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Agro-morphlogical and Quality Characters in two Summer Legume Crops: Mung Bean [*Vigna radiata* (L.) Wilczek] and Guar [*Cyamopsis tetragonoloba* (L.) Taub] Genotypes Grown in Mediterranean Climate Conditions

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ABSTRACT

Background: The aim of the present study was to investigate the grain yield, some yield components and quality parameters of mung bean and guar genotypes as summer legumes in East of Mediterranean region of Turkey.

Methods: The field experiments were organized in randomized complete blocks design (RCBD) with three replications throughout 2016 and 2018.

Result: The greatest the grain yield of mung bean was achieved by genotype KPS1 (3141kg ha^{-1}) and lowest one was obtained from VC6153B6 (2344 kg ha^{-1}) in the average of years. According to the mean years, maximum grain yield of guar was produced by genotype 45 (2354 kg ha^{-1}), while the lowest grain yield was obtained from genotype 37 (1561 kg ha^{-1}). Ash, crude protein, ADF and NDF contents in mung bean genotypes varied beetwen 2.8 and 3.0%, 21.9 and 25.3%, 30.8 and 34.6% and 41.3 and 49.7% in the average of years, respectively. Guar genotypes contain 90.3 to 90.7 drymatter, 4.8 to 5.0% crude ash, 3.8 to 4.6% crude fat and 33.2 to 35.4% crude protein.

Key words: Grain yield, Guar, Mung bean, Quality.

INTRODUCTION

Mung bean (*Vigna radiata* L.) is a pulses crop orginated in Asia. It is widely grown in Asia, Africa, North America, and Australia (Singh *et al*. 2011). Mung bean seed has high protein, carbonhydrates, vitamin A and B (Gunathilake *et al*. 2016; Abdul Rahman, 2018). Grain of mung bean can be used as a food for human and feed for livestock and green manure at the world (Nair *et al*. 2021).

Cluster bean (*Cyamopsis tetragonoloba*) is known commonly guar. Guar or cluster bean is annual legume with tolerant to drought originated from Asia (Singla *et al*. 2016; Nandini *et al.* 2017). Guar is generally grown for grain and it has 40-45% of embryo, 14-16% of seed coat and 38-45% of endosperm in total seed (Gresta *et al*. 2016). Guar gum, which is polysaccharide (glactomannans) provided from seed of guar, is mainly used as a thickening and stabilizing in foods (Jukanti *et al*. 2015). It is used as a vegetable in human food, green manure, seed for human animal food, paper manufacturing and cosmetics (Mudgil *et al*. 2014). Yousif *et al*. (2017) reported that guar lines contain 10.53-11.83% fiber, 25.80-30.52% protein, 43.8-48.7% carbonhydrates.

Spreading mung bean and guar cultivation in Turkey is very important for their wider usage area and economical value. The studies on these crops are quite limited in Cukurova region. It is important to evaluate their different cultivars for production potential and nutritional quality. Cukurova region has a typical Mediterranean climate conditions. Therefore it can be possible to grow mung bean and guar during the spring- summer period in crop rotation.

The aim of present study was to investigate grain yield, yield components and quality parameters for some guar and mung bean genotypes

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MATERIALS AND METHODS

The field of study for mung bean and guar carried out in the Research Area of Field Crop Deparment, Faculty of Agriculture, University of Cukurova under irrigated conditions (Balcali) in Adana, Turkey, throughout 2016 and 2018. Adana province has typical Mediterranean climate conditions. Total precipitation is 625 mm and mean temperature is 18.7°C according to long-terms in Adana. The experiment soil was sandy-loam type textures. The values of pH and salt were 7.85 and 0.25 mmhos cm^{-1}, respectively.

The field experiment was conducted to randomized complete blocks design (RCBD) with three replications. In this experiment, 5 exotic mung bean genotypes [VC6153 (B6)-Taiwan, NM54-Taiwan, NIMB51- Bangladesh, KPS-1-Thailand and VC6173 (B6)-Taiwan] were used as plant material. These mung bean lines were provided from Field Crop Department, Faculty of Agriculture, University of Ondokuz Mayis. The plots were sown at rows of 4 m and 4 rows. The rows were spaced 45 cm apart and 5 cm plant to plant distance in rows. The experiment was established on 21 April 2016 in the first year and 18 April 2018 in the second year. Field emergences were recorded on 30 April 2016 and on 2 May 2018. The plots were harvested on 1 September 2016 and on 28 Agust 2018.

