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INFLUENCE OF DIFFERENT NITROGEN LEVELS ON THE MORPHO-AGRONOMIC AND QUALITY TRAITS OF SOME MUNG BEAN [*VIGNA RADIATA* (L.) WILCZEK] GENOTYPES

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Abstract

The aim of the present study was to reveal the effects of different nitrogen levels on seed yield, yield components and some quality traits in various mung bean genotypes in Mediterranean climate conditions. The field experiment was conducted in the research area of the Department of Field Crops, Faculty of Agriculture, University of Cukurova in Turkey during two years in the growing seasons of 2019 and 2021. The experiment was arranged as three replications in the split blocks design based on the randomized complete blocks. Two local genotypes (Antalya 07 A 05, Gaziantep 27 S 08) and two registered cultivars (KPS1 and Jade AU) were used as research materials. Four nitrogen levels (0, 40, 80, 120 kg ha^{-1}) were applied. As the mean of the years, the maximum seed yield was obtained by KPS1 at 80 kg N ha^{-1} with 2492 kg ha^{-1} followed by KPS1 and Gaziantep at 40 kg N ha^{-1} with 2083 kg ha^{-1} and 1844 kg ha^{-1}, respectively. Swelling capacity and cooking time varied depending on genotypes and N doses between 0.070-0.087 ml seed^{-1} and 16.7-20.0 min., respectively. Mung bean genotypes at different nitrogen doses contained crude protein between 23.4% and 27.9%, moisture content between 9.8% and 12.8%, ash content between 2.83% and 3.89%.

Key words: Genotype, Mung bean, Nitrogen fertilization, Quality parameter, Seed yield.

Introduction

Mung bean (*Vigna radiata* (L.) Wilczek) has great importance as a legume crop for tropical and sub-tropical climatic conditions and its consumption is gradually increasing in the world. It orginates from India and is widely grown in the continents of Asia, Africa, Australia and America (Li *et al*., 2010; Arshad *et al*., 2020). Mung bean is a drought tolerant crop and can be successfully grown in marginal lands (Kaysha *et al*., 2020), but it has higher yield potential under irrigation conditions (Islam, 2007; Bhupendra *et al*., 2018; Khuit *et al*., 2020). Seed of mung bean has high amounts of protein and carbohydrates as well as digestible energy (Sen & Mandal, 2018; Arshad *et al*., 2020) and can be utilized for human diet, livestock feed (Khan *et al*., 2017; Lema *et al*., 2018) and be grown for quality forage (Akbay *et al*., 2020; Karaman *et al*., 2020). It can be also used as green manure and a vegetable (Nair *et al*., 2013; Kaysha *et al*., 2020). It is possible to grow mung bean during the spring-summer period in different regions of Turkey (Canci & Toker, 2014; Peksen *et al*., 2015; Karaman, 2019; Ton, 2021). Local genotypes of mung beans have been grown in Southern Anatolia of Turkey (Akdag, 1995; Toker *et al*., 2002; Dalkilic, 2010).

Nitrogen is essential for plant growth and development. Mung bean provides biological nitrogen fixation (BNF) throughout native rhizobia in soil and nitrogen fixation is affected by soil and environmental factors (Razzaque *et al*., 2015; Favero *et al*., 2021). Wild rhizobia and commercial strains are effective in fixing nitrogen in mung beans in Queensland (Christopher, 2016). Mung beans generally does not need nitrogen fertilization if plants form effective nodulation (Anon., 2021). There may not be enough native rhizobia population that is effective on mung beans in the soil. Therefore, seeds must be inoculated with rhizobial culture before seeding. Mung beans may also need additional nitrogen fertilization for growth and development in unsuitable environmental conditions. Earlier studies indicate that seed yield in mung beans could be increased by nitrogen fertilizer application (Razzaque *et al*., 2015; Kardoni & Fathi, 2018; Yin *et al*., 2018; Khuit *et al*., 2020). The need of nitrogen fertilizer may vary due to climate and soil conditions, crop management and genotypes (Azadi *et al*., 2013). It is important to evaluate various cultivars and to reveal the responses of the cultivars to nitrogen fertilization for seed production in regional conditions (Hussain *et al*., 2021). Cooking time in legumes can also be affected by nitrogen levels and genotypes (Coelho *et al*., 2009). Cooking time and hard seeds of legumes are important for the consumer as eating problems arise (Khattak & Bibi, 2007). Cooking time can vary depending on the seed size and thickness, chemical composition, and growing conditions in various legumes (Ercan *et al*., 1994; Dahiya *et al*., 2015; Ovacikli & Tolay, 2020). Studies on the effect of nitrogen doses in mung beans on cooking quality are limited in the world.

