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PERFORMANCES OF SOYBEAN [*Glycine max* (L.) Merr.] ADVANCED LINES GROWN IN SECOND CROPPING UNDER MEDITERRANEAN CLIMATICAL CONDITIONS OF WESTERN TURKEY

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ABSTRACT

The purpose of this research was to determine promising soybean [*Glycine max* (L.) Merr.] advanced genotypes grown in second cropping under the growing conditions of Mediterranean climate in the western Turkey. The field trials were conducted at the experimental field of the Ege University, Faculty of Agriculture, Department of Field Crops in 2014 and 2015. Ten advanced breeding lines and four registered varieties were grown in a Randomized Complete Block Design (RCBD) with four replications. Results of the combined analysis of variance for all traits (grain yield, plant height, first pod height, pods per plant, days for flowering, days for maturity, 100-seed weight) indicated large variations among the genotypes, years and genotype x year interaction. According to the results advanced breeding lines KASM03, KASM02 and KAMA were the highest yielding genotypes with early maturity. Other promising genotypes should be tested under main cropping conditions due to their late maturity.

Key words: Adaptation, advanced lines, maturity, soybean.

INTRODUCTION

The soybeans are produced in 121 million hectares in the world (Anonymous, 2017). Only, 2.92% of the 1.153 million hectares of oil seeds grown in Turkey is devoted to soybeans (TUIK, 2014). Therefore Turkey is one of the major countries that imports soybeans. A total of US $ 1.164 billion was spent on imports of soybean and soybean meal in Turkey in 2015 (Anonymous, 2016). On the other hand, although the average soybean yield of Turkey is 4370 kg ha^{-1}, the world average soybean yield is 2620 kg ha^{-1} (Yildirim, 2017). These figures demonstrate the importance of soybean in Turkey's oilseed markets.

In Turkey, second cropping of soybean is carried out in the provinces of Adana and Osmaniye (Yilmaz ve Efe, 1998; Gulluoglu et al., 2016). However, Arioglu (1987) informed that second crop soybean cultivation is possible after wheat or barley in the western and southern regions where irrigation is also possible, of Turkey. In these areas where Mediterranean climatic conditions prevail, maturation group of a genotype is another important issue besides yield and quality in soybean genotypes. Since selecting a genotype maturing too early may results in short plants and lower yield also selecting a genotype maturing too late may results green leaves and pods at harvesting time. Therefore, high yielding genotypes with medium early maturity (group III) are needed for second cropping soybean.

This research was planned to determine promising soybean genotypes with high yielding potential and suitable for second cropping in the ecological conditions of Izmir province located in the western Turkey.

MATERIALS AND METHODS

Ten high-yielding early advanced soybean [*Glycine max* (L.) Merr] lines (Table 1) bred by different institutions of "General Directorate of Agricultural Research and Policies, Republic of Turkey" and four registered soybean varieties having maturity group III and IV (Arisoy, Ataem7, Bravo and Nova) were evaluated in two trials conducted in 2014 (planted on June 23) and 2015 (planted on June 24) second crop growing seasons after wheat at Bornova-Izmir. 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 climatical conditions. 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 (Ilker, 2011).

Table 1. Advanced soybean lines and registered varieties studied in the research

Advanced lines (F_9)	Pedigree	Advanced lines (F_9)	Pedigree
BATEM 207	Ataem-6 x A-3935	BDUS-04	Umut 2002 x Sprite 87
BATEM 223	J-357 x 9392	KAMA	Macon x Apollo
BATEM 306	Ataem-6 x ETAE-8	KANA	NE 3297 x AP 2292
BATEM 317	Prota x Ap- 2292	KASM-02	Sprite 87 x Macon
BDSA 05	Sprite 87 x Apollo	KASM-03	Sprite 87 x Macon
Registered varieties: Arisoy, Ataem7, Bravo and Nova			

The trials were laid out in the Randomized Complete Block Design with four replications. Each plots consisted of 4 rows 5 m long spaced apart. The seeds, inoculated with *Bradyrhizobium japonicum* bacteria, were sown by hand as taking place 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 both growing seasons. Sprinkler irrigation was performed 6 times starting with sowing time in both years. Observations and measurements were done for seven characters (grain yield, plant height, first pod height**,** pods per plant, days for flowering, days for maturity, 100-seed weight) from the center rows of the each plot.

A combined analysis of variance over two years was calculated for each traits and LSD (least significant difference) test was applied to compare the differences (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Results from the combined analysis of variance for all traits indicated that differences among mean values for both genotypes and growing years (environment) were significant. Besides, genotype x year interactions for all traits were significant indicating that differences among mean values of genotypes varied with year effects (Table 2).