In this study, 5 guar lines [28 (Pakistan -12), 37 (India-17), 45 (India Guajerat population No. 5), 76 (India Guajerat population No. 30), 91 (India Guajerat population No. 50] were used as material. These guar lines were selected for seed-type from the guar populations at Field Crop Department, Faculty of Agriculture, University of Canakkale Onsekiz Mart. The field experiment was organized in randomized complete block design (RCBD) with three replications. Each plot was planted in rows of 4 m lenght and 4 rows with a spacing of 45 cm between rows. Plant to plant distance in row was 10 cm. The experiment for guar was established on 19 April 2016 and on 17 April 2018. Field emergences were recorded on 30 April 2016 and on 2 May 2018. The plots were harvested on 4 October 2016 and on 30 Agust 2018.

The fertilizer was applied a rate of 50 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} before sowing. 5 kg N ha^{-1} as ammonium nitrate (33% N) was also applied in seedling stage and the plots were watered 3 times during the summer in both of the experiment.

Plant height (cm), number of branches per plant, number of pods per plant, number of grains per pod and grain weight per plant (g) were recorded on five plants that were randomly selected from each plot. 1000grain weight (g), grain yield (kg ha^{-1}) and harvest index (%) were also measured. Nitrogen contents were determined by Kjeldahl method (AOAC, 2000). Crude protein, fat, dry matter, ash, ADF and NDF content (%) were also determined by methods (AOAC, 2000; Van Soest *et al.,* 1991).

The data for morphological and quality traits were analysed according to the RCBD over the years using the MSTAT-C data analysis software. Comparisons among the means were made using LSD multiple range test at 0.05 probability.

RESULTS AND DISCUSSION

Mung bean trial

The highest plant height was found for NIMB51 (71.3 cm), while the lowest value was recorded for NM54 (60.8 cm) in the mean of two years (Table 1). Peksen *et al*. (2015) reported that plant height varied from 39.95 to 72.08 cm. However, Canci and Toker (2014) found that plant height were between 19.5 and 91.0 cm. Plant height was higher in the first year due to greater rainfall and low temperature in the vegetative stage (May) as compared to the second year.

Pods per plant ranged between 16.4 and 23.6 as mean of years (Table 1). Pods per plant due to greater rainfall and temperature during the flowering stage (Early June - Early July) in 2016 was slightly lower than 2018. Similar results by Singh *et al*. (2011) were reported that pods per plant of mung bean genotypes was between 22.8 and 26.3 depending on plant densitity. However, various studies reported that pods per plant varied from 8 to 62 (Taj *et al*., 2003; Canci and Toker, 2014) depending on genotype and plant densitity. The highest value for grains per pod was obtained from NIMB51 (10.7), while the lowest one was with KPS1 (9.4) (Table 2). Grains per pod due to higher temperature and high rainfall in flowering stage in 2016 were

Table 1: Plant height and pods per plant in mung bean genotypes.

Genotype	Plant height (cm)			Pods per plant		
	2016	2018	Mean	2016	2018	Mean
VC615B6	76.5ab	59.2a	67.8a	12.8	25.5	19.2
KPS1	76.8ab	49.7b	63.2b	10.8	21.9	16.4
NIMB51	79.7a	62.9a	71.3a	15.7	31.5	23.6
VC6173	66.4c	59.1a	62.7b	16.7	21.3	19.0
NM54	72.0b	49.7b	60.8b	17.0	21.8	19.4
Mean	74.3a	56.1b	65.2	14.6	24.4	19.5
CV (%)	3.5	6.3	4.7	23.3	19.3	25.8
LSD (5%)	4.8	6.6	3.8	N.S.	N.S.	N.S.
LSD (5%) Genotype × Year			5.4			N.S.

Table 2: Grains per pod, 1000-grain weight and grain yield in mung bean genotypes.

Genotype	Grains per pod			1000-grain weight (g)			Grain yield (kg ha^{-1})		
	2016	2018	Mean	2016	2018	Mean	2016	2018	Mean
VC615B6	7.5	9.7b	8.6	55.7d	57.0b	56.3c	2093	2595b	2344c
KPS1	7.9	9.4b	8.7	76.2a	77.1a	76.6a	2467	3816a	3141a
NIMB51	8.1	10.7a	9.4	50.7d	52.7b	51.7c	2276	2997b	2636bc
VC6173	7.5	9.5b	8.5	69.2b	73.7a	71.4b	2621	3037b	2829ab
NM54	8.8	10.1ab	9.5	62.4c	70.9a	66.6b	2673	2796b	2735abc
Mean	8.0b	9.9a	8.9	62.8	66.3	64.5	2426b	3048a	2737
CV (%)	12.3	4.69	8.6	4.5	7.2	6.0	11.42	13.4	12.7
LSD (5%)	N.S.	0.87	N.S.	5.3	8.9	4.8	N.S.	76.8	426.0
LSD (5%) Genotype × Year			N.S.			N.S.			N.S.

lower than 2018 as in pods per plant. Similarly to our findings, some previous studies reported that grains per pod of the mung bean ranged from 9.3 to 12.0 (Ahmad *et al*. 2004; Peksen *et al*. 2015; Khan *et al*. 2017).

