Selcuk Journal of Agriculture and Food Sciences

http://sjafs.selcuk.edu.tr/sjafs/index

Research Article

Selcuk J Agr Food Sci

(2023) 37(1), 72-85

e-ISSN: 2458-8377

DOI: 10.15316/SJAFS.2023.009

Investigation of the Effects of Potassium on Some Agronomic Traits in Dry Bean Genotypes

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HIGHLIGHTS

- Potassium is an essential mineral for plant growth and development.
- Dry beans are among the most consumed foods due to being satiating, giving plenty of energy and proteins in its content.
- Potassium has effects on the yield and quality of dry beans.

Abstract

This study was carried out to investigate the effects of 5 different doses of potassium (0, 15, 20, 25 and 30 kg da^{-1}) on some yield and important yield components on 6 different dry bean genotypes of bean [*Phaseolus vulgaris* L.] in Yunak Town – Konya City (TURKIYE) ecological conditions. was made in 2018. The aforementioned research was designed with 3 replications based on "Split Plots in Randomized Blocks Trial Design". According to the results of the research, it has been determined that potassium applications at different doses are statistically significant in terms of emergence time, flowering time, pod setting time, and vegetation period. As a result of the research; the emergence period was 6.33 – 15.67 days, the flowering period 32.00 – 71.67 days, the pod setting time 48.67 – 88.00 days, the vegetation period 84.67 – 118.00 days, the spad value 41.57 – 53.87 spad, number of main branches per plant 2.90 – 5.00, first pod height 9.40 – 18.40 cm, root neck diameter of 4.97 – 31.50 mm, the number of pods per plant varied between 13.30 – 42.00, the number of seeds per pod varied between 3.20 – 5.67 values. When evaluated in general, emergence time, flowering time, pod setting time increased with increasing potassium application, while vegetation time, and first pod height (maximum value at 15 kg da^{-1} dose) values decreased. In the study, all of the shortest duration values in terms of all phonological observations emerged in the Akkiraz genotype, which was applied at a fertilizer dose of 15 kg da^{-1}. The highest value for the first pod height was determined in the 25 kg da^{-1} fertilizer dose X Nirvana genotype, the highest pod number value in the 20 kg da^{-1} fertilizer dose X Nirvana genotype, the highest seed number value in 15 kg da^{-1} fertilizer dose X Nirvana genotype. For the consistency of the research findings, it can be said that longer-term studies and evaluation of different genotypes in different ecologies are required.

Keywords: Agronomy, Cultural practices, *Phaseolus vulgaris*, Fertilization

1. Introduction

If global population growth and current food consumption trends continue, 60% more food will be needed by 2050 than today. Increasing agricultural production is the most reasonable means to meet the need for more

Citation: Yıldırım H, Önder M (2023). Investigation of the effects of potassium on some agronomic traits in dry bean genotypes. *Selcuk Journal of Agriculture and Food Sciences*, 37(1), 72-85. https://doi.org/10. 15316/SJAFS.2023.009
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Received date: 02/01/2023
Accepted date: 10/02/2023

food and fight the problem of poverty. Since arable land is limited, increasing agricultural production can be achieved by increasing the productivity of existing areas under production or by improving and developing problem areas (Dibaba, 2015). However, the natural environments in which agricultural production is carried out are also under the influence of abiotic and biotic stress factors in a complex way. Plant responses to these stresses can be just as complex (Cramer, 2010; Kahraman, 2022). Turkiye has a great potential in terms of agricultural production, and besides seed production, it also has an important place in terms of ownership of processed product technology (Doruk Kahraman and Gokmen, 2021).

Legumes, which we use as food, have an important place in human nutrition both in our country and in the world. While cereals are in first place in the production of field crops, edible legumes are in second place (Gülümser, 2016). It has been reported that legumes, which have an important place in the human diet, have been found in tomb excavations and Egyptian pyramids in studies conducted from ancient times until today (Kızmaz and Gümüş, 2021). After cereals, they are the most produced field crops. In addition to nutrition, it maintains a symbiotic life with the symbiotic Rhizobium bacteria and plays a major role in converting the free elemental nitrogen in the air into a form that can be used by plants (Ceyhan et al., 2014).