Table 2. Results of combined analyses of variance over two years 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 (HSW)

Source	Df	GY	PH	FPH	PPP	DFF	DFM	HSW
Years (Y)	1	9923,62**	5384,06**	28,20	34591,46**	10,94**	1872,89**	2364,95
Eror1	6	667,45	30,11	11,69	98,36	0,71	11,80	713,03
Genotypes (G)	13	4607,87**	409,75**	39,73**	971,78**	9,25**	45,27**	2453,33**
YxG	13	3598,13**	160,87**	15,59**	1223,48**	16,69**	16,03**	665,53**
Combined eror	78	1072,95	41,63	3,06	117,43	0,68	1,82	146,01

The mean values of the traits studied are presented in Table 3.

The first pod height is desired higher for machine harvesting. It has been understood that the soybean lines in current study perform better than the control varieties for this trait. Considering the mean values of the two-year, it can be clearly said that soybean lines BATEM306 and BATEM317 are significantly superior genotypes for the first pod height. Our results obtained from all genotypes are in agreement with Yilmaz et al. (2005)'s results. However, in another study involving some common registered varieties, Bakal et al. (2016) reported that the average first pod height of 20 cm was reached in Adana conditions. The differences may be due to the fact that the researchers have already conducted their trials 10 days earlier in each year than this study.

The values of days for flowering (DFF) and days for maturity (DFM) express the earliness especially for the second product conditions. In this study which days for flowering varied between 33 and 36.5 days, it has been determined that there are differences exceeding one week for the DFM. The mean values of the lines and varieties varied from 100.9 days to 109.5 days for DFM. In this study, flowering and maturation days of the registered varieties were generally better than advanced lines for the second crop conditions. At the same time, soybean advanced lines KASM02 and KASM03 were superior to registered cultivars Arisoy and ATAEM7. Also KAMA soybean line has been determined to have the same maturation period with these varieties.

Table 3. Mean values of the genotypes and varieties and the LSD grouping

Genotypes	Grain yield (kg ha^{-1})			Plant height (cm)			First pod height (cm)			Pod number plant^{-1}			Days for flowering (DFF)			Days for maturity (DFM)			100 seed weight (g)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
BATEM 207	3661 bf	3629 ab	3645 ad	91,2 cf	79,7 ce	85,4 b	7,8 be	8,2 ad	8,0 b	81,2 f	82,0 ac	81,6 df	34,8 bd	35,3 c	35,0 de	103,0 f	108,0 ce	105,5 c	15,3 df	17,7 be	16,5 eh
BATEM 223	3826 ad	3619 ab	3723 ac	85,1 dg	85,6 bc	85,3 b	4,2 eg	10,2 ab	7,2 bc	124,9 ac	70,8 ae	97,8 bc	34,0 ac	36,3 cd	35,1 de	102,2 ef	109,8 eg	106,0 c	14,8 f	13,8 g	14,3 i
BATEM 306	3882 ad	3652 ab	3767 ab	101,3 ab	90,5 ab	95,9 a	10,1 b	10,6 a	10,3 a	110,7 cd	68,6 be	89,7 ce	33,5 a	38,5 ef	36,0 fg	102,7 ef	109,5 df	106,1 c	16,2 cf	17,6 be	16,9 dh
BATEM 317	4034 ab	3893 a	3963 a	95,5 bc	94,9 a	95,2 a	14,4 a	9,4 ac	11,9 a	74,6 f	78,3 ad	76,4 f	33,8 ab	39,3 f	36,5 g	106,5 g	112,5 g	109,5 d	15,9 ef	16,8 cf	16,0 gh
BDSA 05	3474 dg	3354 bc	3414 ce	83,3 eg	80,0 ce	81,6 bc	4,9 eg	7,3 ce	6,1 cd	89,1 ef	71,3 ae	80,2 ef	33,2 a	38,0 e	35,6 ef	98,5 ac	111,8 fg	105,1 c	17,1 bd	21,4 a	19,2 b
BDUS 04	3019 g	3274 bc	3147 e	85,7 dg	80,9 bd	83,3 bc	4,3 eg	8,0 be	6,1 cd	110,4 cd	68,0 ce	89,2 ce	33,8 ab	36,5 d	35,2 de	99,2 bd	110,8 eg	105,0 c	20,2 a	22,9 a	21,5 a
KAMA	3774 ae	3672 ab	3723 ac	81,5 f	66,0 g	73,7 de	4,1 eg	8,4 ad	6,2 cd	130,4 ab	64,1 de	97,3 bc	35,5 de	33,5 b	34,5 cd	97,0 a	109,0 df	103,0 b	17,1 be	18,7 bc	17,8 cd
KANA	3564 cf	3998 a	3781 ab	95,0 bc	76,3 df	85,6 b	8,0 bc	7,4 ce	7,7 bc	86,1 ef	74,1 ad	80,1 ef	36,0 e	35,3 c	35,6 ef	101,0 df	109,5 df	105,3 c	17,4 bc	17,9 bd	17,6 cf
KASM 02	3828 ad	3615 ab	3721 ac	85,9 dg	70,8 eg	78,4 ce	5,4 df	4,6 f	5,0 df	116,2 bc	75,7 ad	96,0 c	35,0 ce	33,3 ab	34,1 bc	96,5 a	107,5 cd	102,0 ab	16,0 cf	17,8 bd	16,9 dg
KASM 03	4170 a	3582 ac	3876 a	82,2 gf	63,1 g	72,6 e	3,7 fg	4,6 f	4,1 ef	136,9 a	84,9 a	110,9 a	35,0 ce	33,0 ab	34,0 bc	97,7 ab	106,5 bc	102,1 ab	18,1 b	17,4 ce	17,8 ce
ARISOY	3274 fg	3542 ac	3408 ce	92,5 bd	70,1 fg	81,3 bc	4,0 eg	6,9 df	5,4 de	136,2 a	58,7 e	97,5 bc	34,2 ac	32,3 a	33,2 a	100,0 cd	106,3 bc	103,1 b	15,2 ef	15,9 ef	15,5 hi
ATAEM 7	3350 eg	3312 bc	3331 de	105,4 a	81,5 bd	93,5 a	6,5 ce	6,7 df	6,6 bd	87,9 ef	63,3 de	75,6 f	34,8 bd	32,3 a	33,5 ab	100,7 de	104,8 ab	102,7 b	17,8 bc	19,4 b	18,6 bc
BRAVO	3841 ad	3128 cd	3484 bd	93,3 bd	66,4 g	79,8 bd	7,8 be	5,7 ef	6,7 bd	98,7 de	83,5 ab	91,1 cd	34,2 ac	32,8 ab	33,5 ab	98,0 ac	103,8 a	100,9 a	18,4 ab	16,1 df	17,3 cg
NOVA	3940 ac	2728 d	3334 de	92,1 ce	70,6 eg	81,4 bc	2,7 g	4,6 f	3,6 f	132,8 a	81,2 ac	107,0 ab	33,2 a	33,5 b	33,4ab	97,0 a	105,3 ab	101,1 a	17,3 bc	15,4 fg	16,4 fh
Mean	3688	3500	3594	90,7	76,9	83,8	6,3	7,3	6,8	108,3	73,2	90,7	34,4	35,0	34,7	100,0	108,2	104,1	16,9	17,8	17,3
LSD (%5)	454		321	9,0		6,4	2,5		1,7	15,1		10,6	1,2		0,8	2,0		1,4	18,9		13,4

