Anadolu Tarım Bilimleri Dergisi

Anadolu Journal of Agricultural Sciences

http://dergipark.ulakbim.gov.tr/omuanajas

Araştırma/Research

Anadolu Tarım Bilim. Derg./Anadolu J Agr Sci, 30 (2015) 169-175
ISSN: 1308-8750 (Print) 1308-8769 (Online)
doi: 10.7161/anajas.2015.30.2.169-175

Determination of promising high yielded mungbean (*Vigna radiata* (L.) Wilczek) genotypes under Middle Black Sea Region of Turkey

Erkut Pekşen[a*], Cengiz Toker[b], Funda Öncü Ceylan[b], Tariq Aziz[a] Muhammad Farooq[c]

[a]*Ondokuz Mayıs University, Agricultural Faculty, Field Crops Department, Samsun, Turkey,* [b]*Akdeniz University, Agricultural Faculty, Field Crops Department, Antalya, Turkey,* [c]*University of Agriculture, Faculty of Agriculture, Department of Agronomy, Faisalabad, Pakistan*
*Sorumlu yazar/corresponding author: erkutp@omu.edu.tr

Geliş/Received 13/03/2015 Kabul/Accepted 20/07/2015

ABSTRACT

In this study, 20 mungbean (*Vigna radiata* (L.) Wilczek**)** genotypes were evaluated regarding their adaptation ability and cultivating possibility as a new crop for the legume farmers in Samsun, Middle Black Sea Region of Turkey. Three mungbean genotypes locally grown in Turkey and 17 exotic genotypes were used in the study. Field experiment was laid out in Randomized Complete Block Design with four replications. Mungbean genotypes exhibited significant differences for days to first flowering and pod setting, plant height, number and size of pods, number of seeds per pod, 100 seed weight, harvest index and seed yield. CN95 produced the highest seed yield (1120.51 kg ha^{-1}), followed by CD3 and Basanti (955.00 and 902.91 kg ha^{-1}, respectively). CN95 genotype has higher 100-seed weight (6.26 g) followed by KPS1 (6.20 g) and KPS2 (6.17 g). Days to first pod setting (r= 0.996**), number of racemes per plant (r= 0.677**), plant height (r= 0.851**), first pod height (r= 0.872**) and harvest index (r= -0.702**) strongly correlated with days to first flowering. There was negative association between pod number per plant and 100 seed weight (r= -0.551*). Harvest index showed positive correlation with seed yield (r= 0.603**). Root to shoot ratio and harvest index decreased with the increasing plant height. The study results were promising and gave some important evidences about mungbean cultivation might be a good alternative for legume farmers in both temperate coastal belt and inner drought prone locations of the Middle Black Sea Region, Turkey.

Keywords:
Adaptation
Evaluation
Genotypes
Mungbean
Vigna radiata
Yield

Türkiye'nin Orta Karadeniz Bölgesi koşullarında yüksek tohum verimi bakımından ümitvar maş fasulyesi (*Vigna radiata* (L.) Wilczek) genotiplerinin belirlenmesi

ÖZET

Bu çalışmada, 20 maş fasulyesi (*Vigna radiata* (L.) Wilczek**)** genotipi Türkiye'nin Orta Karadeniz Bölgesinde Samsun şartlarına adaptasyon yetenekleri ve yetiştirilebilme olanakları bakımından değerlendirilmiştir. Denemede Türkiye'de lokal olarak yetiştirilen 3 ve 17 yabancı kaynaklı maş fasulyesi genotipi kullanılmıştır. Tarla denemesi Şansa Bağlı Bloklar deneme desenine göre dört tekrarlamalı olarak kurulmuştur. Maş fasulyesi genotipleri ilk çiçeklenme ve ilk meyve tutumuna kadar geçen gün sayısı, bitki boyu, bakla sayısı ve boyutları, baklada tane sayısı, 100 tane ağırlığı, hasat indeksi ve tohum verimi bakımından önemli farklılıklar göstermiştir. En yüksek tohum verimi CN95 (1120.51 kg ha^{-1}) genotipinden elde edilmiş, bunu CD3 ve Basanti (sırasıyla 955.00 ve 902.91 kg ha^{-1}) genotipleri izlemiştir. 100 tane ağırlığı bakımından üstün genotipler CN95 (6.26 g), KPS1 (6.20 g) ve KPS2 (6.17 g) olarak belirlenmiştir. İlk bakla bağlama başlangıç süresi (r= 0.996**), bitki başına salkım sayısı (r= 0.677**), bitki boyu (r= 0.851**), ilk bakla yüksekliği (r= 0.872**) ve hasat indeksi (r= -0.702**) ilk çiçeklenmeye kadar geçen gün sayısı ile çok önemli ilişkiler göstermiştir. Bitkide bakla sayısı ve 100 tane ağırlığı (r=-0.551*) arasında negatif bir ilişki bulunmuştur. Hasat indeksi tohum verimi ile olumlu ilişki (r= 0.603**) göstermiştir. Kök/gövde oranı ve hasat indeksi artan bitki boyu ile azalmıştır. Çalışma sonuçları ümit verici bulunmuş ve maş fasulyesinin Türkiye'nin Orta Karadeniz Bölgesinin hem ılıman sahil kuşağı hem de kurağa eğilimli daha iç bölgelerindeki baklagil çiftçileri için bir seçenek olabileceği konusunda bazı önemli ipuçları vermiştir.