While 7% in terms of carbohydrates and 22% in terms of vegetable protein are met in the human diet from legumes in the world; 5% of carbohydrates and 38% of proteins are met in the animal diet. The high protein content in legumes plays an active role in meeting nutritional deficiency. In addition, when compared to other protein groups, the reasons such as being easy to obtain, cheap, low-fat content and high fiber value increase the demand for these product groups (Gthb 2020). While 70% of the world's protein needs are provided from plant sources; 48.5% of vegetable proteins are met from legumes and 66% from cereals (Doğan et al., 2011). It contains an average of 18%-36% protein from edible legumes, as well as having plenty of vitamins A, B and D; it has an important place in nutrition because it contains elements such as calcium, iron, phosphorus and potassium (Yolci, 2020).

Bean is an annual herbaceous plant originating from the genus *Phaseolus* of the *Legumes* (*Fabaceae*) family, originating in Central America, and is one of the most important crops widely grown worldwide for both fresh bean and dried grain. Beans, with approximately 76 species, constitute 50% of the legumes consumed worldwide. Five different bean species are cultivated in the world (Celmeli et al., 2018), and two of them, *P. vulgaris* L. and *P. coccineus* L., are also grown in Turkiye (Smýkal et al., 2015).

Although Turkiye is not the homeland of dry beans, it is an important country for beans in terms of both genetic diversity and food culture, as it has micro gene centers (Kan et al., 2019). Beans, which can be grown in every region of our country, are most common in Central Anatolia. Bean, which has a very important place in the economy, is an important source of income for the farmer (Ulum et al., 2020; Doruk Kahraman and Kahraman, 2023).

Turkiye, which used to be an important bean exporter, has been trying to become a more self-sufficient country in recent years (FAOSTAT, 2018). Due to its geographical structure, Turkiye has a wide variety of bean genotypes. Dry beans can be grown in every region of Turkiye. According to the data of the Turkish Statistical Institute (Tuik, 2021), beans take third place after chickpeas and lentils among grain legumes in terms of cultivation area and production amount. The total amount of dry bean production in an area of approximately 103 thousand hectares in Turkiye in 2020 is 280 thousand tons, and the yield is approximately 2.71 tons ha^{-1}. Dry bean consumption per capita in Turkiye is around 3.5 kg per year, and the adequacy ratio is 75%. The provinces with the most common dry bean cultivation are Konya, Karaman, Erzincan, Niğde, Nevşehir, Samsun and Kahramanmaraş, respectively. In Konya, where this research was conducted, the dry bean cultivation area is 14788 ha, production is 49604 tons and yield is 335 kg da^{-1} (Tuik, 2021).

Potassium plays an important role in plant water relations, growth of new tissues, photosynthesis, water balance, transport of carbohydrates and sugars and activation of enzymes required in various plant metabolic

events. (Coker et al., 2003). Potassium deficiency causes increased susceptibility to drought, and diseases, decreased nitrogen use efficiency, fiber quality and low yield.

Potassium, one of the important macronutrients, is one of the main factors in protein synthesis, synthesis of glycolytic enzymes and photosynthesis (Marschner, 1995). Since drought occurs in plants under both drought and salt stress, K+ has the same importance in both stress conditions. As the amount of water in the soil decreases, the amount of K in the plant also decreases. Kuchenbuch et al. (1986), in their study, they stated that low soil moisture reduces root development and K uptake of onion plants. Plants growing under arid conditions are likely to show K deficiency (Beringer and Trolldenier, 1978). Many studies have shown that K fertilization has eliminated the negative effects of drought (Sangakkara et al., 2001). Potassium increases the resistance of plants to drought stress by regulating of stomata, osmoregulation, energy status, protein synthesis and internal balance (homeostasis) (Beringer and Trolldenier, 1978; Marschner, 1995). At the same time, the continuation of K turgor pressure (Mengel and Arneke, 1982) and reducing transpiration in dry conditions can prevent the plant from being damaged by drought (Andersen et al., 1992).