The aim of the present study was to reveal the effect of nitrogen application on seed yield, yield components and some quality traits in various mung bean genotypes when rhizobium inoculation was not applied in irrigated lands in Mediterranean climate conditions.

Material and Methods

Field experiment was carried out in the research area of the Department of Field Crops, Faculty of Agriculture, University of Cukurova during 2019 and 2021 in summer period under irrigation conditions in Adana of Turkey. Climatical data are given in Table 1. The texture of the research soil was silty-clay-loam. The values of pH, salt content, lime and organic matter were 7.25 and 0.25 mmhos cm^{-1}, 36.8%, 1.19 % respectively (Table 1).

Table 1. Some climatic values in the experiment years.

Meterological parameters	Min temperature (ºC)		Max temperature (ºC)		Mean temperature (ºC)		Relatively humidity (%)		Total rainfall (mm)	
Months/Years	2019	2021	2019	2021	2019	2021	2019	2021	2019	2021
May	11.8	14.9	39.4	34.0	24.1	23.9	57.6	64.9	2.6	4.1
June	18.7	18.9	37.5	37.7	27.1	25.9	68.7	67.2	13.8	0.4
July	21.6	23.8	36.3	41.0	28.4	30.0	68.8	68.0	28.0	15.8
August	22.9	22.7	39.6	39.8	29.6	30.5	68.0	64.1	0.0	1.2

In present study, 2 local genotypes (Antalya 07 A 05 and Gaziantep 27 S 08) and 1 exotic genotypes (Jade-AU Australia) provided from Field Crop Department, Faculty of Agriculture, University of Isparta Applied Sciences and 1 exotic genotypes (KPS1) provided from Field Crop Department, Faculty of Agriculture, University of Ondokuz Mayıs were used as a research material.

The experiment was laid out in split plot design based on randomized complete blocks replicated three times. The main plots were genotypes and sub-plots were nitrogen doses (0, 40, 80,120 kg N ha^{-1}). Each plot consisted of 5 rows of 4 m with 45 cm between rows and plant to plant distance in a row was 10 cm. The size of the plot was 9 m^2 (4 m x 2.25 m). Harvested area was 3 m x 1.35 m=4.05 m^2. Fertilizer was applied in a basal dose of 40 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} (di ammonium phosphate) before sowing to other plots except in control treatment (no nitrogen and 100 kg ha^{-1} P_2O_5- triple super phosphate). Additional N fertilizer (Ammonium sulfate- 21%) over the basal dose (40+0 kg N ha^{-1}, 40+40 kg N ha^{-1} and 40+80 kg N ha^{-1}) was also applied at seedling stage (4-6 leaves) to other plots except for control treatment. Rhizobia inoculant was not applied in the experiment and the plots were irrigated 4 times in the germination, flowering and pod stages in both of the experiment years.

The experiments were established on 24th of May 2019 and on 21st of May 2021. The plots were harvested on the 15th of August 2019 and on 31st of August 2021.

Plant height (cm), number of branches per plant, first podding height, number of seeds per plant, number of pods per plant, seed weight per plant (g) were measured on the individual five plants randomly selected from per plot. 100-seed weight was recorded from randomly selected samples of 100 seeds from each plot. Seed yield (kg ha^{-1}) was also estimated in total seed weight obtained from each plot. Seed samples were milled for analysis. Nitrogen contents were determined in milled samples by using Kjeldahl method (Anon., 2000). Crude protein (%) was calculated by using the formula CP=N%x6.25. Seed samples were dried 105ºC to determine for moisture content. Samples were incubated at 550ºC for crude ash analysis. Swelling capacity (ml seed^{-1}) and cooking time were found by the methods used by other workers (Williams *et al*., 1986; Gulumser *et al*., 2008; Karaman, 2019). Swelling capacity is the increase in volume of a seed after 16 h soaking. The seeds placed in boiling water were checked after 10 min and the cooking time was recorded (Karayel, 2012; Karaman, 2019).

$$\text{Swelling capacity} = \frac{[(\text{Wet volume-100}) - (\text{Dry volume-50})] - [(\text{Dry volume-50})/100) \times \text{Number of unhydrated seed}]}{\text{100-Number of unhydrated seed}}$$

Statistical analysis

The data were analyzed according to split plot experiment design for every year separately and combined years by using MSTAT-C computer software package. LSD (%5) multiple range tests were applied to compare differences among the means.