Anahtar Sözcükler:
Adaptasyon
Değerlendirme
Genotip
Maş fasulyesi
Vigna radiata
Verim

1. Introduction

In recent years, Turkish farmer's interest has reduced in conventional food legumes cultivation due to high cost of inputs like certified seed, chemical fertilizer, energy and low market prices of their products. In this situation, legume farmers show increasing interest in mungbean (*Vigna radiata* (L.) Wilczek) cultivation might be a new option for them. It's known for healthy and cheap source of protein in combination with essential amino acids particularly lysine, minerals and vitamins with calm digestion (Keatinge et al., 2011; Saini et al., 2010). Lysine is the first limiting amino acid involve in protein digestion but cereal based diet cause deficiency of certain essential amino acid particularly lysine (Amjad et al., 2003), however mungbean assure a good supplement (Baskaran et al., 2009), and considered as one of the good alternatives (Keatinge et al., 2011). Low phytic acid concentration is an extra advantage over others legume based diets otherwise iron and zinc bio-availabilities disrupt (Kataria et al., 1989).

Mungbean originated in South Asia having leading shares approximately 80% of the total produced but currently widely spreading in Africa, Australia and Latin America (Tomooka et al., 1992). Ninety percent of improved mungbean cultivars found in Pakistan and Thailand (Ali et al., 1997). It can be successfully cultivated even in the hot summer with dry environment (Sekhon, 2008). Mungbean has two planting windows due to integration of photo insensitive traits from wild genotypes (Pratap et al., 2014). Its short growth period allows adaptation in many cropping systems and easily adjusted in crop rotations, hence, diversifying cropping systems (Shanmugasundaram et al., 2009). Mungbean can adjustable in diverse cropping systems under rainfed and irrigated conditions it could not only increase small farmer's income but also improves soil fertility status. Keeping in view their short crop growing period, low cost of production and adaptability in a wide range of soil and climatic conditions, there is a magnanimous opportunity of growing mungbean across the seasons in different region (Pratap et al., 2013).

In Turkey, most commonly cultivated legumes are chickpea, lentil and beans. The area under legume cultivation in Turkey had reduced to 0.8 million ha, while it was reported 2.0 million ha in 1990 (TÜİK, 2013). This debauched situation inserts pressure on legumes import to narrow the demand-supply gap. The import of legumes had reached to 340000 ton which was only 2000 ton in 1988 (TÜİK, 2013). To minimize the possible dependence of mungbean import in future, it will be vital to cultivate mungbean in Turkey. Mungbean had adopted and acclimatized over wide range of agro-climatic zones of different countries. Determination of growth habit and synchronization of maturity and yield response are essential for introducing any new crop into a particular region. In the past, like many other food grain legumes, mungbean received very little research attention in Turkey. Some efforts were made in the past to grow mungbean as a green manure crop due its short growth duration (60 to 75 days) with high value of organic matter, narrow C:N ratio along with higher content of micro and macro elements (Algan and Çelen, 2011). Some studies were conducted in Turkey to evaluate the agronomic, morphologic and phenologic characters and broad sense heritability for yield and yield components in mungbean (Toker et al., 2002; Çancı and Toker, 2005; Çancı and Toker, 2014).

Present study was planned to collect and evaluate different mungbean genotypes in term of genotypic differences for yield characteristics, agronomic and adaptive features in Samsun, Middle Black Sea Region of Turkey. This study helps to the farmers in selection and cultivation of appropriate mungbean genotypes in Middle Black Sea Region.

2. Materials and Methods

The field experiment was conducted at Experimental Area of Field Crops Department, Faculty of Agriculture, Ondokuz Mayıs University, Samsun, Turkey (41.3 °N longitude, 36.3 °E altitude, 150 m above sea level) in 2010.

2.1. Seed collection

In this study, fresh and healthy seeds of mungbean (*Vigna radiata* (L.) Wilczek) genotypes were used which were procured from different countries. A field trail consist of 20 mungbean genotypes including 3 local genotypes from Turkey (Kilis, Gaziantep and Gazipaşa) and 17 exotic genotypes (ML613, ML267, Barimung-2, NIMB10, NIMB51, VB92, NM54, Basanti, VC396088, CD3, CN95, VC6153B6, VC6372, VC6173, KPS1, KPS2 and Pusa 9072) were collected and evaluated.

In 2010 , total rainfall during May, July, August and September were lower than that in the same period in long term (1960-2010) average except for June, while air temperature were slightly higher from May to September similar to the same period (Fig. 1). Therefore, irrigations were applied for 3 times to compensate rainfall water deficit due to low rainfall.

2.2. Soil analysis

Soil samples from the experimental site were collected randomly from 0-30 cm depth for chemical analysis according to the protocol described by Sahrawat et al. (2008). Soil pH was 6.18, $CaCO_3$ 0.48%, total salts 0.061%, P_2O_5 22.9 kg per ha, total nitrogen 0.11%, K_2O 570 kg per ha and organic matter was 3.17%. The soil type was heavy clay.

