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A BREEDING STUDY TO DEVELOP EARLY MATURING SOYBEAN CROSSES SUITABLE FOR DOUBLE CROPPING

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ABSTRACT

The present research was undertaken to evaluate of soybean hybrids environmental interaction and adaptability on Mediterranean region conditions. Seven advanced (F_7) soybean lines selected from the Kunitz x SS-201 and Kunitz x Bert cross populations based on earliness and yield characteristics in the preliminary trials and three soybean varieties (Bravo, Nova and Arisoy) were tested in the trial in four replications in 2017 and 2018 in accordance with the RCBD. The analysis of variance revealed significant variations for all characters. According to results, the yield of lines and varieties 2017 and 2018 varied from 2.87-4,47 t ha^{-1} and 2.61-3.90 t ha^{-1} respectively and KS-39 advanced soybean line had the highest grain yield in terms of two years average. The number of flowering days varied between 32.50 days and 36.75 days according to the two-year averages, and the KS-12 genotype was the earliest flowering genotype. The lines KS-10 (103.38) and KS-12 (103.50) came to the fore as the genotypes with the earliest maturation days. With this study, it has been concluded that promising genotypes can be obtained in regions dominated by the Mediterranean climate zone (especially the Aegean coastline), and soybean cultivation can be done in double crop agriculture within the cropping system.

Keywords: Double crop, Earliness, Mediterranean region, Soybean, Yield.

INTRODUCTION

Soybean is one of the most valuable plant cultivated over the world and is well known as an industrial plant because of rich content in minerals and vitamins has been used over 400 years (Yildirim, 2017). As a legume crop, soybean is capable of utilizing atmospheric nitrogen through biological nitrogen fixation and is therefore less dependent on synthetic nitrogen fertilizers (Pratap et al., 2016). In addition to being a raw material for biofuel production and an indispensable protein source for the animal nutrition sector, it is also a major source of protein and fatty acids in human and animal nutrition. Soybean meal (SBM) is the most commonly used protein source in the animal feed industry (Baker, 2020). High protein content and widespread availability make soybean meal a good source of protein in animal diets (Easter and Kim, 1999). As a source of oil, protein, biodiesel, etc., soybean (*Glycine max* L. Merr.) is the fourth widely grown crop in the world (Ilker et al., 2018b).

World population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050 and can up to 10 billion According the best optimistic predictions, for feeding a world with 9.1 billion population in year of 2050, we will have to increase overall food production by 70%. This implies need production to almost double in the developing countries. On the other hand, urbanization is foreseen to continue and account for urban areas to 70% of world population until 2050. Nowadays agriculture must face with the multiple challenges like increasing demands for food to feed a growing population, have to producing more feedstock for a potentially huge bioenergy market, using sustainable production methods and adapting to climate change. The availability of land and fresh water show a similar picture, there are insufficient and very unevenly distributed in global. Soybean cultivars can be classified as commodity type, which are used for edible or industrial oil and animal feed, and food-type, which are used for human consumption. Developing cultivars with desired seed size and appearance depends on the type of soy food for which the soybeans are destined (Jegadeesa and Yu, 2020). Whereas the major breeding targets for food grade soybeans are high protein, carbohydrates and sucrose content, soybean seed with a high content of high protein content and oil content are preferred for feed industry.