Cassman et al. (1989), in a 2-year field study in which they evaluated the variability in terms of potassium use efficiency related to potassium uptake, distribution and critical potassium requirements, it was determined that the yield was 29% higher in the first year and 35% higher in the second year in the potassium-use effective cultivars in the plots where potassium was not applied; they stated that the differences in variety yield were due to the higher cocoon set at the later fruit formation points, but this was not related to the differences in potassium distribution between vegetative and generative structures. In addition, if the supply of potassium is not limited, variety yields are similar; yields of two cultivars are closely related to leaf potassium concentration and potassium availability in the soil; it was determined that potassium uptake and total potassium accumulation were higher during the boll development period, especially at low soil potassium levels.

Researcher Yenigün (2021) stated that the potassium content of most of Turkiye's soils is high, but there are great debates regarding the use of potassium. The researcher also stated that the climate has an important effect on potassium availability, that new studies should be established in different soil conditions by using the up-to-date climatic data on potassium for each product, and that the most appropriate potassium dose should be determined in this context.

Considering the above-mentioned basic reasons and numerous literature reviews, it was concluded that the realization of this research, taking into account the needs of the region and the country, is of great importance to contribute to the production of functional food, especially for sustainable agricultural systems and healthy human nutrition. It was carried out in Yunak – Konya (TURKIYE) ecological conditions.

2. Materials and Methods

The field studies of this research were carried out in 2018 in the Sarayköy location of Yunak District of Konya province - Türkiye. In this experiment, which was carried out in 3 replications according to the Split Plots in Randomized Blocks Experiment Design, 5 potassium doses (0, 15, 20, 25 and 30 kg da^{-1} potassium sulfate) were placed on the main plots and dry bean genotypes were placed on the subplots.

The soil layers of 0-30 cm and 30-60 cm, which do not have salinity problems, have a clayey loam texture, are very calcareous, have a moderate amount of organic matter, sufficient in phosphorus, insufficient in potassium, and have normal alkaline character. In this research, as a source of potassium due to the high pH of the soil in the Konya Closed Basin where field trials were established; solid form fertilizer containing Potassium Sulphate (K_2SO_4) containing approximately 50% potassium and 46% sulfur as water-soluble mass was used. Considering that the recommended fertilizer dose is 20 – 25 kg da^{-1}, the application should be done

once before planting; 5 different doses of 0, 15, 20, 25 and 30 kg da^{-1} were applied to the plots before sowing and mixed with a harrow. Climatic features were similar to the long-term average.

In the research, 5 of the registered varieties (Akman-98, Red Kidney Bean type - Akkiraz, Karacaşehir-90, Nirvana and Zirve) supplied by the Department of Field Crops of the Faculty of Agriculture of Selcuk University, which was cultivated in large areas in Konya, were studied for many years. A total of 6 dry bean genotypes, including 1 (Alberto), among the foreign-origin dwarf dry bean populations, which stand out especially due to their high protein yield, were used as material. All registered cultivars and local populations used for integrity are designated as "genotype" in this study.

Considering the factors discussed in the research; a field trial consisting of 6 dry bean genotypes x 5 potassium doses x 3 replications, a total of 90 plots, was established. While the soil prepared by the technique was annealed, the seeds were planted on 19 May 2018, taking into account the regional conditions. Each parcel has a total area of 7.5 m^2, 2.5 m wide x 3.0 m long. A gap of 0.5 m was left between the plots and 2.0 m between the blocks. At harvest, the entire 1 row on the sides of the parcel and the 0.5 m long sections from both ends of the other rows will have an edge effect. According to the results of the soil analysis, suitable base fertilizer was given to the seedbed prepared by the technique before planting and mixed with the soil with a rake. In each plot, 5 rows were planted by hand, which will be opened at a distance of 50 cm with the marker, and it was diluted by hand so that the spacing between the rows was 15 cm after emergence.