Results and Discussion

Plant height: The plant height was significantly influenced by genotypes in both years and combined years (Table 2). In mean of the years, the maximum plant height was observed in Jade (83.9 cm) followed by Antalya (81.3 cm), while the minimum value was observed in Gaziantep (65.3 cm). While the differences among the nitrogen doses were significant in terms of plant height in the year averages and in the first year, they were not significant in the second year. Increase in nitrogen levels significantly increased the plant height. As mean of the years, the highest plant height was obtained from 120 kg ha^{-1} nitrogen applications (76.9 cm) followed by 80 kg N ha^{-1}, while the lowest value was determined in the control treatment (71.6 cm). Earlier studies show that nitrogen application at early growth stages increases vegetative growth (Sadeghipour *et al*., 2010; Achakzai *et al*., 2012; Razzaque *et al*., 2015). Increase in plant height may be due to the development of plant tissues and increased photosynthesis (Razzaque *et al*., 2015) Table 2.

Statistical analysis exhibited that plant height was not significantly affected by interaction of genotype x nitrogen dose in both years and in the combined years. Similar to our findings, Achakzai *et al*., (2012) reported that there was non-significant interaction of genotype x nitrogen levels for plant height in mung bean. However, Razzaque *et al*., (2015) recorded that the maximum plant height varied between 40 and 80 kg N ha^{-1} according to different genotypes of mung beans.

First podding height: Genotypic differences for the first podding height were significant, but this trait was not influenced by nitrogen levels in both years and combined years (Table 2). However, interaction of genotype x nitrogen was significant in the first year and mean of the years, but not in the second year. The first podding height was not affected by years. In mean of the years, the maximum value was achieved in Jade in the applications of 40 kg N ha^{-1} with 44.3 cm whereas the minimum value was obtained from Gaziantep in the control application (no nitrogen) with 23.4 cm. Genotypes that form the first pod higher than the ground surface are more suitable for harvesting. Peksen *et al*., (2015) reported that the first podding height varied between 15.75 and 49.33 cm in various mung bean genotypes. Azadi *et al*., (2013) reported that different nitrogen levels did not affect the first podding height, but the highest value was obtained from 150 kg N ha^{-1} with 25.51 cm.

Number of pods per plant: Various levels of nitrogen and genotypes had a significant effect on the pods per plant in both years and mean of the years. However, the interaction of cultivar x nitrogen doses was also significant for pods per plant in both years and combined years (Table 2). Mean of the years showed that the highest pods per plant were achieved by Gaziantep at level of 80 kg N ha^{-1} with 40.7, while the lowest was obtained from KPS1 at 120 kg N ha^{-1} with 15.2. However, as a general trend, 40 or 80 kg N ha^{-1} nitrogen applications in various genotypes increased pods per plant except for Antalya as compared to the control treatment (no nitrogen). These results confirm the results of many previous studies showing that nitrogen application increases the number of pods per plant (Malik *et al*., 2003; Kaysha *et al*., 2020; Khuit *et al*., 2020).

Number of seeds per pod: Significant variation was found for seeds per pod among the genotypes in the second year and mean of the years, but not in the first year (Table 3). As mean of the years, higher seeds per pod were found in Gaziantep with 11.1 followed by Antalya with 10.8 while the lowest value was obtained in KPS 1with 9.81. The number of seeds per pod was not affected by nitrogen doses in the first year and mean of the years. Similar result was reported by Khuit *et al*., (2020) who indicated that seeds per pod were not affected by nitrogen doses. In the second year, seeds per pod varied between 10.5 (120 kg N ha^{-1})-11.3 (40 kg N ha^{-1}) and decreased with increasing nitrogen doses (Table 3).

Seed weight per plant: Interaction of genotype x nitrogen was significant for seed weight per plant in both years and combined years. As mean of the years, the maximum value (21.3 g) was produced by KPS1 at level of 40 kg N ha^{-1}, whereas the lowest value was obtained from KPS1 at level of the control application with 11.1 g. However, the seed weight per plant of KPS1 at 40 level of kg N $ha^{-1}$was similar to that of Antalya at the control dose. Razzaque *et al*., (2015) reported that seed yield per plant increased up to level of 60 kg N ha^{-1} due to the increase of pods per plant and then, decreased in higher nitrogen doses. Present seed weight per plant was similar to the values indicated by Karaman (2019) (8.13-17.92 g) and Singh *et al*., (2013) (11.49-12.75 g). In the present study, seed weight per plant due to increase of pods per plant and 100 seed weight in 2019 (20.9) was significantly greater than seed wight per plant in 2021 (10.9 g).

Table 2. Effects of different genotypes and nitrogen doses on plant height, first podding height and pods per plant of mung bean.

