c-g	6.82de
12	21.81ab	16.83a-f	19.32ab	17.90c	17.36c	17.63b	16.22 0b	11.35bcd	13.78b
13	19.52a-d	16.98a-f	18.25abc	15.33d	15.21de	15.27c	12.03bc	9.95c-f	10.99bc
14	17.30a-f	11.41e-h	14.35b-e	13.47fgh	12.87g-j	13.17efg	8.88c-g	5.20efg	7.04de
Mean	16.18a**	12.65b		15.30a*	14.93b		10.00a**	6.63b	

[a] Karagöz-86, [b] Akkız-86 cowpea cultivars, * significant at P<0.05 and ** significant at P<0.01 level

Table 4. Means of cowpea lines/cultivars for fresh pod yield per plant over two years (2005 and 2006) and two locations, regression coefficients and deviations from regression

Cowpea lines/ cultivars	Fresh pod yield (g plant^{-1})	Regression coefficients (b)	Deviations from regression (S^2d)
1	26.87	0.600	8.7
2	48.26	1.220	32.0
3	107.97	3.280	1182.7
4	33.21	0.590	16.5
5	35.42	0.500	29.7
6	37.79	0.840	17.5
7[a]	61.37	0.880	21.9
8[b]	44.82	1.050	16.6
9	32.85	0.290	118.7
10	37.99	0.610	83.0
11	40.94	0.490	146.6
12	82.68	1.630	8.4
13	65.93	1.210	120.4
14	42.24	0.810	21.3
Mean	49.88±18.13	1.000±0.59	

[a]Karagöz-86, [b]Akkız-86 cowpea cultivars

Scatter diagram for cowpea breeding lines/cultivars, based on both FPY and the regression coefficients, indicated that L3 was the best adapted line to optimum environmental conditions among all genotypes. Adaptability of L12 and L13 lines to the same conditions was found to be lower than that of L3. Except for L1, L3, L9 and L12, rest of the cowpea lines/cultivars showed moderate adaptation to all environmental conditions (Figure 1).

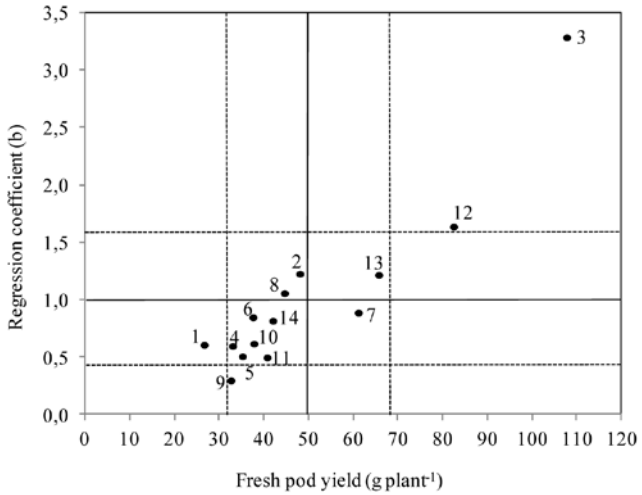

Figure 1. Scatter diagram for cowpea lines/cultivars based on fresh pod yield per plant (g plant^{-1}) and regression coefficient (b)

DISCUSSION

Two big productive alluvial plains, Bafra and Çarşamba, are situated at the mouth of the Kızılırmak and Yeşilırmak rivers in Samsun city of Black Sea Region of Turkey, respectively. Vegetable bean is the most widely cultivated and utilized vegetable legume in that agricultural areas and their production accounts for 23.4% of the total vegetable bean production of Turkey in 2011 (TurkStat, 2012).

It seems that vegetable bean will be the biggest competitor for vegetable cowpea when its planting was started in these two plains. In the recent years, adverse effects of the extreme weather conditions such as drought and heat stress on vegetable bean growth and pod yield have been more evident in both Ambarköprü and Kurupelit. High air temperature over 28°C during the flowering stage increases flower or pod abscission and decreases pod setting in dry and vegetable bean production. Ofir et al. (1993) informed that common bean plants exposed to high temperature of 32/27°C (day/night) for 5 d at anthesis, a reduction in pod and seed numbers occurred as a result of increased abscission of flower buds, flowers and young pods, and the failure of fertilization and seed development. In this case, cowpea may be a good alternative vegetable crop due to its drought tolerance that can make it more competitive when compared to vegetable bean and other crops under drought or heat stress conditions.