During the growing period, cultural treatments (irrigation, fertilization, disease and pest control, hoeing) were carried out by the procedure throughout the experiment. During the vegetation period, irrigation was done according to the need and the plants were not put under water stress. The water needs of the plants were met by the drip irrigation system. After all the plants in the plots have matured, the parts except for the edge effect are harvested by hand, and important agronomic characteristics (emergence time, flowering time, pod setting time, vegetation period, spad value, number of main branches per plant, first pod height, root neck diameter, pod per plant) are harvested by hand. The number of seeds per pod) was determined.

The properties examined within the scope of the research were subjected to statistical analysis with the JUMP 5.0.1 program. As a result of the analysis of variance, the groupings for the features whose "F" value is significant; It was carried out at the 5% level with the "Student's test-test".

3. Results and Discussion

Tables of variance analysis and mean values are given below (From Table 1 to Table 20). As a result of the analysis of variance for the exit time; potassium dose, genotype, and interaction; it was significant at the 1% level. When the potassium dose is examined, the exit time; was detected between 9.44 days (15 kg da^{-1} dose) and 11.28 days (30 kg da^{-1} dose). The emergence times of the genotypes used in the study; while it had the shortest emergence period in the Population genotype with 8.13 days, the longest emergence period was determined in the Karacaşehir genotype at 12.73 days. When the interaction was examined, it was determined that the emergence period varied between 6.33 days and 15.67 days. In another study conducted in Konya ecology, the emergence period in dry bean genotypes was determined in the range of 5.67-19.0 days (Kahraman, 2014). In other studies, on the subject, emergence time in dry bean genotypes; 10-23 days (Yılmaz, 2008), 10.0-15.6 days (Güneş, 2011), 13-25 days (Atıcı, 2013), 6-9 days (Öztürk, 2018). It is thought that the variation in the emergence period may be due to genetic factors, as well as the effects of many factors such as climate, soil structure, and planting depth on the emergence period. A similar situation was observed in other studies conducted in the region (Doruk Kahraman and Gokmen, 2022).

When we look at the flowering period, the effect of potassium dose, genotype and interaction factors was significant at the 1% level. When the fertilizer doses were examined, the flowering period was between 44.39 days (15 kg da^{-1}) and 50.28 days (30 kg da^{-1}). Flowering time values were between 35.47 days (Akkiraz

genotype) and 60.27 days (Karacaşehir genotype). Flowering times for the interaction were determined between 32.00 and 71.67 days. In another study conducted by Kahraman (2014) in Konya ecology, the flowering period in dry bean genotypes was determined in the range of 43.33-63.17 days. According to the results of the studies on beans, the flowering period was 42-50 days (Madakbaş et al., 2004), 42.33-77.00 days (Erdinç, 2012), and 63.72 days (Ekincialp, 2012). The mentioned findings are similar to this study.

As a result of the variance analysis of the pod setting time; the effect of all 3 factors that were the subject of this research was significant at the 1% level. When examined in terms of potassium doses, the said period; was determined between 61.11 days (15 kg da^{-1}) – 64.44 days (30 kg da^{-1}). While the shortest pod tying time was 50.13 days (Akkiraz genotype), the longest time was determined as 77.07 days (Karacaşehir genotype). In terms of interactive effect, the pod setting time varied between 47.33 days and 88.00 days. In another study carried out, it was stated that the eating period of kidney bean and bean genotypes varied between 55-98 days (Öztürk, 2018). In another study carried out on beans, it was reported that genotypes reached eating death in the range of 88.67-128.33 days and the average duration of genotypes was 108.81 days (Loko et al., 2018).

According to the analysis of the variance of the vegetation period, the effect of each of the 3 factors discussed in this study was found to be statistically significant at the 1% level. The values in question in terms of fertilizer dose; it was found that it varied between 95.67 days (30 kg da^{-1}) and 97.22 days (0 kg da^{-1}). Accordingly, the shortest time was 87.67 days (Zirve genotype), while the longest was 111.80 days (Akman). When the values of the interaction were examined, the vegetation period was determined between 84.67 days and 118.00 days. Çirka (2012) conducted a study with 61 poles of 27 dwarf green beans; reported that the dwarf types reached the harvest in 61-83 days. In addition, Erdin (2012) explained in his study that the average harvest time was 92.71 days, and that the genotypes reached the average harvest time of the lowest at 68 days and the highest at 127 days. The researcher's results were found to be quite similar to our results.