Genotypes (G)	Doses (D) $kgha^{-1}$	Plant height (cm)			First podding height (cm)			Pods per plant		
		2019	2021	Mean	2019	2021	Mean	2019	2021	Mean
KPS1	0	68.5	61.6	65.0	37.8cd	27.2	32.5de	31.5efg	14.2bcd	22.8d
	40	64.8	65.7	65.3	22.5g	27.7	25.1g	38.0de	25.2a	31.6c
	80	70.0	70.6	70.3	32.4de	29.1	30.8ef	29.5efg	16.3bc	22.9d
	120	75.5	68.8	72.2	35.9cde	30.8	33.3de	12.1h	18.3b	15.2e
Jade	0	91.2	78.9	85.1	46.6ab	37.4	42.0ab	30.5efg	12.9cd	21.8d
	40	80.0	81.5	80.7	49.3a	39.3	44.3a	37.4de	25.2a	31.3c
	80	97.0	72.5	84.8	40.6bc	38.3	39.5abc	51.9b	14.9bcd	33.4bc
	120	96.2	73.5	84.9	36.1cde	39.4	37.8bcd	30.1efg	18.0b	24.1d
Antalya	0	75.5	72.5	74.0	30.4ef	39.1	34.7cde	37.5de	25.1a	31.3c
	40	95.5	73.3	84.4	32.3de	42.7	37.5bcd	26.6fg	14.1bcd	20.3de
	80	85.1	81.6	83.4	33.3de	40.3	36.8bcd	35.9def	12.9cd	24.4d
	120	88.9	77.9	83.4	40.9bc	38.5	39.7abc	22.3g	10.5d	16.4e
Gaziantep	0	63.4	61.1	62.3	16.7g	30.1	23.4g	51.2bc	25.5a	38.4ab
	40	60.3	65.4	62.8	31.3de	35.7	33.5de	36.3def	24.0a	30.2c
	80	71.2	65.8	68.5	20.7g	31.6	26.1fg	65.0a	16.3bc	40.7a
	120	68.6	66.3	67.5	23.6fg	29.7	26.6fg	41.7cd	18.6b	30.1c
GxD (LSD 5%)		N.S.	N.S.	N.S.	7.26	N.S	5.63	9.87	4.72	5.33
KPS1		69.7c	66.7b	68.2c	32.1b	28.7b	30.4c	27.8d	18.5b	23.1c
Jade		91.1a	76.6a	83.9a	43.2a	38.6a	40.9a	37.5b	17.8b	27.6b
Antalya		86.3b	76.3a	81.3b	34.3b	40.2a	37.2b	30.6c	15.6c	23.1c
Gaziantep		65.9d	64.7b	65.3d	23.1c	31.8b	27.4d	48.6a	21.1a	34.8a
(LSD 5%)		3.71	3.53	2.28	3.07	4.73	2.51	1.24	1.93	1.02
	0	74.7b	68.6	71.6c	32.9	33.4	33.2	37.7b	19.4b	28.6a
	40	75.2b	71.5	73.3bc	33.9	36.4	35.1	34.6b	22.1a	28.4a
	80	80.8ab	72.6	76.7ab	31.8	34.9	33.3	45.6a	15.1c	30.4a
	120	82.3a	71.6	76.9a	34.1	34.6	34.4	26.5c	16.4c	21.4b
Mean		78.2A	71.1B	74.7	33.1	34.8	33.9	36.1 A	18.3 B	27.2
LSD 5%		6.41	N.S.	3.64	N.S.	N.S.	N.S.	4.93	2.36	2.66
CV %		9.72	6.43	8.40	12.99	15.33	14.27	16.2	15.3	16.8

Means with the same letter are not significantly different from each other

Table 3. Effects of different genotypes and nitrogen doses on seeds per pod and seed weight per plant of mung bean.