Soybean cultivars can be classified as commodity type, which are used for edible or industrial oil and animal feed and food-type, which are used for human consumption. Developing cultivars with desired seed size and appearance depends on the type of soy food for which the soybeans are destined. Whereas the major breeding targets for food grade soybeans are high protein, carbohydrates and sucrose content, soybean seed with a high content of high protein content and oil content are preferred for feed industry. Most economically important traits in various agricultural crops are quantitative nature (Silva et al., 2017). Undoubtedly, the increase in grain yield has been the main objective of breeding programs (Bezerra et al., 2017). Soybean yield is a complex quantitative trait and is highly affected by environmental condition. Many analyses under different climate change conditions indicates that climate change may significantly reduce yields in the long run (Porter et al., 2014). On the other hand, availability of genetic variability for soybean offers to improve new soybean varieties by hybridization or assisted breeding. There is an increasing many number of countries or regions, reaching alarming levels of water scarcity of in the world. In Mediterranean climate conditions, soybean can be produced as a double crop. Because of this trends market demand for food would continue to grow and it is expected that the demand for cereals, for both food and animal feed uses be projected to reach some 3 billion tons by 2050, up from today's nearly 2.1 billion tons. Turkey should produce more soybean to reduce soybean imports. Although not a major share of Turkey in world soybean production is ahead of many countries in terms of soybean yield. Soybean has an important place in the Mediterranean Region in terms of planting area and production.

In this study, it was aimed to determine the high yielding and early maturing genotypes suitable for double crop in the soybean breeding program, which has been carried out for many years, within the scope of the variety development project suitable for the Mediterranean climate zone.

MATERIALS AND METHODS

50 single plants were selected separately from two F_5 bulk populations (Kunitz x SS-201 and Kunitz x Bert crosses) which obtained from the soybean breeding project carried out in Izmir Bornova in 2014. The selected lines were planted in rows with a length of 5 m and a row length of 70 cm in 2015, with 45 plants per m^2, in augmented design, together with five replications of 6 control varieties (Arisoy, Nova, Sa88, Umut-2002, Bravo and Ataem-7). Among the genotypes cultivated in the augmented design, 7 soybean lines that stand out in terms of maturation days and flowering days were selected. Seven advanced soybean lines and three registered varieties having early maturity (Bravo, Nova, and Arisoy) were evaluated in two trials laid out in 2017 June22 and 2018 June 26. Field trial was conducted in a randomized complete block design (RCBD) with four replications. Each plot consisted of 4 rows 5 m long. The seeds inoculated with *Bradyrhizobium japonicum* bacteria, were sown in June after wheat harvest by hand over 45 plants per square meter. Before planting, 200 kg ha^{-1} of DAP (36 kg ha^{-1} N, 92 kg ha^{-1} P) fertilizers were applied in all environments. Irrigation was performed four times with sprinkler irrigation system. Bornova is located (Latitude 38°28' and Longitude 27°13') in the western part of Turkey at Aegean Sea with altitude of 27 m and dominated by the Mediterranean climate conditions.

The climatic data during the 2017-2018 growing period in experimental area were presented in Table 1. The experimental area has a heavy soil structure with clay-silt soil at 0-20 cm depth and clay-loamy structure at 20-40 cm depth (Ozturk and Yildirim, 2020). The soil test indicated a pH of 7.63 with 1688 kg ha^{-1} of K_2O and 7.40 kg ha^{-1} of P_2O_5. In addition, the organic matter content of the soil was very low (1.52%) and the lime content was 7.60% (Ozturk, 2021).

Analysis of variance was performed according to the Randomized Complete Block Design (RCBD) for the traits measured in the field trial. The means were compared by using the standard LSD test (Steel and Torrie, 1980).

Table 1. The climatic data during the 2017-2018 growing period in experimental area (Anonymous, 2018)

Months/Years	Average temp. (°C)		Relative humidity (%)		Precipitation (mm)	
	2017	2018	2017	2018	2017	2018
June	19.8	20.7	56.2	55.6	1.8	29.7
July	23.4	23.3	46.5	53.4	1.4	0.3
August	24.0	24.1	49.4	55.8	0.3	5.8
September	17.4	19.7	56.8	58.7	0.9	2.7
October	12.9	14.4	60.7	70.9	45.7	39.7

RESULTS AND DISCUSSION

100 lines selected from F5 bulk populations of Kunitz x SS-201 and Kunitz x Bert hybrid combinations were tested with 5 control varieties on the basis of Augmented trial design in 2015 (Table 2). Variance analysis showed that seven crossed genotypes are statistically superior or similar to the control varieties in terms of flowering and maturation times. These genotypes were selected according to 7% selection intensity for repeated trials.

