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Determination of Yield and Yield Components of Some Dry Bean (*Phaseolus vulgaris* L) Genotypes Grown in Central Anatolia Ecological Conditions

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Abstract: In this study, it was aimed to determine the adaptations, yield potentials of some dry bean genotypes and some agricultural characteristics to the Central Anatolian ecology. The research was carried out in three replications according to the randomized blocks design for two years in 2015 and 2016 in a farmer's experiment area in the center of Mucur district of Kirsehir province. It was determined that there were significant statistical differences between the genotypes in terms of all examined yield parameters. When the agronomic characteristics of the genotypes were evaluated together, it was found that K.1084, A.40, A.130 and GK.314 genotypes had very low values of yield parameters and Goynuk 98, Sahin 90 and A.27 genotypes were found to be more suitable for adaptation to Kirsehir ecological conditions than other genotypes. It was suggested that these genotypes should be laid emphasis on in terms of region.
Keywords: Kirsehir, dry bean, genotype, yield, yield components

INTRODUCTION

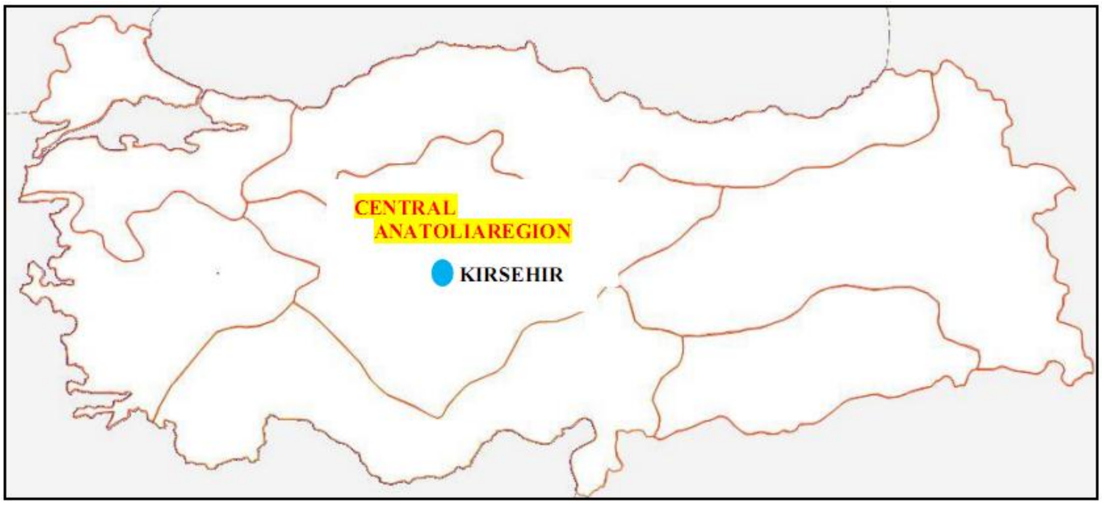
In the world, the dry bean which has a wide adaptation area and is especially grown in the temperate climatic zone can also be produced in areas near sea level in America and Europe, and in areas higher than 3000 meters in South America [1]. Along with the world population growth, nutritional problems and starvation problem have initiated to display itself more seriously. Today, more than half of the world population is nourished with protein-deficient nutrients [2]. The countries where dry bean cultivation is made the most are India (9.100.000 ha), Brazil (2.813.506 ha), and Myanmar (2.700.000 ha) respectively. The most foremost countries in terms of production are Myanmar (3.700.000 tons), India (3.630.000 tons), and Brazil (2.892.599 tons). Moreover, Iraq, the Republic of Ireland and Barbados have the highest yields of dry bean in the world with a yield of 7353 kg, 6069 kg and 5381 kg per hectare, respectively [2].

Cereals are important because of nutrition. Providing animal origin proteins is expensive and difficult. For this reason, providing plant origin proteins is mostly preferred. Among vegetable protein sources, the highest protein amount is obtained from legume plants [3]. Dry bean is from edible legumes that rich in vitamins A, B, D [4] come into prominence with the protein content of 17-35% [5]. When researching edible grain legume plants, in addition to the growing technique, it is important to get the highest possible yield from the unit area as well as to obtain the quality at a certain level [6].