Large variations resulted in statistically different groups with respect to 100-seed weight (range from 14,3 g to 21,5 g). Although the soybean line BDUS04 standed out in terms of 100 seed weights, grain yield of this genotype does not seem to be at the desired level. Sarimehmetoglu (2006) emphasized that grain size in soybean genotypes differed significantly at the probability level. Results of the current study supported the mentioned researcher.

Two soybean lines (BATEM306 and BATEM317) were detected showing a statistically similar performance with the control varieties for the plant height. Although these two soybean lines are promising genotypes in terms of plant height, their vegetation period is too long for second cropping. These genotypes may have performed well in plant height due to their long vegetation period. Our results support Sousa et al. (2015) who reported significant and positive genetic correlation between plant height and vegetation period in 71 F_6 soybean genotypes.

The highest Pod number plant^{-1} (PPP) value in the study was obtained from the KASM03 genotype. This genotype was also determined to be superior in terms of grain yield, followed by Nova, BATEM223 another promising genotype for grain yield, Arisoy and KAMA. Results for PPP from the current study were very higher than those of the researchers who reported PPP numbers between 36-62 (Sincik et al., 2008) and 46-65 (Gulluoglu et al., 2016).

Grain yield of the lines and registered varieties significantly varied from 3963 kg ha^{-1} to 3147 kg ha^{-1}. It was indicated that genotypes of the present study are highly promising lines for second cropping when it compares with the results of Karagul et al. (2011) who reported grain yield ranged from 2540 to 3870 kg ha^{-1} in the main growing conditions in Izmir. In addition, Gulluoglu et al. (2016) reported that soybean yield can reach to 4000 kg ha^{-1} and more in the second cropping conditions at Adana province.

In this study, although genotype x year interactions were significant for grain yield, it has been found that lines which were promising for grain yield were more stable and maintained their superiority in two years. Although BATEM317 and KASM03 soybean lines showed significantly high yielding performance, KASM03, KASM02 and KAMA soybean lines having early maturity and more grain yield than registered varieties, were found to be promising genotypes in the second cropping conditions of Bornova, Izmir, Turkey.

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