Table 2. Mean squares for days for flowering (DFF) and days for maturity (DFM) of the data obtained from the experiment set up in the augmented design in 2015.

Source	Df	DFM, day	DFF, day
Genotypes (G)	4	3.53*	6.453**
Block	5	0.367ns	4.333*
Error	20	0.787	1.553

ns: non significant, *: significant at 0.05 level, **: significant at 0.01 level

Of the selections made according to early flowering and early maturation times (data were not shown), only one (KB-67) belonged to the Kunitz x Bert hybrid combination, while the other 6 promising combinations were obtained from Kunitz x SS-201 F5 hybrids.

Analysis of variance was performed for control genotypes and selected cross genotypes (progenies) according to the Randomized Complete Block Design in the next trial years 2017 and 2018. Since the year interaction is significant for many agronomical traits, the combination over the years was not applied. Results from the analysis of variance for all traits demonstrated that differences among mean values for all genotypes and both growing years (environments) were significant. Besides, there were significantly genotype x year interactions for all traits indicated that differences among average values of genotypes were affected differently for two years except days for maturity, days for flowering, and number of grain per pods (Table 3).

Table 3. Mean squares for grain yield (GY), plant height (PH), first pod height (FPH), pods per plant (PPP), days for flowering (DFF), days for maturity (DFM), 100-seed weight (HKW), and grain per pods (GPD).

Source	Df	GY, t ha^{-1}	PH, cm	FPH, cm	PPP (number)
Genotypes (G)	9	152479.891**	201.772**	38.568**	1596.751**
YxG	9	402385.966**	293.88ns	7.134**	619.335**
Years	1	47709.552**	646.385**	317.206**	8422.434**
Block	3	1447.911ns	99.977ns	2.911ns	17.442ns
Error	57	1460.267	44.32	1.177	71.007
Source	**Df**	**DFM, day**	**DFF, day**	**HKW, g**	**GPP (number)**
Genotypes (G)	9	52.707**	28.089**	28.887**	0.054ns
YxG	9	23.762*	1.744*	2.608**	0.082*
Years	1	0.113ns	0.8ns	21.632**	0.105ns
Block	3	0.546ns	0.1ns	3.196**	0.012ns
Error	57	1.046	0.793	29.543	0.031

ns: non significant, *: significant at 0.05 level, **: significant at 0.01 level

According to the variance analysis results, it was determined that the variation between genotypes for plant height was statistically significant and the genotype x year interaction had an insignificant mean square. Over the two trial years, the KS-11 (94.5 cm) crossed genotype had the highest average plant height and KS-10 (90.5 cm), which is also another crossed genotype, took the second place. The data shows that the average plant height of the three cultivars tested as control cultivars was lower than the advanced lines (Table 4). Similar results were obtained for plant height with other research findings from soybean genotypes in similar maturation groups and conditions (Gulluoglu et al., 2016; Bakal et al., 2015; Yigit et al., 2021). The plant heights observed in this study were found to be higher than the findings of Arslan et al. (2006) and Caliskan et al. (2007).

Table 4. The means of soybean lines and varieties and LSD groups of grain yield (GY), plant height (PH), first pod height (FPH), pods per plant (PPP).