2.3. Experimental design and statistical analysis

Field experiment was arranged in Randomized Complete Block Design with four replications. The obtained data was statistically analyzed by using Fisher's analysis of variance (Steel et al., 1997) and treatment means were compared by using Duncan's multiple range test.

2.4. Planting geometry

Seeds were sown manually with the help of hand drill keeping distance 45x45 cm between rows, while plant to plant distance was maintained 5x5 cm by thinning after

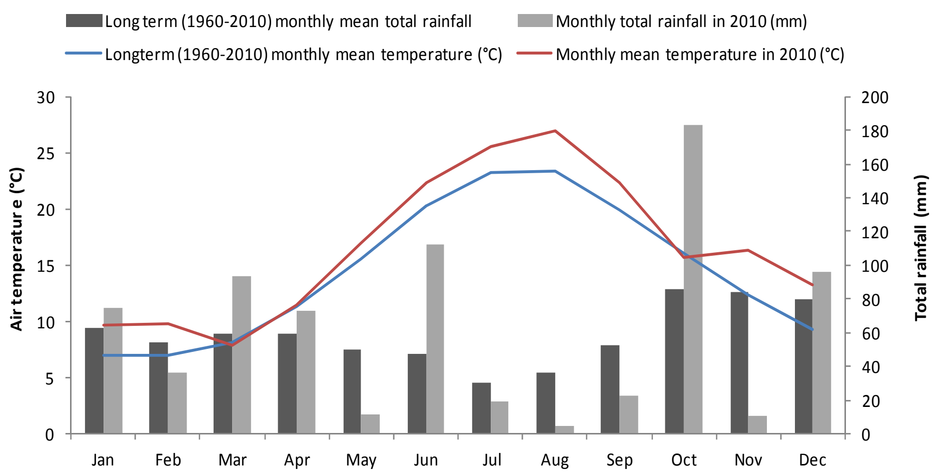

Figure 1. Monthly mean air temperature and total rainfall of the experimental site in 2010 and during the long term (1960-2010)

stand establishment. Every experimental unit was consisted of two rows having four meter length of each.

2.5. Plant protection

Weeds were removed manually through hoeing implements from each plot when the critically economic threshold level of weeds had reached. There was no insect attack during the whole growing season.

2.6. Observations

Days to emergence (DE), days to first flowering (DFF), days to first pod setting (DFPS), plant height (PH), first pod height (FPH), pods number per plant (PNP), number of racemes per plant (NRP), pod length (PL), pod width (PW), pod thickness (PT), seeds per pod (NSP), 100 seed weight (HSW), root to shoot ratio (RSR), seed yield per hectare (SY) and harvest index (HI) were determined in the study. Plants were harvested at maturity and 10 plants were randomly selected to measure PH, FPH and PL (cm) with the help of measuring scale, while number of pods per plant and PNP, NRP and NSP were counted. Following the harvesting and threshing seeds were weighed after sun drying to determine total yield on hectare basis.

3. Results and Discussion

Present study is the first research conducted on mungbean in Samsun, Turkey. This preliminary experiment indicated diversity among the genotypes in terms of days to emergence (7.75-9.25 days), days to first flowering (44.25-65.50 days), days to first pod setting (47.25-68.25 days) and number of racemes per plant (4.53-12.00 racemes) as shown in Table 1. The results indicated that minimum DE was observed 7.75 days in CN95 and KPS1, but were counted higher 9.25 days in ML267. The earliest genotypes for DFF were NM54 (44.25 days), VB92 (44.50 days) and VC6372 (44.75 days), while NM54 (47.25 days), VB92 (47.75 days) and VC6372 and VC396088 (48 days) were the earliest genotypes for DFPS. DFF exhibiting high broad sense heritability (88%) in mungbean (Çancı and Toker, 2005) were noted as 58.2 days and ranged from 46 to 69 days (Toker et al., 2002; Çancı and Toker, 2014). The mungbean genotype ML267 produced more racemes per plant (12.00 racemes) than that the produced by other genotypes. This was followed by Gazipaşa, Pusa9072 and Basanti (10.98, 10.20 and 9.80 racemes, respectively) genotypes (Table 1).

There were significant differences among mungbean genotypes regarding PH and FPH (Table 2). PH being genetically and environmentally controlled trait was measured higher in Gazipaşa (82.53 cm) followed by Kilis (72.08 cm), while minimum was noted in VC396088 (39.95 cm) (Table 2). Pusa9072 variety gave 66.33 cm mean plant height in the present study and it was higher than Pusa 9531 (49.2 cm) and Pusa Vishal (48.4 cm) which were cultivated in India and Taiwan (Singh et al., 2011).

FPH measured in Gazipaşa (49.33 cm) was the highest among all genotypes. This was followed by KPS2 (39.58 cm). The lowest FPH was measured in NM54 (15.75 cm) (Table 2). First pod height is important character for mechanical harvest and genotypes with high FPH are proper for mechanical harvesting than genotypes with low FPH.