As the mean of years, maximum 1000-grain weight was determined in KPS1 (76.6 g), whereas the lowest value was with NIMB51 (51.7 g) (Table 2). Similarly to our study, Canci and Toker (2014) indicated that 100-grain weight varied from 3.1 to 8.6 g. However, 1000-grain weights obtained in this study were greater than values reported by some previous studies. Thus, Taj *et al.* (2003) found that 1000-grain was weight between 26.42 and 28.09 g. Khan *et al.* (2017) reported that 1000-grain weight of mung bean genotypes ranged from 42.60 to 55.60 g.

Grain yield varied from 2344 to 3141 kg ha^{-1} in the average of years (Table 2). The greatest grain yield was produced by genotype KPS1 and the lowest one was obtained from VC6153(B6) in 2018 and combined year. Previous studies showed that grain yield varied between 793.33 to 3120 kg ha^{-1} (Achakzai and Taran, 2011), 2022.2 to 3401 kg ha^{-1} (Khan *et al*., 2017) and 933 to 983 kg ha^{-1} (Ahmad *et al.* 2004). Grain yield is also often limited by temperature and rainfall distribution (Khan *et al*. 2017). Present study showed that the genotypes with high 1000-grain weight had higher grain yield capacity. Similarly to our finding, Nandini *et al.* (2017) indicated that the higher grain yield may be attributed to yield components such as pods number, 100-seed weight and grains per pod.

The highest value for crude protein was found by genotype VC6153B6 with 27.4%, 23.3% and 25.3% in 2016, 2018 and the average years, respectively (Table 3). The lowest value was obtained from NIMB51 with 22.9%, 21.0% and 21.9% in 2016, 2018 and combined years, respectively. Crude protein content in present study was similar to values of 24.52% recorded by Abdul Rahman (2018). However, it is explained in the previous studies that protein contents of mung bean varied from 24.0 to 28.0% (Adel *et al.* 1980).

Ash content varied between 2.6% and 3.4% in the average of two years (Table 3). Adel *et al.* (1980) reported that ash content varied from 3.37% to 4.05%. However, Gunathilake *et al*. (2016) point out higher ash content (3.96%) than the values obtained in the present study. Ash content indicates that grain provides essential minerals (Abdul Rahman, 2018).

As average of two years, genotypes were found to be significant for ADF content (Table 4). The highest value was achieved by genotype KPS1 (34.6%), followed by NIMB51 and VC6173, while NM54 had lowest value with 30.8% for ADF in combined years (Table 4).

NDF content ranged between 42.1-51.9% in 2018 and 41.3-49.7% in mean of the years (Table 4). The greatest NDF content was recorded in genotype NIMB51 and the lowest one was obtained from NM54 in 2018 and combined year. Nair *et al.* (2021) reported that ADF and NDF content of mung bean seed found between 18.3-33.4% and 24.5-45.0%, respectively. This trait was significantly affected by years. NDF content was lower in the first year compared with the second year.

Guar trial

The highest plant height was obtained from genotype 37 (110.1 cm), while the lowest one was found in genotype 91 (80.2 cm) in combined years (Table 4). Mahmood *et al*. (1988) reported that plant height was between 163.8 cm and 168.63 cm, but Khalid *et al*. (2017) indicated from 72.0 to 234.4 cm. This showed that plant height can vary according to the genotypes and environmental conditions.

Pods per plant varied from 39.6 (genotype 37) to 71.2 (genotype 28) in 2018 and from 32.2 (genotype 37) to 48.6 (genotype 91) in the average of years (Table 5). The pods per plant recorded in the second year were significantly higher the first year. The pods per plant in guar genotypes

Table 3: Crude protein and crude ash contents in mung bean genotypes.