	Grain yield (t ha^{-1})			Plant Height (cm)			First Pod Height (cm)			Pods Per Plant (piece/plant)		
Genotypes	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
BRAVO	3,79D	3,41DE	3,60	74.90	82.70	78.80E	14.33C	15.48D	14.90	132,15B	79,65DE	105,90
NOVA	3,91D	3,14F	3,53	77.90	84.20	81.05DE	11.40D	14.60DE	13.00	116,90C	80,90DE	98,90
ARISOY	3,86D	3,34E	3,60	82.95	87.55	85.25BCDE	12.48D	19.50B	15.99	91,85EF	76,05E	83,95
KB-67	2,87G	3,16F	3,02	83.45	83.50	83.48CDE	12.40D	13.88E	13.14	150,15A	109,10AB	129,62
KS-39	4,47A	3,90A	4,18	82.10	84.25	83.18CDE	15.30BC	18.85BC	17.07	112,90CD	116,50A	114,70
KS-14	3,19F	3,65BC	3,42	87.00	91.55	89.28ABC	17.03A	21.80A	19.41	103,10DE	99,23BC	101,16
KS-12	3,19F	2,61G	2,90	73.85	85.90	79.88DE	12.25D	17.48C	14.86	98,80EF	89,70CD	94,25
KS-11	4,28B	3,73B	4,01	93.35	95.75	94.55A	14.40BC	17.65C	16.02	102,29DEF	86,88DE	94,58
KS-10	3,50E	3,60BC	3,55	88.15	92.85	90.50AB	15.45BC	19.40B	17.42	91,10F	78,45DE	84,77
KS-2	4,07C	3,53CD	3,80	80.20	92.45	86.33BCD	15.88AB	22.10A	18.99	100,53EF	78,10DE	89,31
LSD		0,153				6,620		1,527			11,857	

First pod height (FPH) is an important trait associated with reducing grain loss in machine harvesting. Therefore, it is desired to be high. Although the interaction is important for this trait, it was understood that the averages of the leading genotypes in both years were in the same statistical groups. It was observed that especially KS-14 among the crossed lines improved by selections, showed a very high performance (19.4 cm), followed by KS-2 (18.9 cm) and KS-10. It was determined that the FPH averages of these genotypes were higher than the control cultivars and had significant FPH values. While the first pod height obtained in our study was close to Bakal et al. (2015) and Gulluoglu et al. (2016)'s findings, it was higher than Caliskan et al. (2007) and Arslan et al. (2006)'s findings.

The number of pods per plant is one of the most important parameters determining the yield in legumes. The LSD groups related to the number of pods in the plant, which is one of the most important characteristics that determine and affect the yield, are shown in Table 4. While the number of pods per plant of the genotypes included in the experiment varied between 91.10 and 150.15 (KB-67) in 2017, it varied between 76.05 and 116.50 (KS-39) in 2018. The number of pods per plant was higher in the first year of the study. According to the mean yield of two-years, KB-67 was the advanced line with the highest number of pods, while the KS-39 was the second promising genotype for this trait. The number of pods per plant obtained in this study was found to be higher than other studies (Caliskan et al., 2007; Bakal et al., 2015; Gulluoglu et al., 2016; Onat et al., 2017).

In this study, a statistically significant result could not be reached for the number of grains (GPP) per pod (Table 3) It was determined that the average GPP values of the genotypes were generally very similar to each other (Table 5).

Table 5. The means of soybean lines and varieties and LSD groups of days for flowering (DFF), days for maturity (DFM), 100-seed weight (HKW), and grain per pods (GPD).