Mungbean genotypes showed statistically significance differences for the PNP, PL, PW and PT (Table 2). PNP ranged between 28.43 in ML267 and 11.50 in Kilis produced the highest and the lowest PNP, respectively (Table 2). Mungbean genotypes examined in the present study produced less numbers of PNP than that in agro-climatic conditions of Pakistan ranged from 66.5 to 112.5 (Begum et al., 2012). These findings supported by Anwari and Soehendi (1999) and Rahman and Hussain (2003) that also investigating number of pods per plant on the bases on genotypic difference.

Gaziantep was in the first order in terms of NSP (12.58 seeds/pod), while VB92 (9.55 seeds/pod) was the last one. Gebeloğlu and Yazgan (1992a and 1992b) found pod number per plant and the number of seed per pod as

Table 1. Means of days to emergence, first flowering and first pod setting and number of racemes per plant of mungbean genotypes

Genotypes	Days to emergence (days)	Days to first flowering (days)	Days to first pod setting (days)	Number of racemes (racemes/plant)
Kilis	8.25ab**	54.25cd**	57.50cde**	6.53bcd**
Gaziantep	8.00ab	52.50cde	55.25c-f	5.95bcd
ML613	9.00ab	61.50ab	64.50ab	9.55a-d
ML267	9.25a	57.50bc	59.75bc	12.00a
Gazipaşa	8.75ab	65.50a	68.25a	10.98ab
Barimung-2	8.50ab	53.75cd	57.00cde	8.28a-d
NIMB101	8.00ab	60.75ab	64.25ab	7.50a-d
NIMB51	8.50ab	50.25def	53.50efg	6.90bcd
VB92	8.00ab	44.50f	47.75hı	6.80bcd
NM54	8.25ab	44.25f	47.25ı	6.83bcd
Basanti	8.50ab	55.50bcd	59.50bcd	9.80abc
VC396088	8.75ab	45.00f	48.50ghı	4.53d
CD3	9.00ab	56.50bcd	60.00bc	7.48a-d
CN95	7.75b	52.00cde	55.00c-f	7.70a-d
VC6153B6	8.25ab	46.50ef	49.50f-ı	6.10bcd
VC6372	8.75ab	44.75f	48.00ghı	6.50bcd
VC6173	9.00ab	46.50ef	49.50f-ı	5.18cd
KPS1	7.75b	50.25def	53.75d-g	8.03a-d
KPS2	8.25ab	57.75bc	60.00bc	7.38a-d
Pusa9072	8.75ab	55.75bcd	58.75b-e	10.20abc

** significant at 0.01 probability level

11.93-35.20 and 9.13-13.53, respectively.

Mungbean line VC6173 produced the longest pods (10.49 cm) followed by Gaziantep (10.31 cm), Kilis (10.16 cm) and NM54 (10.15 cm). Basanti (6.74 cm) had the shortest pods (Table 2). Zubair et al (2007) reported that PL ranged varied 6.35 and 8.41 cm among forty diverse mungbean genotypes evaluated for 14 quantitative traits. PL determined in all genotypes in the present study was higher than that reported PLs by Mansoor et al. (2010) ranging from 5.76 to 7.09 cm. This was might be due to efficient light interception and utilization, photosynthetic activity and environmental interaction.

Table 2. Means of plant height, the first pod height, pod number, pod length, pod width and pod thickness of mungbean genotypes

Genotypes	Plant height (cm)	First pod height (cm)	Pod number (pods/plant)	Pod length (cm)	Pod width (mm)	Pod thickness (cm)
Kilis	72.08ab**	33.78bcd**	11.50e*	10.16ab**	5.11abc**	4.76abc**
Gaziantep	44.96f	21.58c-f	12.50de	10.31ab	5.17ab	4.80abc
ML613	68.03abc	37.38abc	23.10a-d	8.35fg	4.58b-e	5.12abc
ML267	69.10abc	27.68b-f	28.43a	7.71ghı	4.11e	4.14c
Gazipaşa	82.53a	49.33a	23.28a-d	8.00fgh	4.82a-d	5.26abc
Barimung-2	68.73abc	32.35b-e	18.53a-e	7.11ıj	4.78a-e	6.22abc
NIMB101	63.25b-e	31.53b-f	16.88b-e	9.63bcd	4.44cde	7.14ab
NIMB51	49.58def	21.88c-f	23.92abc	8.59ef	4.39de	7.21ab
VB92	42.08f	19.13def	20.98a-e	8.14fgh	4.75a-e	6.49abc
NM54	46.03f	15.75f	20.18a-e	10.15ab	5.00a-d	7.59a
Basanti	65.80a-d	26.40b-f	25.98abc	6.74j	4.12e	4.09c
VC396088	39.95f	15.91f	16.43b-e	8.23fg	5.27a	5.10abc
CD3	56.70b-f	28.60b-f	23.58abc	7.38hıj	4.13e	4.50bc
CN95	54.43c-f	20.48def	24.88abc	9.98abc	4.64a-e	6.45abc
VC6153B6	50.33def	20.93def	16.70b-e	9.11de	4.73a-e	5.91abc
VC6372	50.45def	23.10c-f	20.00a-e	9.20cde	4.97a-d	5.34abc
VC6173	42.23f	16.80ef	18.03a-e	10.49a	4.95a-d	5.78abc
KPS1	47.65ef	22.53c-f	18.50a-e	9.57bcd	4.94a-d	6.14abc
KPS2	62.95b-e	39.58ab	15.15cde	9.76a-d	4.78a-e	6.02abc
Pusa9072	66.33a-d	28.93b-f	26.63ab	6.92j	4.11e	4.60bc