Genotype	Crude protein (%)			Ash (%)		
	2016	2018	Mean	2016	2018	Mean
VC615B6	27.4a	23.3a	25.3a	3.0	3.8	3.4
KPS1	23.8a	21.2b	22.5cd	2.6	3.4	3.0
NIMB51	22.9c	21.0b	21.9d	3.0	3.2	3.1
VC6173	25.4ab	23.5a	24.5ab	2.9	2.2	2.6
NM54	23.9bc	23.5a	23.7bc	3.2	2.7	2.9
Mean	24.7a	22.5b	23.6	3.0	3.0	3.0
CV (%)	4.9	4.7	4.8	17.2	21.8	19.7
LSD (5%)	2.30	1.99	1.40	N.S.	N.S.	N.S.
LSD (5 %) Genotype × Year			N.S.			N.S.

Table 4: ADF and NDF contents in mung bean genotypes.

Genotype	ADF (%)			NDF (%)		
	2016	2018	Mean	2016	2018	Mean
VC615B6	31.2	31.1	31.1b	40.5	45.8bc	43.1b
KPS1	34.8	34.5	34.6a	42.4	47.0b	44.7b
NIMB51	33.5	34.7	34.1a	47.5	51.9a	49.7a
VC6173	33.2	30.4	31.8ab	40.4	42.8c	41.6b
NM54	31.5	30.2	30.8b	40.6	42.1c	41.3b
Mean	32.8	32.2	32.5	42.3b	45.9a	44.1
CV (%)	4.98	8.96	7.21	9.12	4.80	7.12
LSD (5%)	N.S.	N.S.	2.87	N.S.	4.15	3.84
LSD (5%) Genotype × Year			N.S.			N.S.

Table 5: Plant height and branches per plant in guar genotypes.

Genotype	Plant height (cm)			Pods per plant		
	2016	2018	Mean	2016	2018	Mean
28	88.3ab	102.8b	95.5b	23.9	71.2a	47.5ab
37	98.8a	121.5a	110.1a	24.8	39.6c	32.2c
45	85.1b	106.4b	95.8b	33.9	60.1ab	47.0ab
76	90.0ab	110.6b	100.3b	26.6	48.8bc	37.7bc
91	72.9c	87.5c	80.2c	35.2	62.0ab	48.6a
Mean	87.0	105.8	96.4	28.9b	56.3a	42.6
CV (%)	7.33	5.67	6.43	22.78	17.26	19.48
LSD (5%)	12.01	11.30	7.62	N.S.	18.31	10.16
LSD (5%) Genotype × Year			N.S.			14.37

Table 6: Grains per pod, 1000- grain weight and grain yield in guar genotypes.

Genotype	Grains per pod			1000-grain weight (g)			Grain yield (kg ha^{-1})		
	2016	2018	Mean	2016	2018	Mean	2016	2018	Mean
28	5.9b	7.6b	6.8b	33.6	37.2ab	35.3ab	1382a	2387b	1884bc
37	6.9a	8.5a	7.7a	33.8	38.0a	35.9a	895b	2225b	1561c
45	5.9b	8.0ab	6.9b	33.1	35.3bc	34.2bc	1645a	3063a	2354a
76	6.8a	8.5a	7.6a	31.8	34.6c	33.2c	1268a	2365b	1817bc
91	7.0a	7.9b	7.4a	30.5	31.5d	31.0d	1573a	2699ab	2137ab
Mean	6.5b	8.1a	7.3	32.0b	35.3a	33.9	1352b	2548a	1950
CV (%)	5.29	3.63	4.39	4.47	30.2	3.7	19.14	11.10	13.90
LSD (5%)	0.65	0.55	0.39	N.S.	0.19	1.5	487.5	532.5	331.8
LSD (5%) Genotype × Year				N.S.		N.S.			N.S.

are in agreement with the values recorded by Singla *et al.* (2016) (34.9-49.3 pods plant^{-1}). However, Mahmood *et al.* (1988) indicated in the range of 55.93-77.63 pods plant^{-1} for this trait. Grains per pod varied between 6.8 (genotype 28) and 7.7 (genotype 37) in combined years (Table 6). Genotype 37, 76 and 91 had higher grains per pod as compared to another genotypes in both of the years. However, the lowest value was obtained from genotype 28 in both of the years. Earlier studies revealed that grains per pod of guar genotypes varied from 5.2 to 11.4 (Khalid *et al.* 2017) and 3.7 to 4.4 (Singla *et al*. 2016). Higher temperature and rainfall during the flowering stage in June and July in the first experimental year may have decreased the grains per pod.