	Days For Flowering (day)			**Days For Maturity (day)**			**100-Seed Weight (g)**			**Grain Per Pods (piece/pod)**		
Genotypes	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
BRAVO	33,00C	32,25CD	32,63C	104,75C	105,50CDE	105,13D	16,05CD	16,13C	16,09	2,30C	2,35B	2,32
NOVA	32,75C	33,50C	33,13C	105,25C	104,50E	104,88D	16,73C	15,75C	16,24	2,55AB	2,60A	2,57
ARISOY	32,50C	32,50CD	32,50C	107,50B	106,75C	107,13C	15,08D	15,30C	15,19	2,68A	2,28B	2,48
KB-67	35,50B	37,25A	36,38AB	107,25B	106,00CD	106,63C	13,48E	12,68C	13,08	2,28C	2,40AB	2,34
KS-39	36,25AB	35,25B	35,75B	105,25C	105,00DE	105,13D	16,75C	15,80C	16,275	2,45ABC	2,63A	2,54
KS-14	33,00C	32,50CD	32,75C	111,25A	111,00A	111,13A	20,40A	19,73A	20,065	2,55AB	2,48AB	2,51
KS-12	33,00C	32,00D	32,50C	102,75D	104,25E	103,50E	18,19B	16,18BC	17,185	2,38BC	2,48AB	2,43
KS-11	36,25AB	36,75A	36,50AB	110,25A	109,25B	109,75B	18,48B	17,18B	17,83	2,58AB	2,25B	2,41
KS-10	33,50C	32,75CD	33,13C	102,25D	104,50E	103,38E	16,05CD	15,78C	15,915	2,60AB	2,40AB	2,50
KS-2	37,25A	36,25AB	36,75A	104,50C	105,00DE	104,75D	16,30C	12,60D	14,45	2,58AB	2,35B	2,46

In this study, the number of flowering days of the genotypes varied between 32.50 days and 36.75 days, according to the two-year averages. While KS-12 genotype was the earliest flowering genotype, it was determined that three registered cultivars with KS-10 and KS-14 lines were in the same statistical group as KS-12 and had early flowering characteristics. Although these genotypes are in the same statistical group as the control varieties Bravo, Nova and Arisoy, when the interaction groupings are examined, it was determined that the second year KS-12 had a shorter flowering period than all other genotypes (Table 4). Similarly, KS-10 and KS-12 soybean lines were determined to be the earliest maturing genotypes statistically in this study. Gulluoglu et al. (2011) and Ramteke et al. (2010) reported similar results for number of maturing days of soybean varieties.

100-seed weight is one of the important characteristics that affect the yield and show the grain size. Variations in terms of 100-seed weights were found statistically significant. Although the interaction was found to be significant according to the years, it can be said that this situation is due to the fact that the KS-2 genotype, which is a crossed advanced line, has a relatively low 100-seed weight value in the second year compared to the first year. Besides, with the average temperature values in vegetation period of 2018 September and October being 2 degrees higher than in 2017, a general decrease trend was observed in the hundred-seed weights of all genotypes. The 100-seed weight of soybean varieties and lines ranged from 13.48 g to 20.4 g in 2017 and varied between 12.60-19.73 g in 2017. The two-year average 100-seed weight ranged between 13.08-20.06 g (Table 5). The highest hundred grain weight value was clearly obtained from the KS-14 crossed line. Our results in terms of 100-seed weight are in partial agreement with those reported by Arslan et al. (2006), Bakal et al. (2015) and Gulluoglu et al. (2016).

The results were significant with a 1% probability between genotypes, between years and for genotype x environment interaction, while the difference between replications was insignificant for grain yield (Table 3). Considering the average grain yield values, it was determined that the KS-39 line was the genotype with the highest grain yield with 4.47 t ha^{-1} in 2017 and 3.90 t ha^{-1} in 2018 and 4.18 t ha^{-1} over the two years (Table 4). Following this, KS-11, which is statistically superior to other genotypes in terms of grain yield, has a grain yield of 4.01 t ha^{-1} over an average of two years. However, it has been determined that this promising genotype has a longer maturation period than the others, and therefore it may be beneficial to re-evaluate it under main product conditions instead of second crop conditions. Finally, in this study, the grain yield varied between 2.90 t ha^{-1} and 4.18 t ha^{-1}, and control varieties Bravo and Arisoy cultivars stood out with 3.60 t ha^{-1} (Table 4). It was indicated that genotypes of the present study are highly promising lines and shows superiority than those researchers' Ilker et al. (2018a) who reported grain yield ranged from 2.5-3.4 t ha^{-1} in the same growing conditions in Izmir. Mariani et al. (2012) who reported soybean grain yield between 2.5 t ha^{-1} and 2.8 t ha^{-1} in northern Rio Grande do Sul State conditions on the other hand, current results showed similarities with the findings of Ilker (2017) and the results of Gulluoglu et al. (2016) who reported that soybean yield can reach 4 t ha^{-1} and more in double cropping conditions at Adana province.