* and ** significant at 0.05 and 0.01 probability level, respectively

The highest 100-seed weight of 6.26 g was recorded in CN95 and this was followed by KPS1 and KPS2 genotypes with 6.20 and 6.17 g (Table 3). Akdağ (1995) found that 1000 seed weight of mungbean genotypes were between 35.04 and 38.32 g depending on sowing time. Mean HSW of 19 mungbean genotypes was 5.5 g and ranged from 3.1 to 8.6 g under Antalya conditions (Çancı and Toker, 2014). It was found that mungbean genotypes showed significant difference for HSW changing from 3.90 to 6.23 g (Gul et al., 2007).

Significant variation was found among mungbean genotypes for root to shoot ratio. RSR ranged from found 37.43% in VB92 to 18.55% in Pusa9072 (Table 3). Variation was found among mungbean genotypes in terms of RSR (Del Rosario et al., 1992; Amanullah and Hatam, 2000). Genotypes having higher root shoot ratio may be better to be able to cope against drought stress and may successfully cultivated in drought prone areas. VC396088, VB92 and CD3 gave the highest HI (41.15, 40.88 and 40.58%, respectively). The lowest HI was found in Pusa9072 by 16.85%. The cultivars with high grain yield and low biological yield produces higher harvest index. It means the increase of biological yield has beneficial for grain yield at certain limit (Ghafoor et al., 1993).

Mungbean genotypes having seed yield over 650 kg ha^{-1} were CN95, CD3, Basanti, VB92, VC6153B6, KPS1 and Gaziantep with the seed yield of 1120.5, 955.0, 902.9, 808.0, 771.4, 697.7 and 658.0 kg ha^{-1} (Fig. 2).

Table 3. Means of number of seeds per pod, 100 seed weight, root to shoot ratio and harvest index of mungbean genotypes

Genotypes	Number of seeds per pod (seeds/pod)	100 seed weight (g)	Root to shoot ratio (%)	Harvest index (%)
Kilis	12.30ab**	5.18cd**	25.95a-d*	29.03b-e**
Gaziantep	12.58a	5.59bc	23.38cd	36.03ab
ML613	11.70abc	4.08f	26.03a-d	21.20def
ML267	11.03a-e	3.13g	33.93abc	24.45c-f
Gazipaşa	11.93abc	4.48ef	27.08a-d	17.60f
Barimung-2	11.75abc	3.26g	26.80a-d	17.58f
NIMB101	10.83b-e	5.17cd	28.48a-d	21.98c-f
NIMB51	11.32a-d	4.14f	34.28abc	35.78ab
VB92	9.55e	4.66e	37.43a	40.88a
NM54	10.83b-e	5.85ab	22.78cd	38.30ab
Basanti	11.65a-d	3.16g	23.93bcd	29.23b-e
VC396088	10.00de	4.76de	33.58abc	41.15a
CD3	10.73b-e	3.27g	27.05a-d	40.58a
CN95	12.25ab	6.26a	30.65a-d	38.08ab
VC6153B6	9.98de	5.25cd	36.28ab	32.20abc
VC6372	11.03a-e	4.15f	34.83abc	30.65a-d
VC6173	10.78b-e	6.00ab	33.45abc	36.85ab
KPS1	11.23a-e	6.20a	34.38abc	37.00ab
KPS2	12.20ab	6.17a	31.40abc	19.18ef
Pusa9072	10.38cde	3.10g	18.55d	16.85f