Dry bean, with 30.139.041 hectares of planting area and 25.093.616 tons of production, are in the first rank among edible grain legumes in the world. Nevertheless, it is ranked number three after chickpeas and lentils with 91.110 hectares of planting area and 225.000 tons of production in our country. In the world countries that produce dry bean, yield average is 83.26 kg, while in our country this value is around 235.98 kg [2]. This is actually important due to indicating that if the planting area is increased, a significant portion of the protein need can be satisfied with dry bean. In this study, we aimed to determine the performances of yield and yield parameters of dry bean varieties obtained from different research institutes of our country and advanced lines which are locally collected and purified.

MATERIALS AND METHODS

The study was carried out for 2 years, covering the years 2015-2016 in the trial area supplied by a farmer within the boundaries of Mucur district of Kirsehir province. A total of 11 dry bean genotypes were used in the study, including 5 varieties (Yunus 90, Goynuk 98, Zulbiye, Onceler 98, Sahin 90) registered by different research institutes and 6 advanced dry bean lines (K.1044, K.1084, A.40, A.27, A.130 ve GK.314) collected and purified as a local population. As a result of the analyses of soil samples of experiment area where the study was carried out during the two years, it was determined that pH was 7.6, total salt amount was 0.021%, lime amount was 10.1%, organic matter amount was 1.71%, phosphorus was 6.77 kg da^{1} and potassium amount was 234 kg da^{-1}. According to these results, the experiment area soil in which the study was carried out was slightly alkaline; organic matter was low, potassium content was sufficient. Utilizable phosphorus was high; it had no salt but was limy.



Figu-1: Central Anatolia Region Map

The continental climate is dominant in Kirsehir located in the middle of the Central Anatolia Region (Figure 1). Generally, summers are hot and arid, springs are rainy. The average annual rainfall is 379 mm. Climate data (average rainfall, temperature and relative humidity) for the growing season of the 2015 and 2016 and the average of the long years are given in Table 1.

Table-1: Climate data for Kirsehir*

Months	Average Temperature (^{0}C)			Total Rainfall (mm)			Average Relative Humidity (%)		
	2015	2016	Long Years	2015	2016	Long Years	2015	2016	Long Years
May	16.4	15.1	16.2	39.2	63	10.7	57.5	56.2	56.2
June	18.9	21.3	20.6	161.4	52.3	13.9	65.6	50.9	50.9
July	24.9	24.9	24.8	20.6	40.9	2.9	41.5	38.4	38.4
August	25.9	26.9	24.9	11.8	40.2	1	45.4	37.6	37.6
September	23.8	21.2	19.6	1	43.8	2.6	41.1	41.4	43.3
Average	21.9	21.8	21.2				50.2	44.9	45.3
Total				233.4	240.2	31.1			

*Turkish State Meteorological Service

When Table 1 is analyzed, it is observed that there is a similarity between the monthly average temperature values of these two years and of long years, and the total rainfall for long years during vegetation is about 8 times more than the rainfall of 2015 and 2016. As in the average temperature values, it is observed a correspondence between the values of the relative humidity of these two years and of long years.

The research was carried out in three replications according to the randomized blocks design. Experimental parcels were arranged as "5.0 m x 2.0 m=10 m^{2}". Sowing was made in the first week of May for each two years. The seeds were sown with row to row spacing of 50 cm and plant to plant spacing of 8 cm, each row had 63 seeds which were sown to a depth of 5 cm by hand. Each parcel consisted of 4 rows. After sowing and before growing, herbicides were applied to combat weeds and hand-hoe was operated 2 times during the vegetation. A drip irrigation system was installed to provide the irrigation needs of the experiment and irrigation was performed >6 times throughout the entire vegetation. 15 kg DAP (2.7 N kg da^{-1} and 6.9 P kg da^{-1}) fertilizer was applied to the experiment area together with the sowing. When the harvesting process is being carried out, 50 cm sections of the head and end of the parcels were placed out of the evaluation due to the edge effect. 4.0 m x 1.0 m = 4 m^2 area of the plants were taken into consideration.