CONCLUSION

In conclusion, some agronomic traits of advanced soybean genotypes selected according to early maturing characteristics were investigated in this study. It was determined that among the selected genotypes, KS-39 and KS-11 stand out in terms of yield will be considered as registered variety candidates. Harvesting two crops in one year from the same field enables the efficient use of dwindling agricultural areas. Thus, double crop agriculture has a contribution to the problem of increasing population and decreasing agricultural area. With this study, it has been concluded that promising genotypes can be obtained in regions dominated by the Mediterranean climate zone (especially the Aegean coastline), and soybean cultivation can be done in double crop agriculture within the cropping system.

LITERATURE CITED

Anonymous. 2016. The Meteorological Data for Bornova. Olive Research Institute Meteorological Station.

Arioglu, H.H. 2014. The Oil Crops Growing and Breeding. The Publication of University of Cukurova. Faculty of Agriculture. Faculty number: 220. Book Number: A-70. 204 p. Adana-Turkey.

Arslan. M., N. Isler and S. Caliskan. 2007. Effects of cultivar maturity on growth and yield of double cropped soybean. Acta Agric. Scan. Section B-Soil and Plant 56: 39-46.

Bakal, H., L. Gulluoglu. B. Onat and H. Arioglu. 2017. The Effect of Growing Seasons on Some Agronomic and Quality Characteristics of Soybean Varieties in Mediterranean Region in Turkey. Turk J Field Crops. 22(2): 187-196.

Baker, D.H. 2000. Nutritional constraints to use of soy products by animals. In: Drackley, J.K. Ed. Soy in Animal Nutrition. Federation of Animal Science Societies, Savoy. Pp. 1-12.

Bellaloui, N., H.A. Bruns, H.K. Abbas, A. Mengistu, D.K. Fisher and K.N. Reddy. 2015. Agricultural practices altered soybean seed protein, oil, fatty acids, sugars and minerals in the Midsouth USA. Front. Plant Sci. 31 (6):1-14

Bezerra, A.R.G., T., Sediyama, F.L.D., Silva, A., Borém, A.F.D., Silva and F.C.D.S., Silva. 2017. Agronomical aspects of the development of cultivars. In *Soybean breeding*. Springer, Cham.:395-411

Board, J.E and W. Hall. 1984. Premature flowering in soybean yield reductions at non-optimal planting dates as influenced by temperature and photoperiod. Agron. J. 76: 700-704.

Boerma, H.R. and D.A. Ashley. 1982. Irrigation row spacing and genotype effects on late and ultra-late planted soybeans. Agron. J. 78: 995-1002.

Caliskan. S., M. Arslan. I. Uremis and M.E. Caliskan. 2007. The Effects of Row Spacing on Yield and Yield Components of Full Season and Double-Cropped Soybean. Turk J Agric For. 31:147-154

Easter, R.A. and S.W. Kim. 1999. Routes of use of soybean products. In: Opportunities for Soy Products in Animal Nutrition. Federation of Animal Science Societies, Savoy. pp. 1-8.

Gaffaroglu Yetkin, S. and H. Arioglu. 2009. Determination of Yield and Important Plant Characteristics of Some Soybean Varieties and Genotypes Grown as a Main Crop in the Cukurova Region. Cukurova University. E-Journal of Institute of Natural and Applied Sciences. 20(1):29-37 (in Turkish with English abstract).