* and ** significant at 0.05 and 0.01 probability level, respectively

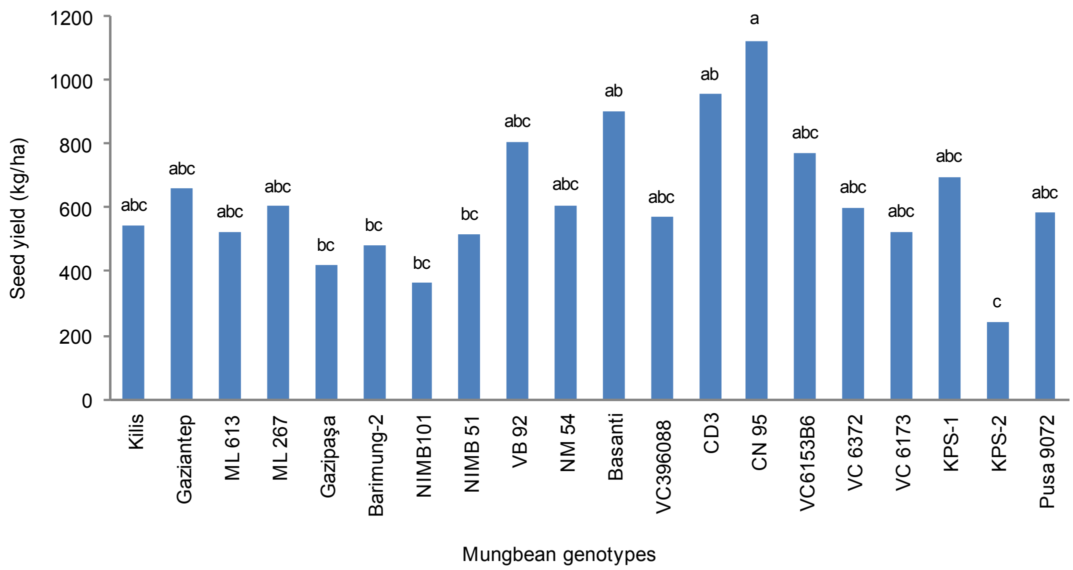

Figure 2. Seed yield of mungbean genotypes grown under Samsun condition (Means followed by different letters are significantly different at *P*<0.01)

The difference in response of mungbean genotypes to new environment might be due to variation ability to respond environmental factors differently. This suggests that some genotypes found favorable environment for their growth in agro-climatic condition of Samsun. Previous studies conducted in Adana and Tokat showed that seed yield of mungbean genotypes were ranged between 242.8-524.7 kg ha^{-1} (Şahin, 1986) and 377-1169 kg ha^{-1} (Gebeloğlu and Yazgan, 1992a). Begum et al. (2012) have also reported significant genotypic differences in grain yield ranged from 21.87 to 45.35 g per plant.

In the present study, fifteen quantitative characters were evaluated and correlations among those characters shown in Table 4. DFF strongly correlated with DFPS (r= 0.996**), NRP (r= 0.677**), PH (r= 0.851**) and FPH (r= 0.872**), but negatively correlated with HI (r= -0.702**). Positive and strong correlations were found between DFPS and NRP (r= 0.657**), PH (r= 0.850**) and FPH (r= 0.875**), while negative correlation existed with HI (r= -0.703**). Extending of time to the first flowering and first pod setting associated with significant increases in NRP, PH and FPH, and significant decrease in HI (Table 4).

Table 4. Correlations among investigated characters in 20 mungbean genotypes

	DFF	DFPS	NRP	PH	FPH	PNP	PL	PW	PT	NSP	HSW	RSR	HI	SY
DE	0.207	0.200	0.172	0.162	0.149	0.216	-0.203	-0.093	-0.401	-0.248	-0.417	-0.054	-0.148	-0.211
DFF	-	0.996**	0.677**	0.851**	0.872**	0.254	-0.344	-0.295	-0.211	0.396	-0.221	-0.427	-0.702**	-0.286
DFPS	-	-	0.657**	0.850**	0.875**	0.243	-0.358	-0.310	-0.202	0.386	-0.240	-0.442	-0.703**	-0.276
NRP	-	-	-	0.756**	0.575**	0.698**	-0.634**	-0.503*	-0.272	0.149	-0.473*	-0.287	-0.657**	-0.047
PH	-	-	-	-	0.885**	0.288	-0.405	-0.274	-0.271	0.359	-0.368	-0.449*	-0.827**	-0.294
FPH	-	-	-	-	-	0.085	-0.248	-0.297	-0.153	0.379	-0.195	-0.303	-0.797**	-0.467*
PNP	-	-	-	-	-	-	-0.703**	-0.555*	-0.114	-0.130	-0.551*	-0.095	-0.165	0.335
PL	-	-	-	-	-	-	-	0.465*	0.320	0.184	0.841**	0.221	0.358	-0.184
PW	-	-	-	-	-	-	-	-	-0.120	0.167	0.164	-0.317	0.364	-0.073
PT	-	-	-	-	-	-	-	-	-	-0.133	0.404	0.299	0.090	-0.248
NSP	-	-	-	-	-	-	-	-	-	-	0.229	-0.260	-0.229	-0.124
HSW	-	-	-	-	-	-	-	-	-	-	-	0.283	0.283	-0.094
RSR	-	-	-	-	-	-	-	-	-	-	-	-	0.385	0.047
HI	-	-	-	-	-	-	-	-	-	-	-	-	-	0.603**

* and ** significant at 0.05 and 0.01 probability level, respectively. DE: days to emergence, DFF: days to first flowering, DFPS: days to first pod setting, NRP: number of racemes per plant, PH: plant height, FPH: first pod height, PNP: pods number per plant, PL: pod length, PW: pod width, PT: pod thickness, NSP: seeds per pod, HSW: 100 seed weight, RSR: root to shoot ratio, HI: harvest index, SY: seed yield per hectare

NRP showed positive correlation with PNP, but negative correlation with pod dimensions such as PL (r=-0.634**) and PW (r=-0.503*). PL, PW and HSW decreased with the increasing competition among more pods bearing in plants due to increasing NRP and PNP. There was positive correlation between PL and HSW (r= 0.841**). PH showed positive correlation with FPH (r= 0.885**) and negative correlations with RSR (r= -0.449*) and HI (r= -0.827**). Increasing plant height caused significant decreases in RSR and HI (Table 4). Sharma and Gupta (1994) reported positive correlation between pod length and seed yield per plant. HI showed positive correlation with SY (r= 0.603**). Amanullah and Hatam (2000), and Amjan and Hassan (2002) reported positive correlation between SY and HI. Malik et al. (2008) also found positive correlation between SY and PH. Islam et al. (1999) reported genetic variability and found correlation between yield components in different mungbean genotypes.