Plant height (cm), first pod height (cm), number of pods per plant (number/plant), number of seeds per plant (number/plant), seed yield per plant (g), 100-seed weight (g) and number of seeds per pod (number/pod), pod length (cm) and pod weight (g) were determined on 10 plants randomly selected from each parcel and the average values per plant were calculated by taking their average. In addition, phenological characteristics such as % 50 flowering time (day) and % 50 pod binding time (day) were included in the study. The obtained data were combined and analysis of variance was applied in SPSS 21 statistical package software. LSD multiple comparison test (P>0.05) was used to determine the significance of the difference between the groups.

RESULTS AND DISCUSSION

As a result of the analysis of variance applied to the data obtained from the conducted study, significant differences were mostly found. The results of multiple comparison test for % 50 flowering time, % 50 pod binding time, plant height, first pod height, number of pods per plant and number of seeds per plant are presented in Table 2.

Phenological Observations

The difference between the genotypes was not significant in terms of the day's number of % 50 flowering for the average of two years. According to the results of the research, K.1084 (37.3 day) was the earliest genotype in terms of the number of % 50 flowering days whereas A.130 and GK.314 genotypes were the late ones with 43 days. The number of % 50 flowering days of other genotypes used in the research varied between these values. The average number of % 50 flowering days was 39.8 days.

When the number of % 50 pod binding days was examined, it was observed that the genotypes changed between 43.0 (K.1084) - 49.3 (A.130) days and the average number of pod binding days was determined as 45.8 days. As in the number of % 50 flowering days, the difference between the numbers of % 50 pod binding days was not significant.

The influence of climatic conditions is very important in determining the flowering period in plants. When the spring heat comes early, the flowering may be early, but if the heat is late, the flowering may also be delayed. In both years of the experiment, the spring heat came early and the flowering time was shortened. Shortening of the flowering period also shortened the maturation period. While Wallace *et al.* [7] point out that increasing temperatures shorten the vegetation period especially in sensitive genotypes, Sepetoglu [8] stated that climate data have a decreasing or enhancing effect on plant flowering. Ciftci & Yilmaz [9] reported that the period of % 50 pods binding in dry bean varied between 67-81 days depending on the climatic conditions and Ozcelik &d Sozen [10] also reported 44-52 days. The data we obtain for the flowering time supports the findings of the researchers. However, the study made by Ozcelik & Sozen [10] in terms of the maturation time was in contradiction with the study of Ciftci & Yilmaz [9] while being in harmony with our study. Of course, the places where these researchers work have very different characteristics of climate conditions compared to our workplace.

Agronomic Observations

As displayed in Table 2, according to the two-year average, the plant height values were obtained minimum in the A.130 genotype with 38.0 cm and the highest in the Sahin 90 genotype with 48.3 cm. The average plant height value of all genotypes was 41.7 cm.

The difference between the genotype of the Sahin 90 having the highest plant height and the Onceler 98 was not significant and they were statistically in the same group. Plant height can vary as a marker of the reaction of the genotypic characteristics of plants against the environment. It is mentioned that plants grown in the same ecological and soil conditions can have different height [11, 12]. The existence of a large variation in plant height is known [13].

Table-2: Multiple comparison results of some agronomic features of genotypes

Genotypes	Agronomic Features					
	%50 NFD	%50 PBD	PH	FPH	NPP	NSP
Sahin 90	37.7	43.7	48.3 a	15.4 c	30.7 a	110.8 a
A.27	40.7	46.7	39.4 b	16.6 b	26.8 b	110.6 a
Onceler 98	37.7	43.9	46.3 a	15.8 bc	32.9 a	96.1 b
Zulbiye	38.0	44.3	43.2 ab	19.0 a	29.8 ab	84.3 c
Goynuk 98	42.0	48.3	42.2 ab	20.5 a	26.8 b	84.0 c
K.1044	40.3	46.7	38.7 b	17.2 b	18.9 c	57.7 d
GK.314	43.0	49.0	41.2 b	16.3 b	18.7 c	51.4 d
Yunus 90	40.3	45.0	41.3 b	19.3 ab	17.6 c	49.6 d
K.1084	37.3	43.0	41.6 b	18.5 a	18.0 c	46.7 e
A.130	43.0	49.3	38.0 b	16.2 b	12.1 d	40.1 e
A.40	38.0	43.7	38.9 b	20.6 a	10.9 d	39.7 e
Mean	39.8	45.8	41.7	17.8	22.1	70.1