Considering the results of the analysis of variance in terms of spad values; differences between genotypes were found to be significant at the 5% level, and significant at the 1% level in terms of interaction. The Nirvana genotype had the lowest spad value with 44.21 spad, and the Akkiraz genotype had the highest value with 47.35 spad. In terms of interaction, the values in question differed between 41.57 spad – 53.87 spad. In another study conducted in Konya ecology, the spad value in dry bean genotypes was determined between 36.82-49.95 days. It is known that chlorophyll content has a significant effect on yield in plant production and varies according to plant and leaf size (Erickson and Wedding, 1956). Similar to the results of this study, Luqueno et al. (2010) examined the effects of different nitrogen sources on yield in beans and determined that the chlorophyll value varied in the range of 10-45 spads. In a study, with chlorophyll content in dry beans; It has been stated that there is a direct and positive interaction with other growth characteristics due to the vegetative growth of the plant (Sara et al., 2013). In another study conducted in the Konya region (Kahraman, 2014), chlorophyll value in dry bean genotypes was determined in the range of 36.82 – 49.95 spads.

Table 1. Variance analysis summary of investigated traits in the trial

		Mean of Squares				
Sources of Variation	**DF**	**Emergence Time**	**Flowering Time**	**Pod Setting Time**	**Vegetation Time**	**Spad**
Replication	2	0,077	1,078	0,533	0,133	49,086
Potassium dose (A)	4	8,600**	88,222**	28,539**	6,961**	7,9603
Error$_1$	8	0,383	0,481	0,339	0,078	4,592
Genotype (B)	5	65,531**	1659,420**	2318,640**	1597,550**	28,611*
(A X B) Int.	20	3,887**	29,002**	45,079**	35,574**	25,8884**
Error$_2$	50	0,296	0,467	0,618	0,089	8,5792
Sources of Variation	**DF**	**Number of Main Branches per Plant**	**First Pod Height**	**Root Neck Diameter**	**Number of Pods per Plant**	**Number of Seeds per Pod**
Replication	2	0,026	0,264	61,668	11,977	3,224
Potassium dose (A)	4	0,436	0,906	73,886	46,092	0,556
Error$_1$	8	0,401	5,549	72,806	24,515	0,652
Genotype (B)	5	2,164**	38,401**	79,442	790,280**	2,054**
(A X B) Int.	20	0,594	23,122**	55,314	117,251**	1,294**
Error$_2$	50	0,375	6,642	56,429	15,571	0,469

*%5, **%1 statistically significance level

Table 2. Table of mean values of emergence time, "flowering time, pod setting time, vegetation time and spad in the bean genotypes