4. Conclusion

Based on present study results, CN95, CD3, Basanti, VB 92, VC6153B6, KPS1 and Gaziantep were the promising genotypes regarding seed yield for Samsun condition. It could be concluded from the present study results and other unpublished data results conducted in both under rainfed and well watered (100% field capacity) conditions in Samsun, mungbean can be successfully grown in the Middle Black Sea Region of Turkey. Comprehensive and comparative researches should be conducted in both coastal belt and inner drought prone locations of the Middle Black Sea Region to get more detailed findings and to be able to recommend promising mungbean cultivars as a new crop option for legume farmers in those regions. Field experiments should be repated in different locations to obtain more detailed results.

References

Akdağ, C. 1995. Tokat şartlarında ekim zamanının maş fasulyesinin (*Vigna radiata* (L.) Wilczek) dane verimi ve diğer bazı özelliklere etkilerinin belirlenmesi. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, 12: 135-140.

Algan, N., Çelen, A.E. 2011. Evaluation of mungbean (*Vigna radiata* L.) as green manure in Aegean conditions in terms of soil nutrition under different sowing dates. African Journal of Agricultural Research, 6(7): 1744-1749.

Ali, M., Malik, I.A., Sabir, H.M., Ahmad B. 1997. The mungbean green revolution in Pakistan. Technical Bulletin No. 24. The World Vegetable Center (AVRDC). Shanhua, Taiwan, ROC. 66 p.

Amanullah, H.M., Hatam, M. 2000. Correlation between grain yield and agronomic parameters in mungbean *Vigna radiata* (L.) Wilcizk. Pakistan Journal of Biological Sciences, 3(8): 1242-1244.

Amjad, I., Khalil, I.A., Shah, H. 2003. Nutritional yield and amino acid profile of rice protein as influenced by nitrogen fertilizer. Sarhad Journal of Agriculture, 19: 127-134.

Amjan, S., Hassan, M.U. 2002. Association analysis for certain plant characteristics in some local and exotic strains of mungbean (*Vigna radiata* L.). Asian Journal of Plant Science, 1: 697-698.

Anwari, M., Soehendi, R. 1999. Improvement of component technology to increase legume and tuber plants productivity. Malang (Indonesia) Balitkabi, 12(1): 46-51.

Baskaran, L., Sundaramoorthy, P., Chidambaram, A., Ganesh, K.S. 2009. Growth and physiological activity of Greengram (*Vigna radiata* L.) under effluent stress. International Journal of Botany, 2(2): 107-114.

Begum, S., Noor, M., Hassan, G., Rahman, H.U., Durrishawar, Ullah, H., Jan, M. 2012. Genotypic association among yield and related attributes in mungbean genotypes. International Research Journal of Agricultural Science and Soil Science, 2(5): 188-193.

Çancı, H., Toker, C. 2005. Maş fasulyesinde [*Vigna radiata* (L.) Wilczek] verim ve verim kriterlerinin belirlenmesi için geniş anlamda kalıtım derecesi tahminleri. GAP IV. Tarım Kongresi, 21-23 Eylül 2005, Şanlıurfa.

Çancı, H., Toker C. 2014. Yield components in mungbean [*Vigna radiata* (L.) Wilczek] Turkish Journal of Field Crops, 9(2): 258-261.

Del Rosario, D.A., Ocampo, E.T.M. Sumague A.C., Paje, M.C.M. 1992. Adaptation of vegetable legumes to drought stress. In: Adaptation of food crops to temperature and water stress: Proceedings of an International Symposium. (C.G. Kue. ed). Asian Vegetable Research and Development Center. Publictaion No. 93-410. pp 360-371.

Gebeloğlu, N., Yazgan, A. 1992a. Mungo fasülyesi (*Vigna radiata* (L.) Wilczek)'in Tokat ekolojik koşullarına adaptasyonu üzerinde araştırmalar-II (Verim özellikleri). C.Ü. Tokat Ziraat Fakültesi Dergisi, 9(l): 76-85.

Gebeloğlu, N., Yazgan, A. 1992b. Mungo fasülyesi (*Vigna radiata* (L.) Wilczek)'in Tokat ekolojik koşullarına adaptasyonu üzerinde araştırmalar-I (Bitkisel özellikler). C.Ü. Tokat Ziraat Fakültesi Dergisi, 9 (l): 65-75.

Ghafoor, A., Zubair, M., Malik, B.A. 1993. Harvest index in mungbean. Pakistan Journal of Agricultural Research, 14(4): 309-313.

Gul, R., Ali, S., Khan, H., Nazia, Ali, F., Ali, I. 2007. Variability among mungbean (*Vigna radiata*) genotypes for yield and yield components grown in Peshawar Valley. Journal of Agricultural and Biological Science, 2(3): 6-9.