NFD: Number of Flowering Days PBD: Pod Binding Days
PH : Plant Height FPH: The First Pod Height
NPP : Number of Pods Per Plant NSP: Number of Seeds Per Plant

The difference between the genotypes in terms of the first pod height was found to be significant (P<0.01). This difference may be considered to be caused by the genetic characteristics of the genotypes. For the first pod height, the A.40 genotype had the highest value with 20.6 cm, Sahin 90 genotype was found to have the lowest value with 15.4 cm and the average value of the first pod height was found to be 17.8 cm. The first pod height did not have a variation as much as plant height has, even if it was affected by plant height. In the study of Senturk [14], the first pod height was 10.15-11.12 cm, Duzdemir & Akdag [15] 9.9-23.9 cm. The values we obtained differed from Senturk's [14] study, but the variation was wider as in the studies of other researchers. It was estimated that this difference was mainly caused by climate conditions.

When we looked at the number of pods per plant, it was found that this character changed between 10.9 (A.40) - 32.9 (Onceler 98) and the average number of pods per plant was 22.1. It was determined that the number of seeds per plant of genotypes varied between 40.1 (A.130) - 110.8 (Sahin 90). The average number of seeds per plant was 70.1. It was stated that the number of pods per plant was an important criterion in various studies done for the determination of high yield genotypes [14, 16, 17]. In the study of Atici [18], the number of pods per plant was 10.47-22.37, while Ulker & Ceyhan [19] were found 11.26-25.17. The variation that researchers obtained was also seen in our work. We think that this is the result of ecological factors and cultural practices. The results of multiple comparisons of seed yield per plant, 100-seed weight, pod length, pod weight, number of seeds per pod and seed yield per decare is given in Table 3. If the variables are examined, it is seen that there are significant differences between the genotypes.

In Table 3, the seed yield per plant was determined the highest for the Sahin 90 genotype with 36.0 g and the minimum for the Yunus 90, A.40 and A.130 genotypes with 14.9 g according to the two years average. Average seed yield per plant was 23.7 g. The seed yield per plant varied depending on the genotype property. It is also known that genotypes display some differences depending on ecological factors and cultural practices [20]. As a result of the study of Biyikli [21], the seed yield per plant for the genotypes was found to vary between 121.9-244.5 g. The results we obtained were quite low. We think the reason for this is regional differences. Because the study of the researchers was in the area where the continental climate dominated and this seriously affected the plants.

Table-3: Multiple comparison results of some agronomic features of genotypes

Genotypes	Agronomic Features					
	SYPP	HSW	PL	PW	NSP	YPD
A.27	31.6 ab	28.2 b	9.9 ab	43.0 b	5.4 a	128.5 a
Goynük 98	31.5 ab	37.7 a	9.8 ab	43.6 b	4.2 b	122.7 a
Yunus 90	14.9 d	34.8 ab	9.1 b	21.5 d	3.3 c	115.6 ab
Zulbiye	31.1 ab	40.4 a	9.5 b	46.3 b	4.3 b	115.6 ab
Onceler 98	29.8 b	32.1 b	9.2 b	46.4 b	4.7 ab	107.0 b
Sahin 90	36.0 a	36.6 a	11.8 a	53.7 a	4.8 ab	104.1 b
A.40	14.9 d	38.5 a	9.6 b	22.8 d	4.7 ab	86.0 c
A.130	14.9 d	36.3 a	9.8 ab	20.9 d	4.4 b	83.6 c
K.1044	21.0 c	35.2 ab	8.9 b	32.4 c	4.1 b	80.8 c
K.1084	16.6 d	35.9 ab	8.4 b	24.9 d	3.7 bc	78.3 c
GK.314	18.3 cd	35.5 a	9.1 b	29.4 c	4.0 bc	70.7 d
Mean	23.7	35.6	9.6	35.0	4.3	99.4