Potassium Dose (kg da^{-1})	Genotypes						Mean
	Akman	**Akkiraz**	**Karacaşehir**	**Nirvana**	**Population**	**Zirve**	
Emergence Time (days)							
0	12,67bcd	7,33mn	13,00bc	11,33ef	7,33mn	9,00jk	**10.11c**
15	12,33cd	6,33o	11,33ef	12,00de	6,67no	8,00lm	**9.44d**
20	11,33ef	9,00jk	13,33b	12,00de	9,00jk	10,00hı	**10.78b**
25	13,00bc	8,33kl	10,33gh	12,67bcd	8,33kl	10,00hı	**10.44bc**
30	11,33ef	9,00jk	15,67a	11,00fg	9,33ıj	11,33ef	**11.28a**
Mean	**12.13b**	**8.00d**	**12.73a**	**11.80b**	**8.13d**	**9.67c**	10.41
Flowering Time (days)							
0	54,67de	33,67o	58,67b	53,00f	36,00mn	39,00ıj	**45,83c**
15	55,33de	32,00p	55,67cd	51,67g	35,00n	36,67lm	**44,39d**
20	51,33g	37,33kl	59,67b	53,00f	38,00jk	41,00h	**46,72b**
25	55,67cd	32,67op	55,67cd	54,33e	37,33kl	39,33ı	**45,83c**
30	51,67g	41,67h	71,67a	56,67c	42,00h	38,00jk	**50,28a**
Mean	**53,73b**	**35,47e**	**60,27a**	**53,73b**	**37,67d**	**38,80c**	46,61
Pod Setting Time (days)							
0	73,33hı	49,33tu	75,00ef	77,33c	50,67rs	52,67pq	**63,06c**
15	72,33ı	47,33v	70,67j	73,67gh	50,33st	52,33pq	**61,11d**
20	68,67k	52,33pq	79,33b	76,00de	52,33pq	54,33no	**63,83b**
25	74,67fg	48,67u	72,33ı	76,67cd	53,33op	51,67qr	**62,89c**
30	64,33l	53,00p	88,00a	71,00j	55,67m	54,67mn	**64,44a**
Mean	**70,67c**	**50,13f**	**77,07a**	**74,93b**	**52,47e**	**53,13d**	63,07
Vegetation Time (days)							
0	118,00a	88,00n	104,00g	98,00j	88,00n	87,33o	**97,22a**
15	115,00c	84,67q	110,00d	96,00k	88,00n	88,00n	**96,94b**
20	108,00e	90,00l	105,00f	96,00k	90,00l	89,00m	**96,33c**
25	116,00b	86,00p	103,00h	96,00k	90,00l	86,00p	**96,17c**
30	102,00ı	90,00l	108,00e	96,00k	90,00l	88,00n	**95,67d**
Mean	**111,80a**	**87,73e**	**106,00b**	**96,40c**	**89,20d**	**87,67e**	96,47
Spad (spad)							
0	43,93e-ı	48,23b-e	41,60ı	46,37b-ı	43,23f-ı	46,27b-ı	**44,94a**
15	46,57b-h	46,77b-h	45,30c-ı	45,97b-ı	44,90d-ı	43,07f-ı	**45,43a**
20	47,63b-f	46,60b-h	42,70ghı	41,57ı	46,70b-h	53,87a	**46,51a**
25	45,97b-ı	45,27c-ı	48,43b-e	44,90d-ı	48,93bcd	42,70ghı	**46,03a**
30	47,20b-g	49,90abc	43,83e-ı	42,27h-ı	44,37d-ı	50,77ab	**46,39a**
Mean	**46,26ab**	**47,35a**	**44,37b**	**44,21b**	**45,63ab**	**47,33a**	45,86

Table 3. Table of mean values of main branches per plant, first pod height, root neck diameter, pods per plant and number of seeds per pod in the bean genotypes