Genotypes (G)	Doses (D) kg ha^{-1}	Seeds per pod			Seed weight per plant(g)		
		2019	2021	Mean	2019	2021	Mean
KPS1	0	8.8	10.4	9.59	13.9h	8.3f	11.1ı
	40	9.1	10.9	10.0	24.2bc	18.4a	21.3a
	80	9.2	10.3	9.77	20.6cdef	9.1ef	14.8efg
	120	10.0	9.7	9.89	15.6fgh	11.3de	13.5fghı
Jade	0	9.3	10.8	10.1	15.2gh	7.9f	11.6hı
	40	9.8	11.5	10.6	20.3cdefg	14.7b	17.5cde
	80	9.4	10.3	9.85	21.9bcde	9.3ef	15.6def
	120	8.6	10.7	9.65	17.3efgh	11.4de	14.3fgh
Antalya	0	11.4	11.2	11.3	26.4b	14.4bc	20.4ab
	40	10.0	11.1	10.6	17.3efgh	8.3f	12.8ghı
	80	11.1	11.2	11.2	24.9bc	9.9def	17.4cde
	120	9.9	10.6	10.2	17.3efgh	7.6f	12.5ghı
Gaziantep	0	10.9	12.4	11.6	23.0bcd	14.9b	18.9abc
	40	10.1	11.8	10.9	18.1defgh	12.1cd	15.1defg
	80	10.9	11.1	11.0	32.1a	8.1f	20.1abc
	120	10.8	11.0	10.9	26.5b	9.3ef	17.9bcd
GxD (LSD5%)		N.S.	N.S.	N.S.	5.31	2.32	2.82
KPS1		9.3	10.3b	9.81b	18.6	11.8	15.2
Jade		9.3	10.8ab	10.1b	18.7	10.8	14.8
Antalya		10.6	11.0ab	10.8a	21.5	10.0	15.8
Gaziantep		10.7	11.6a	11.1a	24.9	11.1	18.0
LSD 5%		N.S.	0.77	0.68	N.S.	N.S.	N.S.
	0	10.1	11.2a	10.7	19.6b	11.4b	15.5bc
	40	9.8	11.3a	10.5	20.0b	13.4a	16.7ab
	80	10.1	10.8ab	10.4	24.9a	9.1c	16.9a
	120	9.8	10.5b	10.2	19.2b	9.8c	14.5c
Mean		9.9B	10.9A	10.4	20.9A	10.9B	15.9
LSD 5%		N.S.	0.59	N.S.	2.65	1.16	1.41
CV %		13.23	6.41	10.1	15.1	12.57	15.2

Means with the same letter are not significantly different from each other

100-seed weight: There are significant differences among the genotypes for 100 seed weight in both years and combined years (Table 4). Mean of the years showed that 100 seed weight was recorded between 5.96 g (Gaziantep) and 7.25 g (Antalya) and differences among the genotypes except for Gaziantep genotype were insignificant. 100 seed weight was not affected by nitrogen doses and genotype x doses interaction. Similar results were reported by Razzaque *et al*., (2015) and Jalali *et al*., (2017) who recorded that the effects of nitrogen levels on 1000-seed weight were non-significant. However, the present results contradict the report of Yin *et al*., (2018) and Khuit *et al*., (2020) who reported that 100-seed weight increased with increasing nitrogen fertilization.

Seed yield: Effects of genotypes on seed yield were significant in both years and combined years (Table 4). As mean of the years, the maximum value was found in KPS1 with 2056.0 kg ha^{-1}, while the lowest one was Antalya with 1103 kg ha^{-1}. The differences among the nitrogen doses in terms of seed yield were significant in the second year and combined years, but not in the first year. In mean of the years, seed yield slightly increased by increasing nitrogen doses up to 80 kg N ha^{-1} and thereafter decreased in 120 kg N ha^{-1} due to the decreasing seed weight per plant, pods per plant and increasing plant height. Similar to our findings, earlier studies report that increase of nitrogen application in mung bean increases seed yield and then higher doses decrease seed yield (Kardoni & Fathi, 2018; Kaysha *et al*., 2020). It has been found in some studies that level of 80 kg N ha^{-1} or 90 kg N ha^{-1} gave the maximum seed yield (Sadeghipour *et al*., 2010; Khuit *et al*., 2020; Anonymous, 2021). Seed yield was also affected by interaction of genotypes x nitrogen doses in both years and combined years. In terms of seed production, KPS1 and Jade excotic genotypes responded better to nitrogen fertilization compared to local genotypes. As mean of the years, the highest seed yield was produced by KPS1 at 80 kg N ha^{-1} with 2492 kg ha^{-1} followed by KPS1 at 40 kg N ha^{-1} with 2083 kg ha^{-1}, while the lowest value was obtained in Antalya at 40 kg N ha^{-1} with 963 kg N ha^{-1}. These findings agreed with Azadi *et al*., (2013) who reported that the effect of genotype x nitrogen doses on seed yield was significant (Table 4).

The seed yield was significantly greater in the first year (1660 kg ha^{-}1) compared to the second year (1436 kg ha^{-1}) where there was higher temperature during the flowering (July). Similarly, Khan *et al*., (2017) reported that seed yield is also often limited by high temperature. The seed yield of mung beans in the first year increased due to pods per plant, seed weight per plant compared to the second year. The results of the present study are similar to the research of Asaduzzaman *et al*., (2008), Sadeghipour *et al*., (2010) and Razzaque *et al*., (2015) who reported that increase in seed weight per plant, seeds per pod increased the seed yield. Maturation (middle of August) was also earlier in the first year (at the middle of August) than the second year (late August).