SYPP: Seed Yield Per Plant   HSW: 1000-Seed Weight   PL : Plant Length
PW : Plant Weight   NSP : Number of Seeds Per Pods   YPD : Yield Per Decare

When the genotypes were evaluated in terms of 100-seed weight, the differences were seen to be between 28.2 (A.27) - 40.4 (Zulbiye) g for the averages of the two years, and it was determined that the average of 100-seed weight was 35.6 g. In the majority of the researches, 100-seed weight was found in the first rank among the yield parameters of the dry bean [22-24]. In some studies conducted on beans, seed yield per plant was found to be positively correlated with 100-seed weight and grain weight [25, 26]. While Babagil *et al.* [27] showed that the 100-seed weight varied between 31.9-56..5 g, Anlarsal *et al.* [28] found that this value varied between 22.3-33..6 g. According to these results, it can be seen that 100-seed weight is very variable and is influenced to a large extent by environment. The results we obtained are the same as those of the researchers.

Pod length of the genotypes varied between 9.1 (GK.314) - 11.8 (Sahin 90) cm for the average of two years and the average of pod height was also obtained to be 9.6 cm. In general, it can be seen that the pod length does not vary greatly. The pod length is related to the plant height. For this reason, if the plant height increases, the number of pod decreases, and the pods length increases. In many studies, it was determined that there were positive and very important relations between seed number and seed yield and pod length [28, 29]. In some studies carried out on the determination of pod length in dry bean, Akdag & Sahin [30] obtained values between 8.22-10.83 cm, Duzdemir [31] 7.48-11.88 cm, and Atıcı [18] 7.1-16.6 cm. It is seen that the values we obtained are within the same limits with other studies. Accordingly, it can be said that the pod length is influenced greatly by environmental conditions. The pod weight, as well as pod height, is also not a little affected by environment. The pod weight is seriously affected by the environment and by the genotype characteristics. In our study, it was determined that the pod weight varied between 20.9 (A.130) - 53.7 (Sahin 90) g and the average value was determined as 35.0 g. It is known that one of the most important traits affecting the yield of dry bean is pod weight. However, this feature varies according to genotypes. This is clearly seen in our work.

When the results of the research were evaluated in terms of number of seeds per pod, it was seen that the genotypes varied between 3.3 (Yunus 90) - 5.4 (A.27) and the average number of seeds per pod was 4.3. Azkan & Yurur [32] reported that the number of seeds per pod was 2.40-4.65 in their study and Akdag and Sahin 90 reported it changed between 2.54-4.11. The findings we obtained are similar to those of the researchers. The number of seeds per pod does not show a great variation, but its weight can change according to the environment and genotype.

Seed yield per decare is one of the most important features for agriculture species. Statistically significant differences were found when comparing the genotypes yield in this study. The seed yield per decare for genotypes ranged from 70 .7 (GK.314) to 122.7 (Goynuk 98) kg da^{-1}. The average seed yield per decare was determined to be 99.4 kg da^{-1}. Yield is a quantitative character that is affected by many factors of genetics. It is also known that genotype, as well as environment and genotype×environment interactions, can also change yield [13]. In the study conducted by Ozbekmez [33], the seed yields of lines and varieties were found to vary between 88-237 kg da^{-1}, while Mishra & Dash [34] reported 86-121 kg da^{-1} and Akdag and Sahin [30] yielded 81-191.7 kg da^{-1}. The yield per decare that we achieved in this study is parallel to the yield data of the researchers.

CONCLUSION

According to the results obtained in the study, it can be said that the genotype A.27 is the most promising genotype. Moreover, since Goynuk 98 genotype is in the same statistical group with A.27, we think it would also be useful to handle this genotype. However, since genotypes K.1044, K.1084, A.40, A.130 and GK.314 have very low yields, it is not likely to be meaningful to study these traits. The A.27 genotype was also found on the front in terms of the grain number per pod and grain number per plant. We think that this genotype is followed by the Sahin 90 genotype and that this genotype should be studied for the region.

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