Islam, M.T., Haque, M.M. Islam, M.O. Malek, M.A. Hoque. M.E. 1999. Genetic variability, correlation and path analysis in mungbean (*Vigna radiata* L. Wilczek). Bangladesh J. Scient. Indus. Res., 34: 103-107.

Kataria, A., Chauhan, B.M., Punia, D. 1989. Antinutrients and protein digestibility (in vitro) of mungbean as affected by domestic processing and cooking. Food Chemistry, 32: 9-17.

Keatinge, J.D.H., Easdown, W.J., Yang, R.Y., Chadha, M.L., Shanmugasundaram, S. 2011. Overcoming chronic malnutrition in a future warming world: The key importance of mungbean and vegetable soybean. Euphytica, 180: 129-141.

Malik, M.F.A., Awan, S.I., Niaz, S. 2008. Comparative study of quantitative traits and association of yield and its components in black gram (*Vigna mungo*) genotypes. Asian Journal of Plant Sciences, 7: 26-29.

Mansoor, M., Khan, H., Ayaz, M., Zubair, M., Nadim, M.A. 2010. Effect of different planting densities on some physiological parameters of mungbean. Gomal University Journal of Research, 26(2): 1-8.

Pratap, A., Basu, P.S., Gupta, S., Malviya1, N., Rajan, N., Tomar, R., Madhavan, L., Nadarajan, N., Singh, N.P. 2014. Identification and characterization of sources for photo- and thermo-insensitivity in *Vigna* species. Plant Breeding, 133(6): 756-764.

Pratap, A., Gupta, D.S., Singh, B.B., Kumar, S. 2013. Development of super early genotypes in Mungbean [*Vigna radiata* (L.) Wilczek]. Legume Research, 36: 105-110.

Rahman, M., Hussain, M. 2003. Genetic variability, correlation and path analysis in mungbean. Asian Journal of Plant Science, 2(17): 1209-1211.

Sahrawat, K.L., Rego, T.J., Wani, S.P., Pardhasaradhi, G. 2008. Stretching soil sampling to watershed: Evaluation of soil-test parameters in a semi-arid tropical watershed. Communications in Soil Science and Plant Analysis, 39: 2950-2960.

Saini, M., Singh, S., Hussain, Z., Yadav, A. 2010. RAPD analysis in mungbean [*Vigna radiata* (L.) Wilczek]: I. Assessment of genetic diversity. Indian Journal of Biotechnology, 9: 137-146.

Sekhon, H.S. 2008. *Vigna* in cropping system. In: MC Kharkwal, editor. Proceedings of the fourth international food legumes research conference. New Delhi: Indian Society of Genetics and Plant Breeding, p. 675-682.

Shanmugasundaram, S., Keatinge, J.D.H., Hughes, J.A. 2009. The mungbean transformation: Diversifying crops, defeating malnutrition. pp. 381-406. In: Spielman, D.J. and Pandya-Lorch, R. (Eds.). Proven successes in Agricultural DevelopmentA technical compendium to Millions Fed, an IFPRI 2020 Book. International Food Policy Research Institute, Washington, D.C., USA.

Sharma, J.D., Gupta, V.P. 1994. Selection parameters in inter-specific derivatives of urbean and mungbean. Ind. J. Pulses Res., 7(2): 174-176.

Singh, G., Sekhon, H.S., Singh, G., Brar, J.S., Bains, T.S., Shanmugasundaram, S. 2011. Effect of plant density on the growth and yield of mungbean [*Vigna radiata* (L.) Wilczek] genotypes under different environments in India and Taiwan. International Journal of Agricultural Research, 1: 1-11.

Steel, R.G.D., Torrie J.H., Dickey, D.A. 1997. Principles and procedures of statistics: a biometric approach. 3rd Ed. McGraw Hill Book Co. Inc., New York. USA.

Şahin, H. 1986. Çukurova Koşullarında Maş Fasulyesinde (*Vigna radiata* L.) Altı Değişik Ekim Zamanının Bitkide Tane Verimi ve Bazı Tarımsal Karakterlere Etkilerinin Araştırılması. Ç.Ü. Fen Bilimleri Enstitüsü, Tarla Bitkileri Ana Bilim Dalı Yüksek Lisans Tezi, 43 s., Adana.

Toker, C., Çancı, H., HAQ, M.A., Çağırgan, M.I. 2002. Evaluation for agronomic, morphologic and phenologic characters of mung bean [*Vigna radiata* (L.) Wilczek] genotypes in the lowland of the West Mediteranean Region of Turkey. Turk. J. Field Crops, 7(2): 78-83.

Tomooka, N., Lairungreang, C., Nakeeraks, P., Egawa, Y., Thavarasook, C. 1992. Center of genetic diversity and dissemination pathways in mungbean deduced from seed protein electrophoresis. Theoretical and Applied Genetics, 83: 289-293

TÜİK, 2013. Agriculture Statistics of Turkey.

Zubair, M., Ajmal, S. U., Anwar, M., Haqqani, A.M. 2007. Multivariate analysis for quantitative traits in mungbean [*Vigna radiata* (L.) Wilczek]. Pak. J. Bot., 39(1): 103-113.