Table 4. Effects of different genotypes and nitrogen doses on 100-seed weight and seed yield of mung bean.

Genotypes (G)	Doses (D) kg ha^{-1}	100- seed weight (g)			Seed yield (kg ha^{-1})		
		2019	2021	Mean	2019	2021	Mean
KPS1	0	6.78	6.73	6.76	1974bcd	1699b	1836bc
	40	7.35	6.40	6.86	2081bc	2084a	2083b
	80	7.52	6.51	7.01	2733a	2251a	2492a
	120	7.18	6.98	7.08	1846bcde	1779b	1812c
Jade	0	7.32	6.62	6.97	1224fg	1167c	1196defg
	40	7.61	6.26	6.94	1614def	1209c	1411d
	80	7.29	6.54	6.92	1240fg	1272c	1256def
	120	7.58	6.75	7.17	1026g	1265c	1146efg
Antalya	0	7.12	6.69	6.91	1635cdef	1046cd	1341de
	40	7.90	6.47	7.19	1093g	833de	963g
	80	7.97	6.96	7.47	1130g	1000cd	1065fg
	120	7.98	6.90	7.44	1426efg	662e	1044fg
Gaziantep	0	6.27	5.20	5.74	1854bcde	1632b	1743c
	40	6.29	5.56	5.93	2101b	1587b	1844bc
	80	6.77	5.51	6.14	1872bcde	1744b	1808c
	120	6.83	5.23	6.03	1712bcde	1744b	1728c
GxD (LSD 5%)		N.S.	N.S.	N.S.	461	276	262
KPS1		7.21b	6.65a	6.93a	2159a	1953a	2056a
Jade		7.44ab	6.54a	6.99a	1276b	1228c	1252c
Antalya		7.74a	6.76a	7.25a	1321b	886d	1103c
Gaziantep		6.54c	5.38b	5.96b	1885a	1677b	1781b
LSD 5%		0.46	0.43	0.33	319	170	161
	0	6.87	6.31	6.59	1672	1386b	1528ab
	40	7.28	6.17	6.73	1722	1428b	1575a
	80	7.39	6.38	6.88	1744	1567a	1655a
	120	7.39	6.47	6.93	1502	1363b	1433b
Mean		7.23A	6.33B	6.78	1660A	1436B	1548
LSD 5%		N.S.	N.S.	N.S.	N.S.	138	131
CV %		7.62	7.42	7.55	16.49	11.41	14.57

Means with the same letter are not significantly different from each other

Cooking properties: Differences among the genotypes were not significant for swelling capacity in both years and combined years. However, the values obtained from various genotypes varied between 0.073 ml seed^{-1} (Gaziantep) and 0.081 ml seed^{-1} (KPS-1) in combined years. Swelling capacity was affected by nitrogen doses in 2019, but not in 2021 and combined years. Swelling capacity in different N doses was recorded between 0.075 ml seed^{-1} (80 kg ha^{-1}) and 0.084 ml seed^{-1} (control treatment) in the first year. Genotype x nitrogen interaction was also significant for this trait in 2019 and the highest value was determined in Antalya at 40 kg ha^{-1} and KPS-1 at the control tretment with 0.097 ml seed^{-1}, while the lowest one was obtained from Jade at 80 kg ha^{-1} and Gaziantep at 120 kg ha with 0.070 ml seed in the first year. Previous studies on various legumes reported that swelling capacity showed differences according to genotypes and years (Karasu, 1993; Karaman, 2019). Present results are similar to the findings of Karaman (2019) (0.06-0.138 ml seed^{-1}) and Dahiya *et al*., (20153) (0.006-0.076 ml seed^{-1}) in mung beans. By contrast, the values obtained for swelling capacity in this study were higher compared to the findings of Khattak & Bibi, (2007) (0.003-0.28 ml seed^{-1}) and Ghosh & Panda (2006) (0.025-0.060 ml seed^{-1}) on mung beans and to the findings of Ovacikli & Tolay (2020) (0.37 to 0.49 ml seed^{-1}) on common beans. However, Raghuvanshi *et al*., (2011) (0.800-3.500 ml seed^{-1}) determined higher values compared to our study on mung beans. Seed size is an important factor for swelling capacity. It was found that genotypes with high seed weight had higher swelling capacity in different legumes (Sfayhi & Kharrat, 2011; Karayel, 2012) (Table 5).