1000-grain weight varied from 31.5 to 38.0 g in 2018 and 31.0 to 35. 9 g in combined years (Table 6). The highest value was indicated from genotype 37, while the lowest one was obtained from genotype 91 in 2018 and combined years. Similarly results to our study, Ton and Anlarsal (2018) exhibited that 100-grain weight was ranging from 3.4 to 3.5 g. Mahmood *et al.* (1988) indicated that 1000-grain weight was ranging from 33.50 to 35.30 g. 1000-grain weight may decrease depending on higher temperature occured during the seed filling stage in July of 2016.

Grain yield varied from 1561 to 2354 kg/ha in combined year (Table 6). Genotype 45 had the highest grain yield followed by genotype 91, while the lowest grain yield was found for genotype 37 in both the years. Previous studies reported that grain yield was recorded between 1117-1162 kg ha^{-1} (Singla *et al*. 2016) and 1650-2065 kg ha^{-1} (Mahmood *et al.* 1988). However, some studies indicated that lower grain yield was obtained in guar. Thus, Ton and Anlarsal (2018) reported between 569-678 kg ha^{-1} and Nandini *et al.* (2017) exhibited between 524.50-743.89 kg ha^{-1}. It was shown that grain yield was might be due to different environmental conditions, genotypes and growing techniques. The grain yield may decrease depending on the higher temperature and rainfall during the flowering stage (June and July) in 2016 as in other yield components (Singla *et al*. 2016).

Dry matter was affected by genotypes in the first year, but not in the second year and combined years (Table 7). The effect of genotypes was not significant on crude ash in both of the years and combined years. According to combined years, dry matter and crude ash in guar ranged from 90.3% to 90.7 and 4.8 to 5.0%, respectively.

Table 7: Dry matter and crude ash in guar genotypes.

Genotype	Dry matter (%)			Crude ash (%)		
	2016	2018	Mean	2016	2018	Mean
28	90.3bc	90.6	90.5	4.9	5.0	4.9
37	90.0c	90.5	90.3	4.8	4.9	4.9
45	90.5ab	90.8	90.7	4.9	4.9	4.9
76	90.3bc	90.4	90.3	4.8	4.9	4.8
91	90.8a	90.5	90.7	5.1	4.9	5.0
Mean	90.4	90.6	90.5	4.9	4.9	4.9
CV (%)	0.27	0.38	0.33	3.51	1.56	0.89
LSD (5%)	0.45	N.S.	N.S.	N.S.	N.S.	N.S.
LSD (5%) Genotype × Year			N.S.			N.S.

Table 8: Crude fat and crude protein in guar genotypes.

Genotype	Crude fat (%)			Crude protein (%)		
	2016	2018	Mean	2016	2018	Mean
28	4.0bc	4.4	4.2ab	32.8	35.2	34.0
37	3.5c	4.1	3.8b	33.1	36.2	34.7
45	4.2abc	4.2	4.2ab	31.8	34.6	33.2
76	4.4ab	4.8	4.6a	34.3	35.3	34.8
91	4.8a	4.4	4.6a	35.8	34.7	35.3
Mean	4.2	4.4	4.3	33.6	35.2	34.4
CV (%)	9.54	8.79	9.16	4.58	3.38	4.00
LSD (5%)	0.74	N.S.	0.48	N.S.	N.S.	N.S.
LSD (5%) Genotype × Year			N.S.			N.S.

In the guar genotypes crude fat content ranged from 3.8% (genotype 37) to 4.6% (genotypes 76 and 91) and crude protein content was varied from 33.2% to 35.3% in the average years (Table 8). The effects of years and genotype × year interaction were not significant for crude fat and protein content. In this study, protein content was slightly higher than the values found by Nandini *et al.* (2017), who explained a range from 29.75% to 30.75%. The chemical composition contents obtained in the present study are slightly higher than the range of 25.80-30.52% protein, 1.93-2.47 oil, 8.37-8.80% moisture, 3.33-3.80% ash reported by Yousif *et al*. (2017). Sharma *et al*. (2017)

reported that maximum protein and ash content in guar genotypes were 26.78 and 5.29% respectively. The differences in the chemical composition may be affected by genetic factors and environmental conditions as in reported by Yousif *et al*. (2017).

CONCLUSION

The results of present study showed that mung bean genotypes KPS1, VC6173, NM54 and guar genotypes 45, 91 had a great grain production potential and high quality traits for growing in summer period under in the Mediterranean climate conditions. The mentioned promising genotypes should be tested in diverse environment of Mediterraenean region in Turkey. Further, the studies relation to growing techniques should be carried out in mentioned mung bean and guar genotypes. Another genotypes also should be tested in this region.

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