Potassium Dose (kg da^{-1})	Genotypes						Mean
	Akman	Akkiraz	Karacaşehir	Nirvana	Population	Zirve	
Main Branches per Plant" (number/plant)							
0	3,57	3,27	3,50	4,63	4,00	4,37	**3,89**
15	4,03	3,33	2,90	4,03	4,33	3,93	**3,76**
20	3,40	3,40	3,53	4,33	4,63	4,33	**3,94**
25	3,17	3,57	4,33	3,30	4,00	3,67	**3,67**
30	3,13	3,53	4,37	4,37	4,03	5,00	**4,07**
Mean	**3,46c**	**3,42c**	**3,73bc**	**4,13ab**	**4,20a**	**4,26a**	3,87
First pod Height (cm)							
0	14,33a-h	14,00b-h	12,60e-j	15,33a-h	12,67e-j	13,13d-j	**13,68a**
15	11,20hıj	18,13ab	16,27a-e	17,80abc	11,70f-j	9,57ıj	**14,11a**
20	13,67c-ı	17,80abc	9,73ıj	14,73a-h	11,63f-j	14,37a-h	**13,66a**
25	9,40j	12,00f-j	17,07a-d	18,40a	12,77e-j	12,17e-j	**13,63a**
30	15,47a-g	17,40abc	15,57a-f	9,47ıj	12,00f-j	11,30g-j	**13,53a**
Mean	**12,81bc**	**15,87a**	**14,25ab**	**15,15a**	**12,15c**	**12,11c**	13,72
Root Neck Diameter (mm)							
0	9,18b	7,11b	7,96b	8,83b	8,90b	7,73b	**8,29a**
15	12,79b	7,67b	7,24b	9,27b	8,33b	5,37b	**8,45a**
20	8,15b	7,92b	7,64b	7,43b	8,40b	6,57b	**7,69a**
25	7,14b	6,55b	9,12b	7,33b	7,17b	4,97b	**7,05a**
30	10,87b	7,58b	7,47b	31,50a	8,93b	7,00b	**12,23a**
Mean	**9,63ab**	**7,37ab**	**7,89ab**	**12,87a**	**8,35ab**	**6,33b**	8,74
Pods per Plant (number/plant)							
0	21,73j-m	29,47f-ı	25,33h-l	37,73abc	20,60k-n	35,50b-f	**28,39a**
15	17,70mno	19,00l-o	14,73no	41,93ab	33,20c-g	31,03d-ı	**26,27a**
20	15,13no	27,80g-j	31,60c-h	42,00a	24,90ı-l	32,90c-g	**29,06a**
25	14,00 o	22,07j-m	16,33mno	30,73d-ı	36,00a-e	32,40c-g	**25,26a**
30	26,73g-k	16,60mno	13,30 o	29,60e-ı	36,93a-d	34,57c-f	**26,29a**
Mean	**19,06e**	**22,99d**	**20,26de**	**36,40a**	**30,33c**	**33,28b**	27,05
Seeds per Pod (number/pod)							
0	4,33c-f	5,33abc	3,67fg	5,13a-d	4,67a-f	3,20g	**4,39a**
15	4,30c-g	4,53b-f	5,27abc	5,67a	4,80a-e	4,23c-g	**4,80a**
20	5,60ab	4,13d-g	5,27abc	3,67fg	3,60fg	4,63a-f	**4,48a**
25	4,67a-f	5,13a-d	4,67a-f	5,27abc	3,97efg	4,30c-g	**4,67a**
30	5,07a-e	5,67a	4,13d-g	5,27abc	3,97efg	4,40c-f	**4,75a**
Mean	**4,79a**	**4,96a**	**4,60ab**	**5,00a**	**4,20b**	**4,15b**	4,62

In terms of the number of main branches in the plant, only the differences between genotypes were found to be statistically significant ($p<0.01$). Accordingly, the lowest value was determined in the Akkiraz genotype with 3.42 units/plant, and the highest value was determined in Zirve genotype with 4.26 units/plant. Singh et al. (1976) stated that the number of major branches in the plant is an important factor affecting the grain yield in dry beans. Similar to our study results, in various studies in which the number of main branches in a bean

was determined, this value was determined to be between 1.27-12.04 per plant (Anlarsal et al., 2000; Pekşen, 2005; Ülker and Ceyhan, 2008; Kahraman and Önder, 2009; Varankaya and Ceyhan 2012; Önder et al., 2013).

As a result of the analysis of variance for first pod height, genotype and interaction factors were found to be statistically significant ($p<0.01$). The said value differed between 12.11 cm (Zirve) and 15.87cm. In terms of interaction, it was determined that the values in question varied between 9.40 – 18.40 cm. The height of the first pod of beans is important in that the harvest can be done by machine. In various studies, it has been determined that the height of the first pod varies between 3.56-42.60 cm in bean, and it covers the values obtained as a result of our study (Bozoğlu, 1995; Anlarsal et al., 2000; Ceyhan 2004; Düzdemir and Akdağ, 2001; Pekşen, 2005; Pekşen and Gülümser, 2005; Kahraman and Önder, 2009; Önder et al., 2013).