The effects of genotypes on cooking time as well as swelling capacity were not significant in both years. Earlier studies reported that higher swelling capacity in mung bean and pea seeds had short cooking time (Karayel, 2012; Akhila *et al*., 2017; Karaman, 2019). As mean of the years, cooking time varied from 17.4 min (Gaziantep) to 19.3 (Antalya) and the differences among the other genotypes, except for Antalya, were not significant. Cooking time was not affected by nitrogen fertilizer in both years and combined years. Ovacikli & Tolay (2020) reported that cooking time was not affected by different nitrogen doses but swelling capacity of seed in common bean decreased with the nitrogen doses. On the other hand, Coelho *et al*., (2009) reported that cooking time decreased with increased N topdressing in mung beans. As mean of the years, cooking time in terms of N doses varied from 17.8 min (40 and 80 kg ha^{-1}) to 18.5 min (120 kg ha^{-1}) in this study. Similar cooking times to our findings in mung bean genotypes were reported by Karaman (2019) (14.0-20.8 min) and Akhila *et al*., (2017) (16.69-19.04 min). The values of cooking time obtained by Dahiya *et al*., (2015) (14-60 min) and Khattak & Bibi (2007) (14 and 26.5 min) were higher than the present study. Cooking time varies depending on growing conditions, size, thickness, chemical composition and wall structure of the grain (Karaman, 2019; Ovacikli & Tolay, 2020).

Table 5. Effects of different genotypes and nitrogen doses on swelling capacity and cooking time of mung bean.

Genotypes (G)	Doses (D) kg ha^{-1}	Swelling capacity			Cooking time		
		2019	2021	Mean	2019	2021	Mean
KPS1	0	0.097a	0.077	0.087	17.0	17.7	17.3
	40	0.073c	0.087	0.080	17.3	17.3	17.3
	80	0.077bc	0.090	0.083	16.3	17.3	16.8
	120	0.083abc	0.067	0.075	17.3	19.6	18.5
Jade	0	0.083abc	0.070	0.077	17.7	19.0	18.3
	40	0.090ab	0.073	0.082	18.0	17.7	17.8
	80	0.070c	0.080	0.075	17.7	18.3	18.0
	120	0.080bc	0.080	0.080	17.3	18.3	17.8
Antalya	0	0.077bc	0.063	0.070	18.3	21.6	20.0
	40	0.097a	0.067	0.082	17.7	20.6	19.2
	80	0.080bc	0.080	0.080	19.3	18.0	18.6
	120	0.077bc	0.070	0.073	19.0	20.0	19.5
Gaziantep	0	0.080bc	0.070	0.075	17.3	16.7	17.0
	40	0.073c	0.073	0.073	16.3	17.0	16.7
	80	0.073c	0.073	0.073	17.3	17.7	17.5
	120	0.070c	0.070	0.070	18.7	18.0	18.3
GxD (LSD5%)		0.015	N.S.	N.S.	N.S.	N.S.	N.S.
KPS1		0.082	0.080	0.081	17.0	18.0	17.5b
Jade		0.081	0.076	0.078	17.7	18.3	18.0b
Antalya		0.082	0.070	0.076	18.6	20.1	19.3a
Gaziantep		0.074	0.072	0.073	17.4	17.3	17.4b
LSD 5%		N.S.	N.S.	N.S.	N.S.	N.S.	1.29
	0	0.084a	0.070	0.077	17.6	18.8	18.2
	40	0.083a	0.075	0.079	17.3	18.2	17.8
	80	0.075b	0.081	0.078	17.7	17.8	17.8
	120	0.077ab	0.072	0.075	18.1	19.0	18.5
Mean		0.080	0.074	0.077	17.7	18.4	18.1
LSD 5%		0.007	N.S.	N.S.	N.S.	N.S.	N.S.
CV %		11.2	17.6	14.5	6.7	7.5	7.1

Means with the same letter are not significantly different from each other

Table 6. Effects of genotypes and nitrogen doses on some quality traits of mung bean.