In vegetable cowpea production, growers tend to prefer climbing tall cultivars since they give higher fresh pod yield when compared to bush types. Farmers prefer green color, big and long size with tender and fibreless pods for home consumption (Pandey et al., 2006). Among genotypes used in the study, L3 line was also a climbing type and had light green, stringless and long pods up to 30 cm that hold fresh, unique appearance and delicate flavor even these pods were harvested at late pod maturity stage. L3 was better than L12 and L13 when marketable pod characteristics took into consideration. When the harvest is delayed in L12 and L13 lines, fresh pods become tough, fibrous, and over mature within a few days. Therefore, fresh pod harvest time of these lines has quite importance to avoid fibrous fresh pods problems. However, L12 and L13 can also be recommended for vegetable cowpea production in Samsun and coastal belt of Black Sea Region, Turkey, which has a temperate climate. It was found that PH was ranged between 62.80 and 120.90 cm among cowpea cultivars (Pekşen, 2004).

In order to select high yielding cowpea cultivars and to increase fresh pod yield, the pod harvest period, average pod weight and number of pods per plant should be taken into consideration (Pekşen, 2004). Similar results have been reported by Kutty et al. (2003).

The pod length is one of the major criteria to select better variety for its higher yield and preferable pod size. Longer pods are preferred by consumers since they have market appealing character. It is obvious that the longer pods produce more yield than short pods (Pandey et al., 2006). Pod number per plant is one of the most important yield components in vegetable cowpea. PN determined in the present study were in agreement with the findings of Pekşen (2004) stated that PN was varied between 13.41 and 29.57 pods plant^{-1}. Nwofia (2012) found higher PN, between 21.83 and 39.58 pods plant^{-1}, than that in the present study. Ombakho and Tyagi (1987) informed that seeds per pod, pods per plant and pod length would be the most useful components for selection in cowpea.

Although L3 line had the lowest PN, it produced the longest pods and the highest FPY per ha (Table 3). L12 and L13 were also promising lines for FPY. In previous studies, G10 genotype, L3 in the present study, had given the highest fresh pod yield per plant both in field trial (Pekşen, 2004) and in greenhouse (Pekşen et al., 2002). Karagöz-86 gave high FPY of 10.23 t ha^{-1}, but not suitable for fresh pod production since it had quite stringy pods and anthocyanin pigments intensively existed on whole fresh pods at early pod maturity stage (Table 1). FPY and PN have been found 4.50-9.57 t ha^{-1} and 11.38-16.57 pods plant^{-1} in vegetable cowpea by Nwofia (2012). In most of the dryland areas, cowpea yield is very low since it is generally grown in marginal land with little or no inputs (Pandey et al., 2006). L3 and L13 had priority to recommend for vegetable production due to its superior pod characteristics in Samsun and in coastal belt of Black Sea Region, Turkey, which has a temperate climate.

We have applied for registration of promising cowpea lines, L3 and L13, based on comparative study results conducted at Ambarköprü and Kurupelit locations in 2005 and 2006. Registration experiments were conducted at Samsun and Çayırova in field condition and under glasshouse conditions in Ankara during 2008-2010, by VRSCC (Variety Registration and Seed Certification Center, Turkey). L3 and L13 vegetable cowpea lines showed good performance again in registration trials for FPY in both these two diverse locations and also under glasshouse conditions. Locations were in different agro-ecological zone of Turkey and had diverse environmental conditions. Then, they were registered on April 15, 2011 as the first vegetable cultivars of Turkey under the name of Pekşen and Reyhan, respectively. Newly registered cultivars were recommended for cultivation both under glasshouse and open field conditions for all regions of Turkey which have similar environmental conditions to Samsun and Çayırova.

CONCLUSION

The results of the 2-year study demonstrated that L3, L12 and L13 cowpea lines exhibited good plant growth and high fresh pod yield performance. L3 was the superior line for fresh pod yield and it was followed by L12 and L13 lines. Genotype x environment interaction for fresh pod yield was found to be significant. L3 line showed the best adaptation to optimal environmental conditions among all lines/cultivars. Except for L3, L12, L1 and L9 lines, all vegetable cowpea lines/cultivars were found to be moderately adaptable to all environmental conditions. Results of the present study revealed that vegetable cowpea can be successfully cultivated in Black Sea Region as a vegetable crop like that in Aegean and Mediterranean. Therefore, it may be a good alternative vegetable crop for the vegetable growers of Black Sea Region of Turkey. There was no registered vegetable cowpea cultivars in Turkey till April 2011. Based on the cowpea breeding program and the present study results, L3 and L13 cowpea lines were registered as the first vegetable cultivars of Turkey under the name of Pekşen and Reyhan, respectively. Pekşen and Reyhan vegetable cowpea cultivars which gave considerable high fresh pod yield in both present study and registration trials can be recommended for vegetable growers in Black Sea Region and the other regions of Turkey that have similar environmental conditions.

Further comprehensive and comparative studies should be carried out to determine and also increase tolerance of these new vegetable cowpea cultivars and the other promising lines to drought conditions at different plant growth stages. Vegetable cowpea breeding program should be focused on selecting of genotypes have multiple resistances to the various pests and diseases.

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