As a result of the analysis of variance in terms of root neck diameter, the effects of the factors that were the subject of this study were found to be statistically insignificant. However, it has been revealed that the values of the root neck diameter show a wide variation in the range of 4.97 mm (25 kg da^{-1} X Zirve genotype) – 31.50 mm (30 kg da^{-1} X Nirvana genotype). It has been stated that there is a statistically significant and positive correlation between root neck diameter and pod filling (Knopkiewicz and Swiecicki, 2013) and the amount of photosynthesis (Stoffella et al., 1981). Researcher Ellal et al. (1982), 3.80-7.20 mm of the diameter of the root neck of dry beans, while Abubaker (2008) determined between 3.54-6.17 mm. In another study conducted in Konya ecology (Kahraman, 2014), the root neck diameter of dry bean genotypes was determined in the range of 5.63 – 20.87 mm.

In terms of the number of pods in the plant, the genotype and interaction effect of the factors that are the subject of the research was found to be significant at the level of 1%. The said value differed between 19.06 (Akman genotype) and 36.40 (Nirvana genotype). When the interactive effect was examined, the number of pods per plant was found to range from 13.30 to 42.00. Ergün (2005) reported that the number of pods per plant of the genotypes ranged from 22.85 to 201.9 units and the average number of pods per plant of the genotypes was 36. Zeytun (1987) found the number of pods per plant between 16.32 and 86.28 in his study. Similar results to our research results were also reported by Ceyhan and Şimşek (2021), Kepildek and Ceyhan (2021), Küçük and Ceyhan (2022), Tamüksek and Ceyhan (2022) and Tekin and Ceyhan (20022).

The effect of genotype and interaction factors, which are the subject of this study, were statistically significant at the 1% significance level in terms of the number of seeds in the broad bean. Accordingly, when the genotypes were examined, this value emerged in the range of 4.15 (Summit) – 5.00 (Nirvana). Considering the interactive effect, it was seen that this value was in the range of 3.20 – 5.67 items. Akbulut (2011) reported that the number of seeds in the pod varied between 5 and 8, and the genotype average was 6.42. Seymen (2010) reported in his research that the number of seeds per pod of genotypes is between 6.7 and 7.5. Zeytun (1987) reported that the number of seeds per pod of 33 bean genotypes grown in the Çarşamba plain was between 3.14 and 5.87. Another researcher reported that the average number of seeds in a fresh pod of 125 genotypes was 5.01, however, the number of seeds in a pod varied between 2.85 and 7.90 (Erdinç, 2012). Similar results to our research results were also reported by Kavasoğlu and Ceyhan (2018), Özsoy Altunkaynak and Ceyhan (2018), Kepildek and Ceyhan (2021), Küçük and Ceyhan (2022), Tamüksek and Ceyhan (2022) and Tekin and Ceyhan (20022)

4. Conclusions

According to the results of this research, in terms of all the phonological observations covered in the study, the shortest time values were determined in the Akkiraz genotype, which was applied at a fertilizer dose of 15 kg da^{-1}. In terms of the first pod height examined in the study, the highest value was determined in the 25 kg da^{-1} fertilizer dose X Nirvana genotype, the highest pod number value in the 20 kg da^{-1} fertilizer dose X

Nirvana genotype, the highest seed number value in the 15 kg da^{-1} fertilizer dose occurred in the X Nirvana genotype.

The main reasons for both the decrease in legume production and the extinction of local varieties in Turkiye are the increase in costs, fluctuations in prices, unreasonable price policies and low yield due to problems in fertilization. Improvement of the economic conditions provided to bean producers, innovations in production practices, and the development of durable and productive bean plants create positive effects on the economy. Due to the increase in population every year, the amount of consumption due to being both a vegetable protein source and one of the basic foods of Turkish cuisine is higher than the previous year.

Author Contributions: Conceptualization, M.O. and H.Y.; methodology, M.O.; investigation, H.Y.; writing—original draft preparation, H.Y.; writing—review and editing, M.O.; visualization, H.Y.; supervision, M.O.; project administration, M.O. and H.Y. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: This article is a part of Hasan YILDIRIM's PhD thesis.

Conflicts of Interest: The authors declare no conflict of interest.

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