Genotypes (G)	Doses (D) kg ha^{-1}	Protein	Moisture	Ash
KPS1	0	23.4	10.8	3.73
	40	24.0	11.2	3.38
	80	23.8	10.9	3.30
	120	24.5	10.9	3.84
Jade	0	25.1	11.1	3.60
	40	24.8	11.7	2.98
	80	25.1	10.4	3.53
	120	24.8	10.9	3.76
Antalya	0	24.4	9.8	3.89
	40	25.6	11.4	3.29
	80	26.1	11.5	3.37
	120	27.9	11.4	3.81
Gaziantep	0	24.8	12.5	2.83
	40	24.4	11.5	3.04
	80	24.3	11.3	3.37
	120	25.2	12.8	3.42
GXD (LSD 5%)		N.S.	N.S.	N.S.
KPS1		23.9	10.9	3.56
Jade		24.9	11.0	3.47
Antalya		26.0	11.0	3.59
Gaziantep		24.7	12.0	3.16
LSD 5%		N.S.	N.S.	N.S.
	0	24.4	11.0	3.51
	40	24.7	11.4	3.17
	80	24.8	11.0	3.39
	120	25.6	11.5	3.71
Mean		24.9	11.3	3.45
LSD 5%		N.S	N.S	N.S
CV %		4.67	7.27	16.05

Means with the same letter are not significantly different from each other

Crude protein: Crude protein content in mung bean seed was not affected by genotypes, nitrogen levels and interaction of genotype x nitrogen (Table 6). However, increasing nitrogen applications slightly increased protein contents. The results showed that protein contents ranged between 23.4% (KPS1 at control dose) and 27.9% (Antalya at 120 kg N ha^{-1}). Similar to our findings, Ovacikli & Tolay (2020) reported that protein content was not significantly affected by different nitrogen doses in common beans. By contrast, Razzaque *et al*., (2015) reported that increased nitrogen doses in low fertile soil increased nitrogen acquisition in mung beans. Increased protein content may be due to providing nitrogen for amino acid synthesis (Malik *et al*., 2003). Various studies on mung beans reported that crude protein content varied from 20% to 28 % (Rodriguez & Mendoza, 1990; Li *et al*., 2010; Chibbar *et al*., 2010; Singh *et al*., 2013; Rahman, 2018; Gunathilake *et al*., 2016; Ahmad *et al*., 2016; Karaman, 2019; Ton, 2021).

Moisture content: Significant differences among the genotypes and nitrogen levels were not observed for moisture content (Table 6). Genotype x nitrogen interaction was also insignificant. The moisture content ranged from 9.8% (Antalya at control dose) to 12.8% (Gaziantep at 120 kg N ha^{-1}). Low moisture limits deterioration due to microbial contamination (Li *et al*., 2010). Genotypes with low moisture had also a higher dry matter ratio (Ahmad *et al*., 2016). Moisture contents observed in this study were slightly higher compared to values declared by Li *et al*., (2010) (7.49-8.45%) and

Bhatty *et al*., (2000) (8.25g/100g). The present study was supported by Dahiya *et al*., (2015) (4.10-15.20g/100g) and Gunalthilake *et al*., (2016) (11.48-11.99g.100g^{-1}).

Ash content: Ash content in mung bean seed was not significantly affected by cultivars and nitrogen levels in the first year (Table 6). Interaction between genotype and nitrogen doses was not found for this trait. However, ash content ranged from 2.83% (Gaziantep at control doses) to 3.89% (Antalya at control doses). Ash content indicates essential minerals in seed (Rahman, 2018). Similarly, some previous studies reported that ash content varied from 2.91% to 4.24% depending on mung bean genotypes (Li *et al*., 2010; Shaheen *et al*., 2012). Some studies also reported that ash contents of mung bean seed varied between 3.41-4.15 g/100 g (Sharanagat *et al*., 2019), 3.95-3.96g/100g (Gunalthilake *et al*., 2016) and 3.76g/100g (Mubarak, 2005). (Table 6).

Conclusions

According to mean of the years, the results of the present study showed that increase of nitrogen doses in mung bean slightly increased the seed yield up to 80 kg N ha^{-1} due to the increasing pods per plant, seed weight per plant and then decreased in increasing nitrogen dose. However, the interaction between genotype and nitrogen doses was significant for seed yield. The maximum seed yield was produced by KPS1 at 80 kg N ha^{-1} with 2492 kg N ha^{-1} followed by KPS1 at 40 kg N ha^{-1} with 2083 kg ha^{-1}, while the lowest yield was obtained from Antalya 07 A5 local genotype at 40 kg N ha^{-1}with 963 kg ha^{-1} when inoculation with rhizobium bacteria was not applied**.** In mean of the years, swelling capacity and cooking time varied between 0.070-0.087 ml seed^{-1} and 16.7-20.0 min. respectively in different genotypes and nitrogen doses. Crude protein, moisture and ash content were not significantly affected by genotypes and nitrogen levels. However, mung bean genotypes in different nitrogen doses contained crude protein content between 23.4% and 27.9%, moisture content between 9.8% and 12.8 %, ash content between 2.83% and 3.89 %.

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