Gulluoglu L., H. Arioglu and C. Kurt. 2011. Adaptability and Stability of New Soybean Cultivars under Double Cropped Conditions of Turkey. African Journal of Agricultural Research Vol. 6(14). pp. 3320-3325. DOI: 10.5897/AJAR10.913

Gulluoglu, L., H. Bakal and H. Arioglu. 2016. The Effects of Twin Row Planting Pattern and Plant Population on Seed Yield and Yield Components of Soybean at Late DoubleCropped Planting in Cukurova Region. Turk J. Field Crops. 21:59-65.

Holshouser, D.L. 2010. Days to Soybean Physiological Maturity. Virginia Polytechnic Institute and State University 3009-1459. Access date: 02.11.2018. Web address: https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/3009/3009-1459/3009-1459_pdf.pdf

Ilker. E. 2017. Performances of Soybean [Glycine max (L.) Merr.] Advanced Lines Grown in Second Cropping under Mediterranean Climatical Conditions of Western Turkey. Turk J Field Crops. 22(1): 104-107.

Ilker, E., M. Kocaturk, A. Kadiroglu, A. Yildirim, G. Ozturk, H. Yildiz, and I. Koken, 2018a. Adaptation Abilities and Quality Parameters of Selected Soybean Lines under Double Cropping in the Mediterranean Region. Turkish Journal of Field Crops 23 (1): 49-55. DOI: 10.17557/tjfc.421584

Ilker, E., M. Kocaturk, A. Kadiroglu, M. Altinbas, A. Yildirim, G. Ozturk and H. Yildiz. 2018b. Stability Analyses for Double Cropping in Soybean [(Glycine max L.) Merrill]. Turkish Journal of Field Crops 23 (2): 80-84.

Jegadeesa S. and Kangfu Y. 2020. Food Grade Soybean Breeding, Current Status and Future Directions. In: Legume Crops-Prospects, Production and Uses. Ed. M. Hasanuzzaman. IntechOpen, London. 10.5772/intechopen.92069.

Kane. M.V., C.C. Steele and L.J. Grabau. 1997. Early maturing soybean cropping system: I. Yield response to planting date. Agron. J. 89: 454-458.

Ozturk, G. and Z. Yildirim. 2020. New Potato Breeding Clones for Regional Testing in Western Turkey. Turkish Journal of Field Crops. 25(2): 131-137.

Ozturk, G. 2021. Field Performance of Different Seedling Types Used in Sweet Potato [Ipomea batatas (L.) Lam] Growing. Turkish Journal of Field Crops. 26(1): 54-59.

Pratap, A., S.K., Gupta, J., Kumar, S., Mehandi, V.R. Pandey. 2016. Chapter 12 - Soybean, Breeding Oilseed Crops for Sustainable Production. Academic Press: 293-315.

Ramteke, R., V., Kumar, P., Murlidharan and D.K. Agarwal. 2010. Study on genetic variability and traits interrelationship among released soybean varieties of India [Glycine max (L.) Merrill]. Electronic Journal of Plant Breeding. 1(6): 1483-1487

Silva, F.L.D., M.D.V.D., Resende, W.H., Ludke and T.V. Bueno. 2017. Quantitative Traits in Breeding. In Soybean Breeding (pp. 81-112). Springer, Cham.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd edition. McGraw-Hill, New York, USA, pp. 20-90.

Yigit, A., O., Erekul and N., Yarasir. 2021. The Effects of Deficit Irrigation and Sulphur Fertilization on Soybean Growth and Chlorophyll (SPAD) Content. COMU J. Agric. Fac. 9(1): 105-117.

Yildirim. A. 2017. Determination of Yield and Important Agronomic Traits of Some Soybean Varieties and Lines

Grown under Second Crop Condition in the Aegean Region. MSc Thesis. Ege University Graduate School of Natural and Applied Sciences. 69 pages.
Yildirim. A., H. Yildiz, E. Ilker and S. Ekren. 2020. Determination of Yield and Agronomic Characteristics of Some Soybean Genotypes Suitable for Double Crop Agriculture in Mediterranean Climate Conditions. 30th Scientific-Experts Conference of Agriculture and Food Industry, 44-50.